WORLD METEOROLOGICAL ORGANIZATION

JOINT MEETING OF THE COMMISSION FOR BASIC SYSTEMS OPEN PROGRAMME AREA GROUP ON PUBLIC WEATHER SERVICES DELIVERY (OPAG-PWSD) EXPERT TEAMS ON IMPACT OF MULTI-HAZARD PREDICTION AND COMMUNICATION (ET/IMPACT) AND ON SERVICES AND PRODUCTS INNOVATION AND IMPROVEMENT (ET/SPII)

Beijing, China, 30th Oct - 2nd Nov 2017

FINAL REPORT

EXECUTIVE SUMMARY

A Joint Meeting of the Commission for Basic Systems Open Programme Area Group on Public Weather Service Delivery (CBS/OPAG-PWSD) Expert Teams (ETs) on Impact of Multi-Hazard Prediction And Communication (ET/IMPACT), and on Services and Products Innovation and Improvement (ET/SPII) was held in Beijing, China from October 30th to November 2nd 2017. In addition to the Chairpersons and members of the Expert Teams, the meeting was attended by the Chair and Co-Chair of the OPAG-PWSD, and a number of experts from the China Meteorological Administration (CMA).

The Chairpersons of the Expert Teams, in conjunction with the Chair of the OPAG, had previously decided that it would be of great benefit to identify both separate and plenary sessions for the respective ETs during the week. Thus, an agenda was designed that was highly interactive. This agenda concept was based on the premise that the service requirements identified by ET-IMPACT should largely drive the priorities executed by ET-SPII, with particular focus on the technologies required to effectively deliver critical impact forecast and warning services.

As was anticipated, a lively discussion ensued during in the plenary meeting sessions, which then gave rise to a highly productive series of break-out sessions. In these breakout sessions, the ETs developed lists reflecting best practices, gaps and recommendations across the "Key Elements in the Development of Impact Forecast and Warning Services", as cited in the "WMO Guidelines on Multi-Hazard Impact-Based Forecast and Warning Services" (WMO No-1150). These lists were discussed in plenary, and then considered by the experts in both Teams to create more refined paragraphs for inclusion in the final joint meeting report for both teams. The content of this report therefore has a focus on best practices, gaps and recommendations with regard to service delivery, as well as those relating to product innovation and improvement.

Issues of particular note arose from the reports to the ICT from the Chairperson of the OPAG, and the Chairpersons of the ETs, and from subsequent discussions, including consideration of the following over-arching initiatives:

(a) The WMO Service Delivery Strategy and its Implementation Plan;

(b) The development of a General Service Delivery Guide applicable across all service-focused areas of WMO work;

(c) Impact-based forecast (IBF) and warnings services;

(d) The proposed Global Multi-Hazard Alerting System (GMAS);

(e) Consideration of the specific role of PWSD in defining services to meet growing urban needs;

(f) PWSD contribution to a concept paper on the development of a Common Interface for Service Delivery (CISD);

(g) Application of the Competency Assessment framework within PWS;

(h) Application of technologies to PWS delivery;

(i) Assessment of the Social and Economic Benefits of Met/Hydro services;

(j) Communication aspects of PWS;

The Joint Meeting of the ETs decided on the following key Resolutions, some with associated actions and proposals to the Implementation and Coordination Team on the OPAG-PWSD and onwards to the Commission on Basic Systems:

- Stress to all NMHS that a nation's capability to protect its citizens is fundamental, and that each should exercise this responsibility through one or more organisations collectively identified as official alerting authorities to provide the single 'Authoritative Voice'.
- OPAG-PWSD to adopt an overarching principle equivalent to 'enabling anyone, anywhere to have at least one way to receive, and then to be able to understand and benefit from, weather warnings'
- Stress the importance of following WMO Service Delivery Strategy, including Quality Management Systems (QMS), in view of the movement towards IBF.
- 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.
- Review and update Competencies to ensure focus on IBF KSAs ('Knowledge, Skills and Abilities'), e.g., risk assessment, establishing partnerships, and change management).

1. OPENING

1.1 At the kind invitation of the Government of the People's Republic of China, a Joint Meeting of the Commission for Basic Systems Open Programme Area Group on Public Weather Service Delivery (CBS/OPAG-PWSD) Expert Teams on Impact of Multi-Hazard Prediction and Communication (ET/IMPACT) and on Services and Products Innovation and Improvement (ET/SPII) was held in Beijing, China from October 30th to November 2nd 2017. In addition to the Chairpersons and members of the Expert Teams, the meeting was attended by the Chair and Co-Chair of the OPAG-PWSD, and a number of experts from the China Meteorological Administration (CMA). The Meeting opened at 0900 hours in Meeting Room 701 of the Huafeng Building, CMA in the Haiden District of Beijing. In their opening remarks, Mr. Gerald Fleming (Chair, OPAG-PWSD), Mr. Eli Jacks (Chair, ET/IMPACT) and Dr. Will Lang (Chair, ET/SPII) welcomed the participants and outlined some of the logistical arrangements for the meeting.

1.2 The Vice President of CBS, Prof. Meiyan Jiao, Deputy Administrator of CMA, welcomed the participants and emphasised the importance of their work to CBS and to WMO. The Deputy Director General of the CMA Public Meteorological Service Centre, Mr Jinjun Pan, also extended a warm welcome to the participants.

2. ORGANIZATION OF THE MEETING

2.1 The Meeting agreed on its working hours as 0900 - 1700 with appropriate time allowed for lunch and coffee breaks.

2.3 CMA kindly provided a tour of some of its facilities in the Huafeng Building at 1600 on Tuesday, October 31st, including presentations on recent developments in forecasting and a visit to their broadcasting studios.

2.4 During the morning of Thursday 2nd November, the meeting was addressed via videoconference by Mr Michel Jean (President of CBS) who thanked the ET members for these efforts and discussed the main themes of the meeting, including the technical challenges faced by the PWS community, and the drivers to promote common systems and standards for sharing of authoritative meteorological data and information.

3. REVIEW OF THE RELEVANT DECISIONS OF Cg-17, CBS-16 AND EC-69

3.1 Mr. Fleming presented an introduction to the WMO structure and decision-making processes for the benefit of new ET members. He then outlined the relevant decisions made at Cg-17, CBS-16 and EC-69 and highlighted issues for discussion and comment for the OPAG-PWSD ETs, namely:

- Participation in creating a 'General Service Delivery Guide' and contribution to a concept note on 'Common Interfaces for Service Delivery' (CISD)
- Development of training materials and an implementation strategy for IBF
- Guidance on collection, processing and sharing of impact-related data
- Recommendations for urban service delivery

4. REPORT OF THE CHAIRS OF ET/IMPACT AND ET/SPII

4.1 Mr. Jacks commented on the success of publication WMO No-1150, the guidelines on IBF, which was now being applied by a number of initiatives worldwide, including the United States' Weather Ready Nations programme.

4.2 He described how IBF would provide a framing theme for this meeting, via which the assembled experts would explore wider issues such as service delivery, new technology, urban provision and training needs.

4.3 Dr. Lang welcomed the expanded membership of ET/SPII and welcomed the opportunity for both ETs to meet together following the structure for coordination of OPAG-PWSD activities which had been developed at the ICT meeting in Dublin, Ireland in 2015.

4.4 Dr. Lang also noted that the WMO Strategy for Service Delivery and its Implementation Plan (SSD-IP) was also an influential document, and was a natural counterpart to the IBF guidelines; impact-based forecasts and good service delivery go hand-in-hand and thus there was a natural synergy between the goals of the ETs. Along with the PWS Competencies – to be discussed at the ICT meeting following the ET meeting – these documents defined the core principles driving the OPAG's activities.

4.5 ET/SPII had completed the document 'Guidelines on Development of Nowcasting Systems' in 2016. A decision had been made in late 2016 to pass this to OPAG-DPFS to be merged with the DPFS 'Guidelines for Nowcasting Techniques' (WMO No-1198) which was also approaching publication. Dr. Lang noted that the ET/SPII contribution to the draft merged publication was much less substantial than had been anticipated by the ET, and asked the Secretariat to proceed with publication of the complete ET/SPII document via the PWS website to ensure members could benefit from its useful content.

4.6 The Nowcasting document above was the main deliverable agreed at the previous ET/SPII meeting in Exeter, UK in July 2016. Standing deliverables such as regular review and reporting on WWIS/SWIC would continue, but otherwise a new set of deliverables would be agreed based on the discussions in the current meeting.

4.7 The Chairs observed that the current ToRs for ET/SPII (and ET/IMPACT) had recently been reviewed and were judged to remain valid, though it was noted that the pace of change around new technology in particular suggested that the wording and direction of the ToRs should be reviewed regularly.

