WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

MEETING OF THE STEERING GROUP OF THE SEAMLESS GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM (GDPFS)

GENEVA, SWITZERLAND, 1 – 4 NOVEMBER 2016

FINAL REPORT

First row : Alice Soares, Michel Jean, Ken Mylne, Abdoulaye Harou, Paul Davies, Jean-Pierre Ceron,
Second row: Jan Danhelka, Jaiho Oh, Michel Béland
Third row: Yuki Honda, David Richardson, Ata Hussain, Stefania Ciliberti

EXECUTIVE SUMMARY

The meeting of the Steering Group of the Seamless Global Data-processing and Forecasting System (GDPFS) was held at WMO Headquarters, in Geneva, Switzerland, from 1 to 4 November 2016. Mr Michel Jean (Canada) chaired the meeting on behalf of the president of the Commission for Basic Systems (CBS), Mr Fred Branski. Participants to the meeting included representatives of technical commissions (except CIMO), ECMWF representative, co-chairpersons of the OPAG-DPFS, and representatives from some relevant WMO departments.

The representatives of the technical commissions (TCs) provided updates on TCs' activities in the area of data-processing and forecasting since the February 2016 meeting, including contributions/revisions to the draft White Paper. The meeting noted that Mr Gilbert Brunet (Canada, CAS representative) was nominated as the regional association (RA) IV representative to the Steering Group, and Mr Yuki Honda (Japan, OPAG-DPFS co-chairperson) and Mr Jaiho Oh have been identified as the RA II representatives.

The meeting prepared a draft GDPFS Imperative document, as given in Annex III, which follows the approach of the WIGOS documentation, and agreed that the long version of the draft White Paper should be its annex. The meeting also reviewed the draft outline of the implementation plan and prepared two tables that would be attached to it; one describing the areas of improvement, benefits and related WMO expected results; and a second table listing the tasks, priority, nature (business as usual/transformations), responsibility, areas of improvement, deliverables, milestones and timelines, and performance indicators. The revised draft outline of the implementation plan and tables are provided in Annex IV. The meeting decided to present the draft GDPFS Imperative document and the draft outline of the implementation plan (except the tables) to CBS-16 session (November 2016) as an INF document and make it available for consideration of CHy-15 session (December 2016). The meeting also reviewed the CBS-16/Doc. 5.6(1) on seamless GDPFS, and suggested a few changes as provided in Annex V.

The Steering Group recommended changing the name of GDPFS to clearly reflect the evolution the system towards seamless global data-processing and forecasting system, while it recognizes the concern that the Manual on the GDPFS is being replaced by a new one aiming at expanding its scope beyond the World Weather Watch (WWW).

Identified actions/timelines include:

- To present the draft GDPFS Imperative document and the draft outline of the implementation plan (except the tables) to CBS (November 2016) session as an INF document and discuss it also at CHy (December 2016) session,;
- To present the draft GDPFS Imperative document and the draft outline of the implementation plan (except the tables) to PTC/PRA meeting, in January 2017;
- To hold a Webex call with the Steering Group members by end January/early February 2017, to review the outcomes of the CBS and CHy sessions, as well as of the PTC/PRA meeting.

GENERAL SUMMARY OF THE WORK OF THE SESSION

1. OPENING OF THE SESSION

1.1 The meeting of the Steering Group of the Seamless Global Data-processing and Forecasting System (GDPFS) was opened at 09:00 hours on Tuesday, 1 November 2016, at the WMO Headquarters, in Geneva, Switzerland, by Mr Michel Jean (Canada), on behalf of the president of the Commission for Basic Systems (CBS), Mr Fred Branski. Mr Jean welcomed participants to the meeting, and invited Mr Abdoulaye Harou, Chief of the WMO Data-processing and Forecasting Systems Division, to address the meeting.