5. PRESENTATION OF TASK TEAM REPORTS

5.1 Dr. Lang explained that ET/SPII has been coordinating input from two Task Teams, TT-IPWSD (Task Team on Innovative Exploitation of Emerging Data for Improved PWS Delivery) and TT-PPP (Task Team on Cooperation Between Public and Private Sectors for Public Weather Service Delivery).

5.2 He also conceded that progress on the TTs had been slow to start and difficult to progress but he was grateful that the TTs had been able to prepare initial reports of their findings in time for the current meeting. He suggested that a more formal approach be adopted to the TTs involving regular contact between members (e.g., videoconference), clear deadlines for tasks and the possibility of face-to-face meetings. The Secretariat offered to help facilitate this approach.

5.3 TT-IPWSD work had focussed on a survey of the crowdsourcing capabilities of a sample of NMHSs. This survey is based largely on a survey of European NMHSs independently undertaken by ZAMG, Austria. The staff undertaking the ZAMG survey had been asked to join the TT and kindly contributed the findings of their survey.

5.4 The initial survey results highlighted the increasing importance and use of crowdsourced (and 'spotter network') observational data to NMHSs – most of those sampled were actively using crowdsourcing and looking to develop new ways of gathering and exploiting these new sources.

5.5 The meeting agreed with the suggestion to extend the TT-IPWSD survey beyond Europe, and proposed that the Secretariat aid the TT through using the PWS Focal Points to widen the sample.

5.6 TT-PPP's report focused on a provisional definition of the 'Authoritative Voice' (AV), for consideration and use within the broader WMO discussions around PPP. In summary, the report proposes that the AV is a mechanism a nation should use to warn its citizens, and that use of the AV should be delegated by a nation's government to an organisation (or organisations) which collectively meet the required standards of service delivery (e.g., reach, accuracy, relevance) for warnings and high-impact weather advice. This will usually be delivered, or at least coordinated by, the NMHS.

5.7 ET members agreed broadly with the definition presented in the TT-PPP document. There were suggestions around making greater links with the concept of 'attribution', and an opportunity to make greater use of the WMO PWS list of Official Alerting Authorities. The TT was asked to consider these changes to the document, which would then be circulated through CBS for use in the wider PPP discussions.

6. SUMMARY OF DISCUSSIONS AROUND MAJOR TOPICS

IMPLEMENTATION OF IBF: 'WEATHER READY NATIONS' EXAMPLE

6.1 The meeting was joined via videoconference by Mr. Dan Beardsley (NWS, United States) and Dr. Rochelle Graham (Hydrologic Research Centre, United States). They described the Weather Ready Nations (WRNs) projects around implementation of IBF. Work with Barbados, South Africa, El Salvador and Costa Rica was underway, with work with Guatemala and Indonesia soon to begin.

6.2 The project goals are based around improving the usefulness of the products and services for decision-making offered by NMHSs.

6.3 Project activities include stakeholder workshops to formulate risk matrices, - following the process described in WMO No-1150, developing web-based tools, and conducting demonstrations, with SOPs for processes and training for both forecasters and disaster risk managers.

6.4 Challenges highlighted by the projects include development of closer relations between agencies, managing change, incorporation of social science, and the need to create impact databases.

6.5 The ET members thanked Mr. Beardsley and Dr. Graham for their contributions, and agreed that it was very encouraging that the IBF Guidelines were an integral part of their work. There was discussion around whether formal links should be established between WRNs and OPAG-PWSD. It was also noted that WRNs is one of a number of implementation activities now underway based on the IBF Guidelines, including WMO regional workshops and SWFDPs.

6.6 It was proposed that there should be a mechanism to a) feed the findings, experiences and lessons learned through these implementation groups back to the OPAG for possible future updates to the Guidelines, and to b) allow the OPAG to ensure consistency and assess quality of the implementation activities based on the Guidelines. This might be achieved through a workshop involving representatives from the OPAG and from each implementation group.

COMMON INTERFACE FOR SERVICE DELIVERY (CISD)

6.7 The Secretariat gave context to CISD, referencing Decision 40 (EC-69) stating that a concept note for a 'Common Interface for Service Delivery' (CISD) should be submitted to EC-70.

6.8 The ET members reviewed background documents supplied by Dr. Qin Zeng (CMA, China) and Mr. Simon Swan (Met Office, UK). The first document described the CISD concept. The second presented OpenWeather (designed by a consortium of European NHMSs) as an example of the new technologies which might be used to underpin a future CISD design.

6.9 Mr. Jeremy Tandy (WMO Secretariat, on secondment from the Met Office, UK) joined the meeting by videoconference to provide technical background and advice on CISD. Jeremy highlighted the need for a user requirement to be developed for CISD before technical work would progress. A variety of technical solutions were possible based on this requirement.

6.10 The meeting discussions queried the purpose of CISD and the business case behind it, including intended audience and usage. Questions around usage included whether CISD is intended as an official, attributable source of data for use by data aggregators (e.g.,Google) and other businesses, a support tool for global and regional DRR activities (such as those provided by WMO on a trial basis to the UN), or a mechanism to help Members develop digital capabilities.

6.11 The meeting also questioned the potential overlap with similar activities and systems such as GMAS, the World Weather Information Service and Severe Weather Information Centre (WWIS/SWIC), the Global Data Analysis and Processing System (GDPFS), the WMO Information System (WIS), and the Global Disaster Alert and Coordination System (GDACS). It was noted that there was a perceived lack of join-up between discussions around CISD and these systems.

6.12 Mr. Armstrong Cheng (HKO, Hong Kong, China) asked how 'gaps' in data/content in a CISD from nations unable to provide appropriate input would be filled. He cited HKO experiences with WWIS, in which around 40% of Members are still not able to provide the data required for that system. Are we demanding a technical proficiency which many NMHSs may not have? And how do we ensure attribution of the CISD content to each nation's 'Authoritative Voice'?

6.13 There was further discussion on CISD during a break-out session on Wednesday. Further questions arose around how nations and their designated providers of information to a CISD would be able to select who was able to access their data, how to charge for it in some cases, and how individual members could monitor use of their data.

6.14 The role of the private sector in CISD was queried. Would they be required to build and host the system (working with organisations specialising in cloud-based technologies, for example), or would they be largely consumers and aggregators of the data?

6.15 Mr. Tandy replied that CISD should be designed to facilitate delivery of Members' strategies for reach and use of data and forecasts. He urged members to develop 'Digital Strategies', examples of which already exist in some NMHSs.

6.16 Many of the questions above remained unanswered, highlighting the need for further discussion and evaluation of the idea, formulation of user requirements and the creation of a concept note. The outcomes from the current discussion would be further considered at the ICT meeting following the ET meeting.

UPDATE ON WWIS/SWIC

6.17 Mr. Cheng presented a review of the current status of the WWIS/SWIC. It was noted that an update to the website was made in 2017 to include a number of new features such as current weather, global satellite imagery, sunrise and sunset information. The new

website also features a new user interface to facilitate quick search of cities, and adopts responsive web design that provides a better browsing experience for mobile users. Updated versions of MyWorldWeather app, featuring the new content of the WWIS/SWIC website, were also made available for iOS and Android platforms.

6.18 The WWIS provided weather information for over 2,100 cities contributed by 169 members in 11 languages. The usage statistics also showed a significant boost after launching of the new websites and app. It was particularly noted that some Members were not providing forecasts to the WWIS reliably although many efforts were made to engage them. It was recognized that the recommendation of last ET/SPII meeting to request ECMWF provide ENS data to augment the gaps of missing forecast on the WWIS had met with a positive response, with some conditions. The coming Coordination Meeting on WWIS website hosts would further explore means to increase participation of Members, with the use of ECMWF ENS data to "fill in the gaps" employed as a last resort.

6.19 It was also noted that official hydrometeorological alerts issued by Members are planned to be aggregated and made available on the proposed WMO (GMAS). The SWIC would be upgraded to become a display platform of GMAS, while the WWIS would also be enhanced subsequently to display the alerts for cities concerned.

DISCUSSION ON URBAN SERVICE PROVISION

6.20 Dr. Liisa Jalkanen (WMO) made a presentation to the meeting on urban issues. She noted that world population was expected to rise to 9 billion by 2050, two thirds of which would be based in urban areas. The number of megacities is due to rise from 23 to 37 by 2025.

6.21 Dr. Jalkanen provided background to the relevant UN-activities (HABITAT III, the UN-wide New Urban Agenda and Sustainable Development Goals) and the establishment of the WMO cross-cutting urban focus through Resolution-68 (Cg-17, 2015).

6.22 She then stressed the need for guidance on urban weather and climate service provision to be 'useful, usable and used'.

6.23 Mr Qing Wang (CMA, China) gave a presentation on urban issues based on experiences in delivering urban weather and climate services in Shanghai. With 24 million inhabitants, Shanghai is densely populated and congested, with critical weather-sensitive areas such as downtown, the airports and harbours. He highlighted the 'magnification effect' in which slight events can have significant impacts, and the 'domino effect' in which secondary and tertiary impacts can have both short and long-term consequences. He gave examples of impact based forecasts around urban flooding and health impacts, the latter exploiting simple, cartoon-like graphics to aid reach and understanding by users.

6.24 During subsequent discussion, members highlighted the particular importance of IBF, and the technical aspects surrounding IBF service delivery in the urban environment. The need for integration of information across systems and collaborative decision-making across agencies is vital in this context, and that urban service provision implies, indeed requires, an impact-based approach.

7. BEST-PRACTICE AND GAPS IN SERVICE DELIVERY OF IMPACT BASED FORECASTING

7.1 ET members were asked to give short presentations on issues relevant to the meeting themes. ET/IMPACT members were asked to identify best-practice and gaps in impact-based warning provision, using experiences based on their own organisations and nations. ET/SPII members were asked to identify broader emerging issues which will affect PWS delivery.

7.2 Summaries of these presentations are given in Annex IV.

7.3 ET Members then discussed the issues identified in break-out groups before reconvening to agree on actions in plenary. These issues were organised into categories based on the five key elements of IBF services described in WMO No-1150.

7.4 Outcomes, including ET and Secretariat actions and recommendations to the ICT and CBS MG, are presented In section 8 below.

8. IBF BEST PRACTICES AND GAPS, WITH RECOMMENDATIONS AND ACTIONS

8.1 Area 1: Partnerships

Best Practices:

- **Conduct annual and "as required" (e.g., post-event or 'end of season') assessments between NMHS and DMAs to improve services and clarify needs.**
  - Should include factors such as warning timeliness, whether proper action was taken, whether life and property were 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.
  - NMHS set clear requirements to partners for required data formats to facilitate NHMS support.
  - Excellent 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 do 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, there is a lack of data transfer automation.
- 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 to 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 Strategy for Service Delivery (SSD) (and competency frameworks) to define baseline for PWS performance.

- PROPOSED RECOMMENDATION TO EC FROM CBS MANAGEMENT GROUP: OPAG-PWSD suggests that a nation's capability to protect its citizens is fundamental, and that it should enact this responsibility through one or more organisations collectively identified as official alerting authorities to provide the 'single authoritative voice'. PRs should also encourage an update of the WMO Register of Alerting Authorities.

- ACTION FOR ET IMPACT: ET IMPACT team members to send Eli Jacks, by 31 March 2018, examples of interactions between NMHS and partners, especially during big events, as a reference source of PWS. Examples could include events such as the CMA annual meeting with partners, NZ annual survey with regional authorities, and HKO interactions not only with DMA but with all other government departments. Text should be no more than one page and demonstrate how the interactions benefitted the partners and/or the public, and how these interactions exemplify the goals of IBF. Graphics may also be included to support the text.

- RECOMMENDATION TO EC FROM CBS MANAGEMENT GROUP: Stress importance of enhanced QMS database in view of movement to IBF. Gerald Fleming to draft a statement for transmission to CBS Management Group by February 28, 2018.

- 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. Miriam Andrioli to ensure inclusion of sessions to foster discussion of IBF best practices is scheduled for all upcoming RA Workshops.

- SECRETARIAT ACTION: Establish a one-stop shop for cross-cutting WMO documentation related to socio-economic benefits, partnerships (DRR, WWRP, WB, HiWeather, etc.) and solicit NMHS to send examples to populate this link. Secretariat to establish this new web site and publicize to the entire PWS group by February 28, 2018.

- ET SPII and ET IMPACT ACTION: Gather and publish examples of people working in embedded advisor roles. Stress best practices and pitfalls. John Koch of ET SPII to create template (one page) and collect examples of how

NMHS advisors support partners from all PWS members. Members should send examples to John by April 30, 2017.

8.2 Area 2: Impact-Based Information and Service Development

Best Practices:

- Linking directly to partners and users to set impact-based criteria and building impact based models to support provision of critical decisions.
- Provision of spatially and temporally-specific information in easily 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 the Common Alerting Protocol (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" with regard to 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 emojis
- 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 additional 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

- **F**OR ICT DISCUSSION: How do we set a course to best integrate external data sources to assure their quality, and deal with increased needs relating to the integration of new forecaster smart tools, dashboards, etc.? TT-IPWSD to be asked to report on ways of integrating external data sources into forecaster systems and report back by June 30, 2018.

- 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. This information could be used for a possible update to (or addendum to) to WMO #1150. Miriam/Sam to request1-2 page documents with graphical attachments as needed from Dan Beardsley (for WRNs) and other focal points to inform PWS, and provide integrated document to PWS ET SPII, ET IMPACT and PWS ICT by March 31, 2018.

- PWS RESOLUTION: PWSD 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.

- SECRETARIAT ACTION: Collaborate with SPII to reference any relevant ISO standards. Note WCAG example. Explore way forward for harmonizing languages and accessibility role. Ming Mei Li to draft a PWSD Resolution to cite the need for universal accessibility to NMHS warning information and also a short report on initial steps to attain this goal via CISD and GMAS by March 31, 2018.

8.3 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 flexibility 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).

- SECRETARIAT ACTION: Publish existing ET/SPII report on Nowcasting Systems onto PWS Web pages by January 31, 2018.

- 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. Will Lang to coordinate, gathering input, completing draft by end Sept 2018.

- ET-SPII ACTION: TT-IPWSD to extend initial European survey on crowdsourced data to rest of world, using PWS Focal Points, and issue report by June 30, 2018.

8.4 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 is 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, iIncluding 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" for forecasters on Impact-based Decision Support Services (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)

- 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. Jennifer Milton to send a separate solicitation to specify formats for collection of these examples. Provide to ET and PWS Chairs, and Secretariat for review by April 30, 2018.

- FOR ICT DISCUSION: Review and update Competencies to ensure focus on IBF KSAs (e.g., risk assessment, establishing partnerships, and change management).

- 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. Miriam and Sam to create a one-stop shop web site for existing training information for review by PWS leadership by April 30, 2018.

- 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. Secretariat to advise on the results of consultation and provide draft training recommendations by May 30, 2018.

8.5 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 DICSUSSION: How can we access needed social science expertise to support IBF? See PWSD action just below.

- PWSD ACTION WITH SECRETARIAT: Collect and publish examples of post-event assessments and methodologies for collecting impacts. All PWS team members to provide examples of post-event assessments for posting on the PWS website by March 31, 2018.

- 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). Will Lang to make contact with leads within these groups (by 31 March 2018) to establish and maintain links.

- ACTION FOR ET IMPACT AND SPII: Collect examples highlighting infusing social science into new product development and assessment. Eli Jacks and Carolina Cerrudo to provide examples of social science interactions for posting on the PWS website by March 31, 2018.

- SECRETARIAT ACTION: Collect names of experts on social sciences and economists that could support NMHS with selected needs. All PWS team members to provide names of social science experts who could support PWS by March 31, 2018.

9. PREPARATION OF THE REPORT OF THE MEETING.

9.1 The Chairs of the Expert Teams asked that the ET members prepare contributions to the meeting report commensurate with their areas on which they had made presentations. They would then work with the Secretariat to finalise the report.

10. ANY OTHER BUSINESS

10.1 There was no other business which had not already been covered in the agenda and discussions.

11. CLOSURE.

11.1 The meeting closed at 17.00 hours on Thursday, November 2nd 2017.

JOINT MEETING OF THE COMMISSION FOR BASIC SYSTEMS OPEN PROGRAMME AREA GROUP ON PUBLIC WEATHER SERVICES DELIVERY (OPAG-PWSD) EXPERT TEAMS ON IMPACT OF MULTI-HAZARD PREDICTION AND COMMUNICATION (ET/IMPACT) AND ON SERVICES AND PRODUCTS INNOVATION AND IMPROVEMENT (ET/SPII)

LIST OF ANNEXES TO THE FINAL REPORT

Annex I: List of Participants

Annex II: Meeting Programme

Annex III: Terms of Reference (TORs) of the ICT/PW

Annex IV: Summaries of presentations from ET members and invited experts

Annex V: Task Team reports

ANNEX I

JOINT MEETING OF THE COMMISSION FOR BASIC SYSTEMS OPEN PROGRAMME AREA GROUP ON PUBLIC WEATHER SERVICES DELIVERY (OPAG-PWSD) EXPERT TEAMS ON IMPACT OF MULTI-HAZARD PREDICTION AND COMMUNICATION (ET/IMPACT) AND ON SERVICES AND PRODUCTS INNOVATION AND IMPROVEMENT (ET/SPII) - Beijing, China, 30th Oct - 2nd Nov 2017