1.2 Mr Harou welcomed participants and thanked them for their great support, which reinforces the importance of moving towards seamless GDPFS. Mr Harou recalled that the World Meteorological Congress, at its seventeenth Session (Cg-17, May-June 2015), adopted Resolution 11 – "*Towards a future enhanced integrated and seamless WMO Data-processing and Forecasting System"*. He also recalled the first meeting of experts (identified by the presidents of technical commissions) to represent their commissions and to participate in the meeting held in Geneva, Switzerland, from 10 to 12 February 2016, to begin to address Resolution 11 (Cg-17). Mr Harou noted that the WMO Executive Council, at its 68th session (EC-68), endorsed the vision and scope of this work, and decided to establish a Steering Group on Seamless GDPFS (chaired by the president of CBS and involving the participation of representatives of technical commissions and regional associations) to develop the implementation plan and a white paper for its consideration at EC-69 (May 2017). He also noted that the experts that participated in the first meeting have been nominated by their respective Permanent Representatives to form the Steering Group on Seamless GDPFS, and therefore have been invited to the present meeting.

1.3 The WMO Secretary-General, Professor Petteri Taalas, welcomed participants to the WMO Headquarters and to Geneva. He noted that work being carried out by the Steering Group for the seamless GDPFS is very important to WMO Members and that the upcoming session of the Commission for Basic System (CBS), in November 2016, would consider the results of the present meeting. Professor Taalas underlined the move to data-centric in the aviation business, and to impact-based forecasting at the national level and more customer-oriented services at global, regional and national levels. In addition, he pointed out that the gap is increasing between developed and developing countries in the area of prediction therefore there is a need to use technology to reduce it. He noted that recently we have been experiencing temperature records and therefore the Paris agreement may need to be revised as climate change and variability would need to be seriously considered, including in the upcoming COP22 meeting, in Marrakech, Morocco, starting the following week. He also noted that seamless predictions are crucial for important sectors such agriculture and water management, and for health and well-being. He highlighted the importance and challenge of combining the research work with operations, and he is confident that within the framework of the seamless GDPFS, this will be a reality.

1.4 Professor Tallas recalled that Cg-17 gave a direction to review the structure of WMO Constituent Bodies, including technical commissions and regional associations, and the need to streamline WMO meetings and their contents to be more effective and efficient. He highlighted that CBS core activities, such as those associated with the World Weather Watch (WWW), would need to be retained, while noting that these need to evolve as technology advances. In particular, Professor Tallas recalled that EC-68 requested the development of a concrete implementation plan for the seamless GDPFS for consideration by EC-69 (May 2017). He noted the fact that the private sector is increasingly getting in the business and that, the issue was important enough for EC-68 to devote one day on this issue. The Secretary-General indicated his eagerness to get more resources to support WMO developing Members considering that more donors are looking forward to supporting developing countries meteorological services. Finally, he thanked the participants for their willingness to do the work related to the seamless GDPFS. He wished a successful meeting. He then took a few clarification questions. Mr Jean, the chairperson of the meeting, thanked the Secretary-General for opening the meeting and for his guidance.

2. ORGANIZATION OF THE MEETING

2.1 Adoption of the agenda

2.1.1 The meeting adopted the provisional agenda, as provided in Annex I to this report.

2.2 Working arrangements

2.2.1 All working documents submitted for the meeting are referenced and hyperlinked in the Documentation Plan (INF. 1), which had been posted on the WMO web site at:

http://www.wmo.int/pages/prog/www/DPFS/Meetings/SG-Seamless-DPFS_Geneva2016/DocPlan.html

2.2.2 The meeting agreed its hours of work and other practical arrangements for the meeting. Participants briefly introduced themselves, to facilitate interactions throughout the meeting. The list of participants in the meeting is provided in Annex II to this report.

3. INTRODUCTION

3.1 Review of minutes of the February 2016 meeting

3.1.1 The chairperson, Mr Michel Jean (Canada) provided an overview of the motivations to re-examine the GDPFS, and the activities that have been carried out. In this context, he recalled that the World Weather Watch (WWW), as defined in the WMO Technical Regulations (WMO-No. 49), is “the worldwide, coordinated, developing system of meteorological facilities and services provided by Members to ensure that all Members obtain the meteorological information they require both for operational work and for research”. He also recalled that the essential elements of the World Weather Watch are the Global Observing System (GOS), the Global Telecommunication System (GTS) and the Global Data-processing and Forecasting System (GDPFS). Mr Jean noted that GOS and GTS have expanded to WIGOS and WIS, and similarly the GDPFS needs to evolve to address the rapid transformations in the practice of operational numerical prediction, and the ongoing and emerging requirements from service-oriented programmes which support different sectors of society. In this context, Cg-17 decided to initiate a process for the gradual establishment of a future enhanced integrated and seamless WMO Data-processing and Forecasting System, in light of the conclusions of the first World Weather Open Science Conference (WWOSC-2014, Montreal, Canada, August 2014), in particular that a seamless system encompasses several dimensions including timescales, multiple weather related hazards, and societal impacts.