LIST OF PARTICIPANTS

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ANNEX II

MEETING PROGRAMME

Monday 30 October 2017			
	PLENARY SESSION		
0900 - 0930	**1. OPENING** **2. ORGANIZATION OF MEETING** • Adoption of the Agenda and working arrangements	• CMA • WMO • G. Fleming	30 mins
0930 - 1030	**3. REPORT BY CHAIRS** • PWS Overview and Key Items • ET/IMPACT Perspective & Goals for Week (EJ) • ET/SPII Perspective & Goals for Week (WL)	• • G. Fleming • E. Jacks • W. Lang	30 Mins
1030 - 1100	**COFFEE/TEA BREAK**		30 Mins
1100 - 1145	**4. REVIEW OF THE RELEVANT DECISIONS OF CBS-16, CBS- MG-17 AND EC-69**	• G. Fleming • E. Jacks • W. Lang	45 Mins
1145 - 1230	**5. REVIEW OF TERMS OF REFERENCE (TORS) FOR BOTH TEAMS** • Explore synergies	• All	45 Mins
1230 - 1400	**LUNCH BREAK**		90 Mins
1400 - 1530	6. **PRESENTATIONS AND GROUP DISCUSSIONS** • ET/IMPACT presentations and group discussion to cover: "IBF: Suggested Best Practices; Current Gaps & Challenges"	ET/IMPACT members make presentations on "best practices" and "gaps"	90 Mins
1530 - 1545	**COFFEE/TEA BREAK**		15 mins

1545 - 1630	**PRESENTATIONS AND GROUP DISCUSSIONS (Cont.)** • ET/SPII presentations and group discussion, including: - Reports from TTs (WL) - WWIS report • Other ET/SPII members report on emerging issues	• Will Lang • A. Chen • ET/SPII members present on challenges & opportunities presented by emerging tech.	45 Mins
1630 - 1700	• ET-IMPACT presentations for discussion within plenary • Provision of Urban Services • CISD discussion	• Experts • Liisa Jalkanen • WL, MA & J. Tandy (on phone)	30 Mins
Tuesday 31 October 2017			
	7. DISCUSSION AND DECISIONS ON THE MAJOR TOPICS TO BE ADDRESSED		
0900 - 1030	**BREAKOUT DISCUSSION GROUP FOR ET/SPII** 1. Advice on collecting and sharing impacts (YT) 2. Consider input into CISD concept paper (AC) 3. Consider input into General Service Delivery Guide (LMM) **Chair (WL) to facilitate among sub-groups and input as required**	**BREAKOUT DISCUSSION GROUP FOR ET/IMPACT** Break out groups: Per IBF Guidelines, develop slides on best practices and gaps on: 1. Partnership development 2. Information and Services Development 3. Functional Requirements 4. Capacity development in IBF including the role of RTCs 5. Service validation 6. Items related to EC decisions on IBF 7. Urban and environmental services; EC approved guides **Chair (EJ) to facilitate among sub-groups and input as required**	90 Mins
1030 - 1100	**COFFEE/TEA BREAK**		30 Mins

1100 - 1230	**BREAKOUT DISCUSSION GROUP FOR ET/SPII (CONT.)**	**BREAKOUT DISCUSSION GROUP FOR ET/IMPACT (CONT.)**	90 mins
1230 - 1400	**LUNCH BREAK**		90 Mins
	PLENARY SESSION		
1400 - 1530	• ETs brief each other on morning discussions; take notes of discussion to enable paragraph development • Joint discussion of recommendations for report	All	90 Mins
1530 - 1600	**COFFEE/TEA BREAK**		30 Mins
1600 - 1700	**8. TOUR OF CMA FACILITIES**		60 Mins
Wednesday 01 November 2017			
	BREAKOUT DISCUSSION GROUPS FOR ET/SPII AND ET/IMPACT (CONT.)		
0900 - 1030	**ET/SPII** Break out groups (continued): 1. Draft report paragraphs Further discussion of other emerging issues.	**ET/IMPACT** Break out groups (continued): Draft report paragraphs based on slides developed on Tuesday	90 Mins
1030 - 1100	**COFFEE/TEA BREAK**		30 Mins
1100 - 1230	Break out groups (continued):	Break out groups (continued):	90 Mins
1230 - 1400	**LUNCH BREAK**		90 Mins
	PLENARY SESSION		
	9. PREPARATION OF THE REPORT OF THE MEETING		
1400 - 1530	• Joint discussion of draft paragraphs. • Agree report outline and harmonize input	• E. Jacks • W. Lang	90 Mins
1530 - 1600	**COFFEE/TEA BREAK**		30 Mins
1600 - 1700	• Joint discussion of draft paragraphs (Cont.) • Agree report outline and harmonize input (Cont.)	• E. Jacks • W. Lang	60 Mins

Thursday 02 November 2017			
	PLENARY SESSION		
0900 - 1030	Brief joint catch up to plan finalisation of input to report	All	90 Mins
1030 - 1100	**COFFEE/TEA BREAK**		30 Mins
	10.DRAFTING OF NEW DELIVERABLES		
1100 - 1230	1. Expand and finalise report items 2. Draft new deliverables and any TT requirements	1. Expand and finalise report items 2. Draft new deliverables and any TT requirements	90 Mins
1230 - 1400	**LUNCH BREAK**		90 Mins
	11.CLOSURE OF THE MEETING		
	PLENARY SESSION		
1400 - 1500	Close for ET members early afternoon Chairs huddle to write report(s)		45 Mins

ANNEX III

JOINT MEETING OF THE COMMISSION FOR BASIC SYSTEMS OPEN PROGRAMME AREA GROUP ON PUBLIC WEATHER SERVICES DELIVERY (OPAG-PWSD) EXPERT TEAMS ON IMPACT OF MULTI-HAZARD PREDICTION AND COMMUNICATION (ET/IMPACT) AND ON SERVICES AND PRODUCTS INNOVATION AND IMPROVEMENT (ET/SPII) - Beijing, China, 30th Oct - 2nd Nov 2017

TERMS OF REFERENCE (TORS) OF THE EXPERT TEAMS ET/SPII AND ET/IMPACT

ToRs of the Expert Team on Service Provision Innovation and Improvement

(a) Monitor, evaluate and advise on challenges and opportunities for Public Weather Service Delivery presented by emerging science and technology;

(b) Address the user requirements identified by ET/IMPACT for data provision, management and visualization, through collaboration with OPAG-DPFS and other partners as necessary;

(c) Take responsibility for PWS guidance on, scientific and technical aspects of Service Delivery improvement, including now casting, uncertainty, CAP and mobile/web services;

(d) Provide oversight and coordination of the continuing development of WWIS/SWIC;

(e) Complement and enhance the delivery of user-oriented PWS, and devise strategies for NMHSs and partners to optimize use and analysis of non-traditional data in forecasting and warning services, using collected examples and use of such data, e.g., crowdsourced weather, impact and behavioural data or social media information;

(f) Assist the relevant bodies dealing with cooperation between the public and private sectors in matters relevant to public weather service delivery;

(g) Remain mindful of the PWS needs of LDCs and SIDS when innovating and developing new services, in the spirit of the principle that 'no country is left behind'.

(h) Identify experts to advise on technical aspects of Service Delivery improvement as required by the mandate above, specifically in the areas of Big Data and Public Private Partnerships.

ToRs of the Expert Team on Impact-Based Forecasting and Risk-Based Warning

(a) Building on the WMO Guidelines on Multi-hazard Impact-Based Forecast and Warning Services (WMO No. 1150), develop an implementation strategy which describes actionable steps and evolution.

(b) Develop and maintain an expert resource to facilitate activities and projects in the area of Impact-Based Forecasting, including representatives from the social sciences.

(c) Actively promote Impact-Based Forecasting by identifying a network of champions within NMHSs, sharing best practices through symposiums, journal papers and communication outlets.

(d) Provide NMHSs with guidance on how to standardize Impact-Based Forecasting messaging protocols and formats (e.g. colour-coding, language, icons etc.).

(e) Working with external users and stakeholders, technical commissions, regional associations, relevant OPAGs and Programmes of WMO establish user requirements for service improvements through science and technological innovation and implementation.

(f) Evolve current methodologies for verification and evaluation to incorporate a focus on Socio- Economic Benefits.

(g) Identify skills and relevant training needs for NMHSs and external users associated with wider implementation of multi-hazard impact-based forecast and warning services.

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ANNEX IV

SUMMARIES OF PRESENTATIONS BY ET MEMBERS AND INVITED EXPERTS

1. Challenges of Providing early warning for weather disasters

Roger Deslandes, General Manager National Operations
Bureau of Meteorology, Australia

Introduction

The Bureau of Meteorology operates under the authority of the Meteorology Act 1955 and the Water Act 2007. The Bureau is an Executive Agency under the Public Service Act 1999, and a non-corporate entity under the Public Governance, Performance and Accountability Act 2013. The Meteorology Act 1955 requires the Bureau to fulfil Australia's international obligations under the Convention of the World Meteorological Organization (WMO) and related international treaties and agreements.