3.1.2 Mr Jean noted the first meeting of the experts, composed of representatives of technical commissions, including the president of CBS and the co-chairpersons of the CBS Open Programme Area Group (OPAG) on DPFS, was held in Geneva, Switzerland, from 10 to 12 February 2016, to discuss how to address Resolution 11 (Cg-17). Major outcomes of this meeting included the definition of the Vision of the future GDPFS and rough draft outlines of a white paper and an implementation plan were developed. He noted that EC-68 endorsed the vision and scope of this work, and decided to establish a Steering Group on Seamless GDPFS to develop the implementation plan and a white paper for its consideration at EC-69 (May 2017).

3.2 Status of the "Seamless GDPFS" project

3.2.1 EC-68 decisions

3.2.1.1 Mr Abdoulaye Harou, the Chief of the WMO Data-processing and Forecasting Systems Division, introduced the EC-68 decision document on the seamless GDPFS. The meeting noted that, following the decision by Cg-17 to initiate a process for the gradual establishment of a future enhanced integrated and seamless WMO Data-processing and Forecasting System, EC-68 decided to establish a Steering Group, chaired by the president of CBS and comprising representatives of technical commissions and regional associations, and the chairperson and co-chairperson of the CBS OPAG on Data-processing and Forecasting Systems (DPFS), with the following Terms of Reference, which would be reviewed at EC-69 as necessary:

(a) Provide guidance and monitor the development of the process for the gradual establishment of a future enhanced integrated and seamless WMO Data-processing and Forecasting System, based on the achievements of the World Weather Watch (WWW);

(b) Manage the integration of new components in the GDPFS, including addressing synergies with and requirements of all WMO Programmes and Regions, through active consultations with technical commissions and regional associations;

(c) Develop a description of the set of products the system should produce;

(d) Complete the Implementation Plan for the process for consideration by EC-69.

3.2.1.2 The meeting further noted that this Steering Group is a high level group, established under and reporting to the Executive Council, which demonstrates the importance of this work. It also noted that EC-68 encouraged advanced GDPFS Centres to pilot a seamless Data-processing and Forecasting System, following the approach described in the White Paper, and share with all Members the results and lessons learnt in order to improve the process.

3.2.1.3 The meeting noted that a draft White Paper and an outline of the implementation plan were presented to EC-68, who decided to retain only the Vision for the Seamless GDPFS, and requested the Steering Group to review the Paper and develop the Implementation Plan for the seamless GDPFS, for consideration by EC-69. While acknowledging that the Vision has been approved by EC-68, the meeting stressed the need for consistency across timescale when dealing with "monitoring", and recognized that this may not be the appropriate word to use in the first item of the Vision and may recommend to EC-69 an amendment. While noting that downscaling and post-processing have not been clearly stated in the Vision, the meeting agreed that these aspects are part of the seamless GDPFS, and would add them as a recommendation to EC-69. The meeting agreed to address these issues under agenda item 4.3.

3.2.1.4 The meeting discussed the meaning of the word "seamless" and agreed with the definition given by EC-68, in line with the first World Weather Open Science Conference (WWOSC-2014, Montreal, Canada, August 2014) definition, which acknowledged that "seamless" spans over several dimensions, including:

(a) Space and Time (nowcasting, through weather and ocean forecasts for days and weeks ahead to long-range forecasts on seasonal and up to multi-annual scales);

(b) Disciplines (hydrology and oceanography: flood, inundation, and water management; ocean forecasting, marine and coastal: wave and storm surge; air quality and sand and dust storm; natural resources, energy, tourism, transport, etc.);

(c) Prediction of non-weather-related elements, including the assessment of likelihood and probabilities of impacts and risks associated with hazards taking into account vulnerability and exposure information to support risk-based decision-making.

3.2.1.5 The meeting also acknowledged that the WWRP Scientific Steering Committee discussed this issue in its meeting on the previous week, and agreed that there is a fourth dimension in seamless, which relates to the transition of research results to operations.

3.2.1.6 The meeting also discussed the scope of the seamless GDPFS in terms of timescales and noted that it should be from nowcasting to near-term climate prediction (i.e. decadal prediction), while the Commission for Climatology is advocating for the inclusion of longer timescales (multi-decade and beyond) within the seamless GDPFS remit.

3.2.1.7 In the context of the scope and role, Mr Ken Mylne recalled the purpose of the GDPFS and how it is organized as a world-wide network of operational centres that provide outputs from their operational systems, and in some specialized activities, also provide interpretation of model outputs (i.e. provide a guidance service) and training to WMO Members, to support their provision of services in their countries. Mr Mylne also recalled the efficient delivery of GDPFS through the Severe Weather Forecasting Demonstration Project (SWFDP) Cascading Forecasting Process, and that this well-proven mechanism has been applied across wider hazards and applications, in a seamless approach. In summary, he noted that (a) GDPFS has been successful in supporting Members' NMHSs in their Service Delivery in their countries; (b) future seamless should aim to extend these successes to the wider operations across WMO technical commissions and programmes; and (c) the increasing need to move towards seamless GDPFS as systems become more complex and integrated. The meeting noted that GDPFS services are mostly provided by 24/7 centres, however it was pointed out that there are some services are not required in real time.

3.2.1.8 Mr Mylne expressed concerns with the vision adopted by EC-68, which appears very challenging to achieve. For example:

(a) Due to scientific predictability limitations for increased skill, as well as the requirements for computer enhancements to allow increases in resolution, skill and ensemble size;

(b) Transferring forecasts into impacts, especially in developing countries, is very challenging due to the complexity of impact modelling;

(c) Political sensitivities, by expanding the work to other WMO technical commissions and programmes, and engaging the private sector, may be seen as CBS telling them what to do;

(d) Sustainability (e.g. in relation to training requirements).

3.2.2 Draft White Paper

3.2.2.1 Mr Michel Béland (Canada) introduced the long version of the draft White Paper, which includes the contributions provided by the various WMO technical commissions and programmes on system and service requirements. This version was available on the WMO website at http://www.wmo.int/pages/prog/www/DPFS/Future%20GDPFS/Future-GDPFS.html. He informed the meeting that a short version of the White Paper was prepared for EC-68.

3.2.2.2 Mr Béland noted that the White Paper responds to Cg-17 request to initiate a process for the gradual establishment of a future enhanced integrated and seamless WMO Data-processing and Forecasting System, by describing: (1) why we are doing this; (2) the scope; (3) the vision; (4) general considerations on GDPFS core aspects, needs and characteristics, linkages with observations and data exchange, services, role of regional bodies, international organizations, research, and capacity development, the priorities, (5) the benefits, (6) opportunities, success factors and challenges, and (7) the mechanism for implementation and timelines. He pointed out the issues that need to be addressed by the meeting in order to prepare a roadmap (timeline) and a draft implementation plan, as requested by EC-68. The meeting agreed to review this document under agenda item 4.3.

3.2.3 IPT-SWISS

3.2.3.1 The meeting was informed that the CBS Management Group decided to include Space Weather under the remit of the OPAG-DPFS, while noting that the 4-year Space Weather Implementation Plan has a very short section on prediction (details on the implementation plan are provided in agenda item 4.2.1). The meeting noted the budgetary and staff resources implications of such decision and brought this issue to the attention of the WMO Secretary-General. The meeting noted that background information related to Space Weather aspects is provided under agenda item 4.2.1.

4. WAY FORWARD

4.1 Updates on TCs' activities related to GDPFS

4.1.0 The representatives of the technical commissions (TCs) provided updates on TCs' activities in the area of data-processing and forecasting since the February 2016 meeting. The meeting noted that Mr Gilbert Brunet (Canada, CAS representative) was nominated as the regional association (RA) IV representative to the Steering Group, and Mr Yuki Honda (Japan, OPAG-DPFS co-chairperson) and Mr Jaiho Oh have been identified as the RA II representatives.