Our purpose is to provide Australians with environmental intelligence for safety, sustainability, security, well-being and prosperity. Our forecast and warning services inform Government, the decisions of our partner agencies, our communities and industry.

Strengths

- The Bureau is a front-line emergency service agency.
- We partner with Federal Government and advise the Prime Minister and other Ministers on emergency management matters.
- Through an intergovernmental agreement the Bureau sits as a partner on a *Hazards Services Forum* with all state-based (jurisdictional) emergency management agencies to work towards a national standardisation of our Severe Weather Warning, Fire Weather and Flood warning services.
- Our services are largely delivered from State-based forecast centres in collaboration with a central National Operations located in Melbourne. Our point of service delivery and customer interaction is therefore attuned to state-based and local Governments, emergency responder agencies and local communities.
- The National Operations Centre is prototyping a risk and impact-based outlook product that involves assessing and combining community impact, operational impact and hazard likelihood rubrics to tier events in terms of their impact. The rubrics can also be combined to manage operational staffing during events and will be implanted as a foundation for a post event review management process.

Challenges & Gaps

- Ensure that the Bureau delivers value and impact to our communities;
- Ensure the Bureau delivers the benefits of Government infrastructure investment - the Bureau's super-computer, *Australis*;
- Continuing along a trajectory away from a thresholds-based warning system and towards a truly cohesive Multi-Hazard Early Warning System;
- Partnering with agencies to provide a nationally consistent, seamless service for our communities;
    - Many agencies currently deliver community "warnings" and alerts
    - Incorporate strong impact knowledge into warning services

- Big Data: intelligent alerting and tools to inform impact-based decision making;
- Streamlining routine forecast production to enable greater forecaster focus on high-value activities;
- Utilising probabilistic information and crafting and delivering services that meaningfully inform the decisions of our customers
- Talent Management and shaping the workforce: enabling cultural change towards IBF; defining capabilities, developing new roles; recruiting new staff to these and training existing staff to ensure current competency for IBF.

2. WMO Joint Meeting of CBS/OPAG-PWS ET-SPII and ET-IMPACT

Chris Noble, Meteorological Service of New Zealand Ltd.

The Meteorological Service of New Zealand Ltd (MetService) operates primarily from its head office in Wellington, and functions as a modern National Meteorological Service (NMS). Surrounded by a vast expanse of ocean in the South Pacific, MetService has significant areas of regional responsibility in the marine and aviation sectors over and above its domestic land-based public forecast and severe weather warning service. For marine, MetService is responsible for METAREA XIV stretching from the Equator to Antarctica and encompassing; high seas forecasts and warnings, operation of Tropical Cyclone Warning Centre (TCWC) Wellington, backup of RSMC Nadi-TCWC, along with provision of the Severe Weather Forecasting and Disaster risk reduction Demonstration Project (SWFDDP) in the South Pacific. For aviation, MetService operates the Wellington Volcanic Ash Advisory Centre (VAAC), a Meteorological Watch Office (MWO), and services the large Oceanic NZZO Flight Information Region (FIR).

Domestically, forecast and warning services are delivered via multiple channels, with social media engagement now playing a key role in outreach and communication, enhanced by a dedicated media meteorologist shift operating 7 days/week. Examples of impact-based nowcasts and forecasts were presented from both the public and commercial spheres.

The Severe Weather Warning service was outlined, noting it is primarily a threshold-based service, but including regional variations implemented under agreement with stakeholders, with ("poor-mans"?) impact-based statements included. A key achievement recently has been milestones delivered under a Severe Weather Modernisation Project, including graphical production of warning areas with the addition of delivery in the Common Alerting Protocol (CAP) format. Further enhancements are planned to include a reduction of warning types and implementation of a colour-coded warning scheme.

Impact-based warnings are also under consideration, being informed in part by research led by social scientist Dr Sally Potter (Post-Doctoral Fellow, Joint Centre for Disaster Research – Massey University and GNS Science). This research included a public survey (conducted late 2015) in which half of respondents were presented with a phenomena-based warning and half with an impact-based warning to test perceptions and stated intended actions. Key findings were that impact-based warnings were more effective in altering perceptions of the hazardous event, but not much more effective at prompting a response. A report of this survey and data is available for free online via http://shop.gns.cri.nz/sr_2017-001-pdf/.

Finally, a summary of challenges and gaps was presented, with the main challenge in NZ being the split of meteorological and hydrological warning services (MetService is responsible for the meteorology, but hydrology and flood forecasting services rest with 15 Regional Councils). As such, an inter-agency approach will be required for impact-based warnings (especially rain/flood events) leading to challenges including; timeliness, message ownership (and potential conflict), and the readiness/willingness of agencies to collaborate. A significant gap is the lack of a national impact database. Other challenges cited were; exposure and scale differences, how to manage

variable thresholds, how to verify impact-based warnings, and how to resource the increasing demand for consultant/embedded meteorologists by agencies/clients.

3. IBF and Warnings

LEE Lap Shun, HKO, Hong Kong, China

- HKO is looking for more government resources to properly transition to impact-based warnings.
- Examples of warnings that have an Impact-aspect
  1. Landslip (impacts developed in conjunction with Geotechnical agency)
  2. Storm Surge (specific vulnerabilities of coastal fishing and tourist areas)
  3. Fire warning (enhanced by cultural practices, such as the tradition of providing burnt offerings at the places of ancestors during holiday periods).
- Some gaps – the granularity of digital elevation model data is too coarse (in the order of a few metres) to be useful in predicting specific areal flooding risks. Understanding of relationship between traffic problems and heavy rain is not well-understood.
- Looking for correlations between wind direction and risk of falling trees.
- One challenge is the collaboration with stakeholders / partners. Gathering all the data in compatible formats is one such specific challenge. Disaster management is under the Security Bureau – weather is just a small part of their job.

4. Status of Impact Based Forecast and warning services in Mauritius: Best practices and gaps

Prem Goolaup, Mauritius Meteorological Services

Introduction

Located close to the tropic of Capricorn in the Indian Ocean, the tiny Island Mauritius lies in the path of tropical cyclones. The other hydro-meteorological hazards likely to affect the island are heavy rainfall leading to flood and flash flood, landslide and rock fall, storm surge, high waves and thunderstorms.

Current Practice

The current Early Warning System is well documented in the National Disaster Scheme of the National Disaster Risk Reduction and Management Centre (NDRRMC). Following a workshop held in October 2015, the Mauritius Meteorological Services (MMS) is working towards a Multi-hazards Impact-Based Forecast and Warning Services (MHIBFWS) in collaboration with the NDRRMC and other partners. NDRRMC is issuing an impact based bulletin with information provided by MMS and situational maps.

Historic data of past weather hazards and disasters are well archived at the MMS whereas impacts data are in the custody of other stakeholders, namely Agricultural Services of the Ministry of Agriculture, Water Resources Unit, Central Electricity Board, Aviation Department among others. These are being assembled and risk maps for the various hazards, namely flood, coastal inundation and areas prone to flash floods have been prepared. A catalogue of case studies and impacts is being compiled from the various archives. Thresholds for issuing warnings have also been established or recently reviewed.

Over the last two decades, since the built environment has changed significantly, the new developments have increased the vulnerability of the population to floods and flash floods. In other settlements people have simply ignored the building code as defined by the Municipal councils. Thus, both exposure and vulnerability of a given location has increased and are constantly changing.

Gaps and challenges
1. The main challenge is the shift in paradigm from early warning based on threshold to impact based forecast and risk based early warning leading to several "miss" with loss of lives in the past.
2. Needs of high resolution model products
3. Strengthen collaboration with other partners, namely: Agriculture, Water, Health, Energy and Public Infrastructure
4. Keep track of changing vulnerability
5. Capacity building of MMS and NDRRMC personnel
6. Accessibility of impact data from other partners
7. Education and awareness of the public
8. Need of colour coded early warnings

5. Impact based forecasting in Argentina: in the beginning of the process

Carolina Cerrudo, Lic. In atmospheric sciences
Hydrometeorology division - National Meteorological Service Argentina.

Among the functions of the Argentinean National Meteorological Service are the issuing forecasts, outlooks, and advisories in the entire country and adjacent seas (including the antarctic Argentinean sector).

Since 2014 some initiatives have been put into practice in order to move towards an impact-based forecast. In this sense, the "Weekly outlook of high impact weather events" has been developed, which is a two-week forecast that puts the emphasis in areas where high impact weather events are expected. It consists of a text description of the phenomena and a map with polygons indicating areas of potential impact. This product was specially thought to be useful to civil protection organizations and risk managers, and it is sent through their own lines of communication via ftp, interoperable format and email, apart from the web page and social networks. The forecast is the result of collaborative work between the departments of Hydrometeorology, Agrometeorology, Climatology, and the National Meteorological Center office. The decision of the polygon area to draw is based on the current situation. The current situation is the result of the collection of impact data, monitoring of height of rivers, heavy rainfalls, flooded areas, droughts, fires, avalanches, heavy snowfalls, storms, damage caused, number of evacuees, etc. This kind of information sometimes is very difficult to get access to. This difficulty in part is due to the municipality organization of the civil defenses.