4.1.1 CAS

4.1.1.1 Mr Deon Terblanche, the Director of the WMO Atmospheric Research and Environmental Branch, recalled that the Commission of Atmospheric Sciences (CAS), at its 15th session (CAS-15, 2009) initiated discussions on building better connections with users, i.e. from research to service delivery; and, at its 16th session (CAS-16, 2013), it identified the priorities for the World Weather Research Programme (WWRP) and the Global Atmosphere Watch (GAW), including *inter alias* the High Impact Weather, Polar Prediction and High Mountains, Sub-seasonal to Seasonal prediction, integration of the Earth system components, GAW dimension and urban aspects. Mr Terblanche noted that WWRP and GAW have independent Scientific Steering Committees (SSC), which develop and agree on their strategic and implementation plans, and establish close collaboration with the WCRP as appropriate. He also noted that at the recent meeting of the SSC-WWRP, seamless prediction was discussed and it was agreed that seamless also means the transition of research results to operations; therefore, there is a strong link to the GDPFS and its initiative to move towards seamless.

4.1.1.2 Mr Terblanche informed the meeting that at the recent management retreat, close links between research and operations or services-oriented WMO programmes were mentioned as important, and bridging the gap between research and operations is key for successful services. The initiative to move towards seamless GDPFS was seen as an ideal approach to address this issue, while noting that 45% and 65% of WWRP and GAW members, respectively, are outside NMHSs (i.e. in academics and other research institutions) and engaging them in the seamless GDPFS would be a challenge although necessary. The meeting agreed that co-design, coordination and the development of joint initiatives would be a good approach, within the context of the seamless GDPFS. Feedback mechanisms should also be established e.g. through verification, as raised by Gilbert Brunet, for improvement of systems.

4.1.1.3 Mr Terblanche described the plans for the next CAS session, in 2017, and associated Technical Conference (TECO). The meeting noted that the CAS session would have only 2 days for intergovernamental decisions, and TECO would be longer than usual, and would be considered as a "Science Summit", where common research aspects of weather, climate, hydrology and environment would be discussed. Transition of research results to operations would also be an important aspect to consider at the "Science Summit". In this context, the meeting discussed potential priorities for the seamless GDPFS, and agreed that (a) services for megacities would be highly beneficial both for users (70% of global population live there) and for WMO (for possible private sector support and other types of funding, and for high visibility); and (b) operationalization of the Integrated Global Greenhouse Gas (GHG) Information System (IG3IS), which raised interest at the UNFCCC and would be presented at the COP22 meeting in Marrakesh, Morocco, in a couple of weeks, would have the potential of being a very useful tool for GHG control, and would give significant visibility to WMO. In addition to these aspects, it was considered that operationalization of results of the High Impact Weather (including social science), Polar Prediction and High Mountains, and Sub-seasonal to Seasonal prediction projects should also be part of the seamless GDPFS initiative, while noting that the operationalization of TIGGE would require negotiations with the global centre providers.

4.1.2 CAeM

4.1.2.1 Mr Greg Brock, the Scientific Officer of the WMO Aeronautical Meteorology Division (formerly the ICAO Chief of Meteorology, and previously an UKMO officer), introduced the paper on behalf of Mr Ian Lisk (UK), the co-president of CAeM and its representative to the Steering Group, who was unable to attend the meeting. Mr Brock noted that the International Civil Aviation Organization (ICAO) is responsible for establishing the aeronautical requirements for meteorological service provision while WMO is responsible for establishing the standardized meteorological technical methods and practices to fulfil the aeronautical requirements. These heavily regulated and regularly audited aeronautical meteorological services are described in ICAO – Annex 3 Standards and Recommended Practices and in WMO Technical Regulations, Volumes I and II, and are supported by quality management system requirements, aeronautical meteorological personnel competency standards and service cost recovery mechanisms.

4.1.2.2 The meeting noted that the Commission for Aeronautical Meteorology's (CAeM) mandate is to improve the ability of Members to provide sustainable high quality services in support of safe, regular, efficient, economically sustainable and environmentally responsible international air navigation at a national, regional and global level. In this context, the meeting noted that CAeM is keen to continue to work and coordinate with the regional associations to agree top priorities and to monitor/review regional implementation activities; and with other WMO technical commissions (notably CBS, CIMO and CAS), on a range of service development activities that would ensure that aeronautical meteorological service providers are positioned to address the challenges and maximize the opportunities over the coming 15 years and beyond brought about by aviation's transition to a globally interoperable, harmonized air traffic management system of the future.