In terms of weather alerts and storm warning, meteorological thresholds are used combined with subjective consideration of the impact according to the knowledge of the forecaster. Weather alerts are currently in text format, but in the future there will be graphic-colored alerts. Storm warnings are in text and polygon format, and they are issued in terms of radar coverage and monitoring. There are some improvements that storm warnings will have in the future such as better discrimination of the phenomenon, definition of intensity of storms, identifying the location of storms and their displacement, including of safety actions for population, improvement of the graphic format, and verification of warnings. In contribution to this last point, a survey has been developed for civil defenses to report the impacts. The "Alertamos" app has been implemented, which is the first official app in Argentina that allows any citizen to report surface weather phenomena, as well as flood or wind damage.

Since 2016 NMS has created the Meteorology and Society Department, with the objective of working on vulnerability, impact and risk communication. It is constituted by professionals of social sciences such as anthropology, sociology and geography specialists, with the objective of social and interdisciplinary construction of knowledge. Several workshops have been organized with users about NMS products and their communication, and surveys have been carried out in 60 areas of the country about impact thresholds (precipitation, wind) in different regions, in order to work on the generation of impact-based thresholds with input from the user. The processing of this information is a huge work that requires human resources for the contrast of the information with historical data and case studies. Besides, it is necessary forecasters training to a properly integration of vulnerability, exposure and impact data. In terms of the determination of hot wave thresholds, there is a study of heat wave mortality in the warm semester 2013-2014 in the central and northern regions of the Argentine Republic, which has been made in conjunction with Ministry of Health.

As a summary here are the gaps and challenges:

- Difficulty in obtaining the information of risk and impact.
- Lack of national impact data base.
- Lack of human resources.
- Training the forecasters on impact data integration in the forecast.
- Regionalization of impact data. How to consider different kinds of impacts in different regions.
- How to work with dynamic thresholds. The thresholds depend on the impact. The impact depends on the vulnerability and exposure, and these characteristics are variable in time and space.
- Improve coordination with other organizations.
- Arrival of the forecasts and warnings everywhere. Improve infrastructure and communication protocols.

6. Building a Weather Resilient Canada – highlights, challenges and considerations towards impact-based services in MSC

Jennifer Milton, Meteorological Service of Canada (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.

7. Impact based forecasting and decision support services in France

Cyrille HONORE, Meteo France

Mr Honoré started his presentation with the French national warning service : Vigilance.

From the very beginning in 2002, the service design did put the emphasis on the potential impacts of adverse weather rather than on meteorological metrics. In that respect, colour coded warning levels of can be interpreted homogeneously throughout the country despite a huge variability in some of the hazard intensity leading to potential similar impacts.

The warning areas are "departments", an administrative partition of the country so as to fit with Civil Protection disaster management and response organization and not Météo-France organization. The number of warning colours is 4, an even number so as to make a clear difference between "usually bad" weather and significantly high impact events. In these cases, warnings convey a message that not only deals with the meteorological forecast but also describe potential impacts. Moreover, behaviour advice is also provided. These items of advice were elaborated jointly with stakeholders such as the Ministry of the Interior (Civil Protection), the Ministry of Ecology and Sustainable development (Risk Prevention General Directorate), the Ministry of Health etc. Mandate was given to Météo-France to incorporate them with the warnings. Therefore, the general public is informed of what the weather will do and what they need to do as well.

Mr Honoré then insisted on the interest to assess the usefulness of the service over time. Since 2004, a assessment committee including the above-cited ministries, road management authorities etc has been meeting three times a year to evaluate whether or not warnings were relevant with respect to weather forecast, impacts registered on the field as well as preventive measures taken to mitigate these impacts. This kind of assessment is therefore fairly different from the usual verification standards applied to weather forecasts within the meteorological community. The

results is a range of performance indicators such as false alarms and non-detection rates, anticipation, that are followed at the highest level including Parliament.

It is to be noted that Meteo-France established internal procedures to contribute to this evaluation scheme. They require forecasters to come to work in office hours, out of shift, to perform a post-event review, thus contributing to the building of a collective experience.

Attention was also paid to the general public understanding. Annual surveys soon brought evidence that the service and its principles were very well known by the general public, with more than 90% positive answers. However, although television channel long remained the major information source cited by the public, the rise of new technologies and mobile devices in particular led to the need of updating not only the dissemination channels but also the messaging of the information itself. Collective intelligence seminars were conducted, including citizens along with stakeholders. Their conclusions will lead to the implementation of additional features in the service, including better localization in time and space in addition to the original department pattern, renewed display and messaging.

Mr Honoré went on with other examples of impact based services for a variety of professional sectors, including agriculture, ground transportation management. He highlighted that meteorologists need to engage in fully understanding user expectations and fear not developing partnerships in order to design and provide fully relevant services. Meeting theses requirements may lead to develop applicative impact models that integrate user information, be it static or dynamic in real time, along with atmospheric parameters in order to bring added value to the service.

The conclusion was that the Vigilance experience, brings evidence that impact based warning services are sustainable over time. One may note the idea was shared and implemented within Eumetnet/Meteoalarm and even more widely now.

However, a number of issues still need to be addressed and improved, such as vulnerability assessment, damage and loss recording/monitoring, impact model design. Mr Honoré then suggested that solutions are very probably to search from partnerships, (including PPPs), digital collaboration and tools, training and communication.

8. Exploration of Impact-based forecast and warning services in Shanghai

Qiang Wang, CMA (Shanghai), China

Shanghai is already the nation’s economic heart, and aims to be the financial, trade, transportation and shipment center of China. Critical (weather-sensitive) locations such as downtown, airports, harbors, etc. are highly sensitive to climate and weather events. And people live in Shanghai are also highly sensitive to weather events. Considering demands from users, Shanghai Meteorological Service focus on Impact-based forecast and warning services. The impact-based forecast and warning services in Shanghai takes both the users' capacities and the decision-making processes into account, making itself a brand new interactive style of forecast service.

The development of Impact-based forecast and warning services benefit from the progress of SMS regional NWP and SMS MHEWS platform. Development in respect of impact-based forecasts and warning services focus on urban flooding, aviation, marine navigation, health and transportation based on high resolution numerical weather forecasting products.

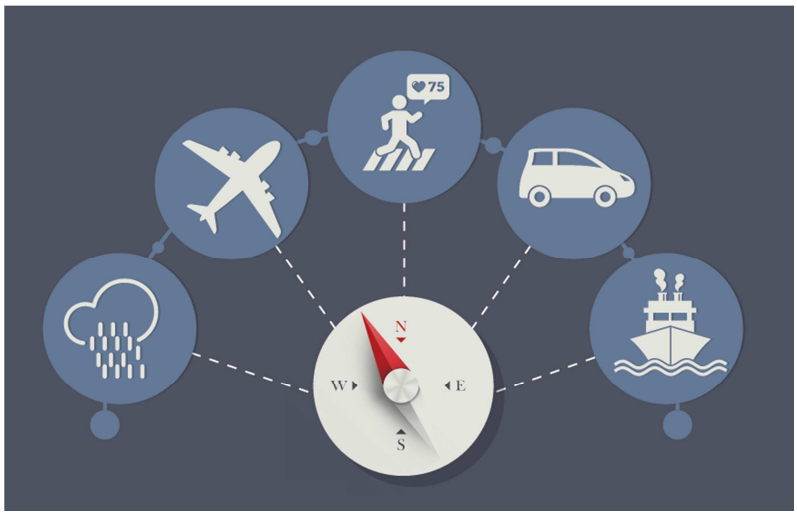

Fig 1 directions of Impact-based forecast and warning services in SMS

Fig 2 Urban flooding Impact-based forecast and decision making support system

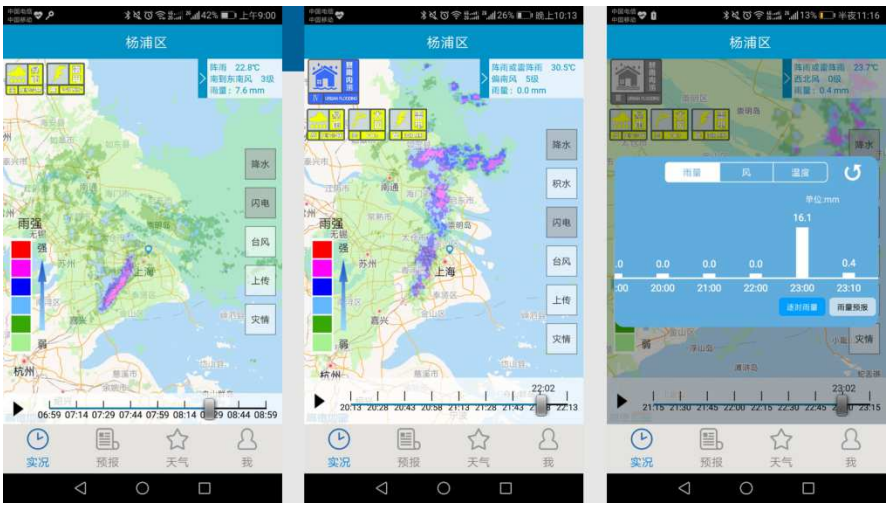

Fig 3 mobile apps used to disseminate urban flooding warnings to users

During the process of developing Impact-based forecast and warning services in SMS, gaps and challenges have been found as follows:

1. How to integrate the current SOP and impact-based forecast and warning services?

2. How to develop the impact models facing various demands, physical model or Big Data model?

3. Which one is users' favourite, probabilistic forecast or determinate forecast?

To develop Impact-based forecast and warning services better, solutions for these gaps and challenges should be found. 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. 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. 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. 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.

9. JMA's Impact/Risk-Based Early Warning System: Perspective and Lessons Learned

Juiya Fukuda, JMA, Japan

JMA has improved early warning system for many years, especially, the most basic information, warnings and advisories. For example, JMA divided warning zone into municipality, launched emergency warnings, introduced indices having stronger correlation with the hazard potential for rainfall-related warnings and determined warning criteria based on disaster statistics through coordination with the local government, and so on.

However, recently, various disasters especially rainfall-related disasters have occurred in Japan. From these disasters, JMA learned that in order for our warning services to lead to more appropriate emergency response, such as prompt judgments of issuing evacuation orders by Mayors and proactive evacuation of residents, we needed to develop information /services and partnership as follows.

1) Information and services

1.1 Need to convey proactively the risk of hazardous phenomena that has much social impact, even if the probability is not high, such as introduction of "Probability of Warnings" showing the probability of warning-level phenomena with two categories of high and middle, specifying phenomena and time frame in alert.

1.2 Need to develop information formats that help users understand risks of hazardous phenomena and their urgency, such as introduction of "Time series of Expected Warnings" providing 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 and "Real-time Risk Map" providing

spatially specific information about risk-level of landslide, inundation and flood in colors using a standardized color code.

2) Partnership

Need to promote the efforts to help DRR stakeholders and residents interpret and utilize JMA's warning information, such as enhancement of cooperation, for example, dispatch of experts for local DRR to local government, instruction and training about how to use information in normal situation, construction of face-to-face relationship in normal situation for effective hotline consultation in disaster situation.

JMA will continue to improve our early warning service like this.

10. L Jalkanen, WMO

Liisa Jalkanen 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. She noted that the world population reached 7 billion mark in 2011 and that 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 crisis. 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.

Liisa Jalkanen finished by stressing that local, national, regional and international collaboration is critical for success and that the products need to be usable, useful and used.

The presentation is available on the meeting website.

11. Yoshiro Tanaka, JMA, Japan

Yoshiro Tanaka made his presentation titled Rebooting Weather-for-Business Activities in Japan. He pointed out the dynamic increase of productivity using weather data is expected in broad-ranging industries considering IoT and AI technology development. The advanced utilization of weather data however is not achieved in many cases. Weather data is "dark data" with much potential, and it will become more valuable when combined with other data, and/or used with leading edge technology. In the case of Japan, Tanaka identified two challenges to address; (1) weather service delivery as required by industries and (2) dialogue producing new business utilizing weather data. To address these challenges, he stressed the importance of improving availability of fundamental weather data as well as business matching between private weather services and various industries. In particular, he introduced the Weather-for-Business Consortium (WXBC), the official English name to be determined, was established in March 2017 in order to jointly promote business that truly utilizes weather data. Comprising of private enterprises including private weather services as well as academia and government bodies, WXBC aims at the creation of advanced business models utilizing new weather data taking advantage of IoT and AI as well as continuous improvement of weather data and necessary capacity development. Tanaka concluded his presentation remarking that NMHS are experiencing the paradigm shift from traditional weather service where observation and forecast were provided solely by NMHS into "new stage" where weather services involve wider stakeholders in rapidly developing circumstances (IoT, AI, big data, crowdsourcing, private sector and global enterprise) to ultimately meet various requirements of various users.

12. Challenges and Opportunities in PWS Delivery

John Koch, NOAA/NWS, USA,

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; and Bureaucracy

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. User perception of level of service can be very different from our perception. Ethical considerations are relevant here.

Good medical analogy:

If you are ill, would you prefer to speak to a consultant or to get a read-out of your diagnosis? That is where our value lies. Relationships with our users are key to our survival and ability to thrive.

13. Challenges and Opportunities in Public Weather Service Delivery

Presented by Emerging Science and Technology:
Armstrong Cheng, HKO, Hong Kong, China

In embracing the provision of impact-based or impact forecasting and warning services, NMHSs have to employ not only state-of-art weather forecasting systems, but also latest science and technology such as big data, artificial intelligence, crowd-sourcing in the development of public weather service delivery. One example was the Hong Kong Observatory engaging partners of other government departments in a Big Data pilot project to predict the impact of rainfall on traffic speed for selected road segments installed with traffic sensors in Hong Kong. Actual rainfall data, nowcasting rainfall data, traffic speed data, accident data were employed in training an artificial neural network (ANN) model on a big data platform using clustering technique. The pilot demonstrated the capability of predicting impact of rainfall on traffic speed for individual road segments with reasonably good accuracy through an ANN model. Further efforts were undertaken to explore the extension of coverage to the whole territory by means of crowd-sourcing technology to gather users' locations with a view to deriving a real-time traffic map. In the development of impact-based or impact forecasting and warning services, NMHSs will face new technological challenges in areas where they may not have expertise in traditionally. Strong partnership with other organizations will be needed to overcome the technological challenges. On the other hand, the challenges also open up opportunities in the development of new services that may not be possible in the past.

17. Siobhan Ryan – Met Eireann, Ireland

Ireland's current warning system is one which primarily involves the use of colour coded thresholds. Modifications are however made as the forecaster sees fit, with Impact Forecasting set to become the new norm. On the 16th of October 2017, Storm Ophelia, at one point a Status 3 Hurricane, moved directly up over Ireland. This was the first time Ireland lit up fully RED, with the

decision to go 'all out' largely impact driven. The country essentially 'closed shop'; the schools shut their doors and everything else followed suit. 3 people died despite 99% of the population remaining indoors. The response was overwhelming with the public themselves exclaiming the fact that lives were 'undeniably saved'. The benefits of Impact Forecasting were clear for all to see, both internally and externally, with even the non-believers converted. However with schools closing for a further day for clean-up operations, the knock on socio-economic effect may well be a matter for discussion. Whilst the cultural shift is in evidence, a lag occurs across swathes of the work place. The following broad areas were highlighted as having 'gaps', or at the very least requiring fine tuning.

Develop partnerships with stakeholder: Understanding their needs with regard to services and how they use forecasts and warnings to make decisions; exchange expertise/knowledge of vulnerabilities and impacts at a local/regional levels for informed decisions; suitable structures to facilitate ongoing consultation and for efficient response to SWEs.

Technical infrastructure and forecaster tools: Enable the availability of weather observations and additional relevant data to monitor the weather and its impacts in order to support timely decision making; provision of reliable and robust forecast and warning input systems and databases, suitable tools for briefing, teleconferencing and broadcasting; means to include probabilities and uncertainties in forecasts; verification of forecasts and warnings.

Organizational and operational structures: Facilitate productive engagement with stakeholders on an ongoing basis; ensure a protocol for dealing with severe weather events; provision of efficient and flexible staffing structures; communicate impact based guidance, forecasts and warnings to stakeholders and the general public.

Implement training, outreach and education: Educate forecasters on hazards, impacts and vulnerabilities of people, places and regions; educate stakeholders on meteorology, climatology, forecasts and uncertainty; educate the public on all relevant aspects of weather and weather related hazards and impacts.

Meteorological and climatological research: Ongoing improvement of NWP and impact forecasting methods.

18. Emerging technologies: Challenges & opportunities

Ana Portillo,
State Meteorological Agency of Spain (AEMET)

In this presentation, some examples of how new technologies contribute to the improvement of services were given.

Big data: New Data Policy of AEMET came into force in 2016 and led to be freely available, a great amount of observational and climatological products and also permitted the greatest achievement in this field: **AEMET Open Data**[1]. With more than 50,000 downloads per day on average, this powerful tool helps all economic sectors to know the impact that meteorological events have on their own activities. It also contributes to crowdsourcing, citizen science, etc.

GIS format: AEMET prepares adapted products for transport sectors. For example, **METEORUTA**[2] integrates the physical maps from Google Maps/Open Street Maps, the official road

[1] *Open Data:* https://opendata.aemet.es/centrodedescargas/inicio

[2] *Meteoruta:* http://meteoruta.aemet.es/p_index.html

maps, the severe weather warnings and the outputs of the numerical weather model to show the weather just over the path selected by the user, in the period of interest. The benefits of using this kind of services are that the user could take the appropriate decisions before his/her travel, by adjusting the schedule to travel before traveling or/and select an alternative and more secure trajectory, if possible. All of this, contributes to improve security and welfare of society.

Another example of service provided in GIS format are the shape layers of network stations and air quality data stations network, freely available on the **GEOPORTAL**[3] website of the Agriculture & Environment Ministry of Spain, following the *Inspire EU Directive*[4]. This legal framework aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment. In the near future, this framework could help us learn more about the impacts that meteorological phenomena have on the environment in Europe.

Warehouse documentation: Other sector that can benefit from new technologies include education and information dissemination. **ARCIMIS**[5], the Institutional AEMET repository of documentation, with more than 7,000 files uploaded and almost three millions of downloads since October 2015.

Recommendations before launching new services: In addition to presenting all these services based on new technologies, some good practices were shared:

- Preparing user guides to help download information, or use it, depending on the user profile (programmer, beginner, senior, older people).
- Training technical service staff before launching the applications to ensure queries are addressed by qualified personnel.
- Holding conferences/workshops with users to explain the changes or the new services.

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[3] *Geoportal:* http://sig.mapama.es/geoportal/

[4] *Inspire EU Directive:* https://inspire.ec.europa.eu/

[5] *Arcimis:* https://repositorio.aemet.es/

ANNEX V

TASK TEAM REPORTS

TT-IPWSD

This informal Task Team (TT) has been asked to assess current capabilities of NMHSs to successfully engage in crowdsourcing[6] activities.

Around the world National Meteorological and Hydrological Services (NMHS's) and agencies are implementing hundreds of crowdsourcing approaches, citizen science programs, and other efforts to harness the collective ingenuity of people in the advancement of science.

Task Team members individually tapped into their own various networks to (first) anecdotally and then (secondly) to systematically compile a list of NMHSs that were actively engaged in some form of crowdsourcing weather and climate information.

It became obvious very quickly that nearly all NMHSs have engaged "citizen scientists" in some way, shape or form (see Annex 1).

Then, during the European Meteorological Society meeting in Dublin, Ireland Sept 2017, researchers led by Thomas Krennert from the Central Institute of Meteorology and Geodynamics in Vienna, Austria, presented a paper surveying NMHSs Crowd Sourcing activities (poster - see Annex 2).

From this preliminary work it was discovered that 86% of the surveyed European NMHSs actively applied or used crowdsourcing as a way to gather and report on various weather related parameters. Furthermore of the 14% of NMHSs not actively asking for information, internal forecasters and scientists were encouraged to access available and open information via different sources.

Recommended next steps:

It is now quite clear that further investigation is required with following recommendation.

1. The preliminary survey of the European NMHSs should be extended internationally with the following questions being addressed:
   I. That the "crowd" definition be refined into groups i.e. are they trained weather spotters?
   II. Was it a "push" or "pull" mechanism by which the information came to the NMHS i.e. did a forecaster scour social media reports for (say) hail? Was the information sent directly to the NMHS via (say) a mobile device?
   III. What type of meteorological information is being collected? Storm reports? Hydrographic events? Hurricane or Tsunami impact reports?
   IV. How is the data being stored or archived?
   V. Is the NMHS making this data collectively available publically?
   VI. Is any of the data being assimilated into forecast models?

[6] The practice of obtaining weather related information or content by soliciting contributions from a large group of people (citizens) rather than from traditional employees or suppliers. For the purposes herein, it was decided that the data collected need not necessarily be assimilated in any formal or academic process.

From a large extension of the European survey it will then be possible to assess a collective NMHS ability, resources, capability and usefulness for the data. It will also become apparent as to best practices for data collection as well as guidelines for public data access.

Considerations moving forward:

That the TT meets to develop the tactical implementation plan for expanding the research into international use of NMHS crowdsourced meteorological information.

It is also recommended that the WMO consider the future possibility of leveraging its online portal http://worldweather.wmo.int/en/home.html as a possible collection "hub" for global crowdsourced weather data.

TT-PPP

WMO OPAG-PWSD Task Team on Public Private Partnerships

Melanie Harrowsmith (UK Met Office), Michael Staudinger (ZAMG, Austria), Will Lang (UK Met Office, ET/SPII sponsor), Karen-Helen Doublet (Met Norway)

On 'The Authoritative Voice'

Prepared for OPAG-PWSD meeting Beijing, China, 30th Oct – 3rd Nov 2017

INTRODUCTION

This paper presents the initial discussions of this small, informal TT around possible 'rules of engagement' for public-private engagement in Public Weather Services. The discussions aim for consistency with WMO Service Delivery Strategy and the WMO aspiration that 'no country is left behind' in capability to warn its citizens, plan for, and manage the risks severe weather (in accordance with the Sendai Framework for Disaster Risk Reduction). There is also consideration of the vital role of the private sector in the Global Weather Enterprise, in which socio-economic benefit of weather and climate information may be maximized through public-private engagement. Perhaps most fundamentally it asserts that responsibility for protecting citizens lies with a nation's government, which will usually delegate this responsibility – 'the Authoritative Voice' - to its NMHS. This privilege should be earned, however, through demonstration of an effective, credible warnings capability designed around user needs in line with Service Delivery Principles.

Being 'the Authoritative Voice' for Weather, Hydrometeorology and Climate

An NHMS can attain Authoritative Voice (AV) status through two means:

1) By being the official authoritative voice, as nominated by the NHMS country's Government
2) Be recognized as the authoritative voice by the NHMS users/customers/partners.

However if an NMHS fails to deliver its service in line with customer expectations, then the 'official authority' designated by government will not necessarily enable the NHMS to retain its authoritative status. Members of the public will look elsewhere and the NMHS will no longer be recognized as the authoritative voice, even if officially it remains the AV. Thus *perception* of authority is as important as government-mandated authority.

To be the 'authoritative voice for weather, hydrometeorology and/or climate', an NWS or NHMS will:

1. be the principal source (determined by user feedback) of all meteorological, hydrological and/or climatological warnings, advice, guidance and/or science

2. be endorsed by government to provide services which enables its government and citizens to minimize weather-related risks and impacts thereby protecting property, infrastructure and economy
3. be the provider of credible advice, through proven and relevant scientific expertise, effective communication channels, and understanding of user needs
4. be subject to quality standards, such as suggested by WMO Service Delivery Strategy
5. have the reach and credibility required to influence decisions and trigger actions to minimize risks
6. work with or in partnership with other organizations to ensure the authoritative voice for weather/hydrometeorology/climate is represented alongside other expert fields
7. play a pivotal role in managing and coordinating the Authoritative Voice around weather, but also sometimes for climate and some other natural hazards

The role of government in setting the authoritative voice

1. As the principal funder for NMHSs, government should have the right to define how its Authoritative Voice is employed and delegated, and ensuring that it works in the national benefit.
2. A government should be proactive in ensuring its Authoritative Voice is used effectively, but only when necessary, based on possible impacts. Hence the concept is intimately related to strategy for Impact Based Forecasting and Warning.

Challenges to the Authoritative Voice

- Other weather providers may have a greater market share than the NMS/NMHS
- Other weather providers may be perceived to be more accurate and therefore users consider them to be the authoritative voice.
- Even if use and management of the Authoritative Voice lies primarily with a single organization, such as the NMHS, its use is a privilege which carries responsibility and has to be earned through demonstration of meeting the required standards.
- Alongside the NMHS, other authoritative organizations may need to be worked with, to ensure the core mission of the NMHS is delivered. These organizations may include the following: civil protection and emergency services, other natural hazards organizations, media, research institutes and the private sector. What matters is that, between them, these organizations can work together to represent a common, agreed view which reaches the required standards.

ET/SPII and ET/IMPACT are asked to support these definitions and pass to CBS MG and beyond for use in the wider discussions around public-private engagement. Subsequent discussions should consider the following:

1) Should the concept of authoritative voice be actively encouraged across NMHSs?
2) Should a government be able to elect **not** to have an AV?
3) Should there be a minimum standard for an NMHS to act as the the AV? E.g. an NHMS which has poor forecast accuracy, no reach and no influence when others might be able to do much better?
4) If so, who should define those standards? E.g. WMO or users of the NHMS services. Is, for example, WMO Service Delivery Strategy, sufficient to help define these standards in each nation.
5) Should the government recognize the importance of the AV being the NHMS, rather than another provider, and therefore support it accordingly? Or should it be allowed to be employed by any organization(s) recognized by the government who can meet the required quality standards?