4.1.2.3 The meeting noted that the future vision for international civil aviation would realize trajectory-based operations enabled by a data-centric, performance-based, service-oriented architecture of system-wide information management, with meteorological information translated into aviation constraints and operational impacts. This would better enable users to make informed, collaborative decisions based on a common situational awareness. This approach would require a new model of aeronautical meteorological service provision, which would require a transition from a product-focused approach (i.e. product-centric) to an information-oriented approach (i.e. data-centric). In this context, the meeting raised the role of the forecaster in the whole process. It also discussed the potential benefits of the transition to the data-centric request, which would allow better use of the information than can be obtained presently, with possible improvements in security and profitability, both for airports and carriers.

4.1.3 JCOMM

4.1.3.1 Ms Stefania Ciliberti (Italy, JCOMM representative) highlighted some challenges associated with (a) the need to strengthen synergies between meteorological and oceanographic systems; (b) the importance of some peculiar physical processes (such as wave-currents, air-sea interaction for improving short-term forecast, integrated water cycle to include the coastal area and marine environment, etc.); (c) natural hazards (i.e. sea level rise, wave-currents interactions and impacts in coastal and marine areas); and (d) the need to capitalize the ongoing experience in JCOMM concerning wave-current interaction, operational oceanography and coastal hazards.

4.1.3.2 In this context, Ms Ciliberti provided an updated version of the marine and meteorological services' section of the draft White Paper (item 2.1.5), as follows *(additions in bold)*:

> *The long-term objectives of WMO Marine Meteorology and Oceanography Program include, as a priority, enhancing the provision of marine meteorological, oceanographic and climate services. The coordination of implementation and development is made through JCOMM, primarily in generation and analysis, reanalysis and forecast of ocean conditions, of observations and knowledge of the marine atmosphere and ocean in support of numerous applications, including:*
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> - ***Improving the short-term ocean forecasting capabilities for services in support of all marine and ocean applications for e****nhanced safety of life and property*
> - *Contribute to improve marine and ocean forecasting from the global to the coastal scales by incorporating research innovation in operational systems*
> - *Advance understanding and improve predictability of the global integrated Earth system.*
> - *Contribute to the prevention and control of marine pollution, sustainable development of the marine environment, coastal area management and recreational activities, and in support of the safety of coastal habitation and activities and risk assessment.*
> - *Contribute to development of ocean-based economic and industrial activities*
> - *Contribute to coordination and enhancement of the provision of data, information, products and services required to support atmosphere and*

ocean weather forecasts and detection and prediction of climate variability and change.

- *Sustaining the global ocean observing system (in situ and satellite based) in order to achieve optimal sampling capabilities for analysis, reanalysis and forecasts*
- *Advance understanding and improve predictability of the global integrated Earth system.*
- *Contribute to improve marine and ocean forecasting from the global to the coastal scales by incorporating research innovation in operational systems*
- *In doing so, JCOMM promotes a state-of-the-art, globally distributed, and fully integrated marine observing, data management, and services system based on present and next-generation technologies and capabilities. The main challenges that the Marine Meteorology and Oceanography Program (MMOP) is facing are:*
- *Enhancing the coordination of global real-time, near-real time and delayed-mode (up to 1 month) data acquisition of ocean data between the "oceanographic community" and the National Meteorological and Hydrological Services, including the national navies, oceanographic institutions and centers, operational and research centers, etc.*
- *Moving from the "full scale global operations" to the regional and national implementation in order to meet user needs. This may be achieved through developing a marine equivalent of the WAFC concept, where a very few Global Centers are responsible for the deep water areas, with regional and national inputs being provided for near shore and coastal areas.*
- *Meeting the users requirements and establishing good connections between the end product users, their producers, as well as with data providers, and observational programs. Within this, the role of governance of the safety services must be considered, where ensuring connections with, for example, the International Maritime Organization (IMO), are paramount.*
- *Sustaining the global ocean observing system (in situ and satellite based) in order to achieve optimal sampling capabilities for analysis, reanalysis and forecasts*
- *Organizing training workshops and on-line learning modules for Capacity Development at the different stages of the production line.*
- *Ensuring that relationships with other agencies engaged in the provision of safety information, such as IMO and the International Hydrographic Organization (IHO) are robust and resourced appropriately.*

Moreover, end-users will soon require new application areas, driven both by safety at sea, and socioeconomic pressures. Some examples are:

- ***Safety and sustainability of maritime transport***
- ***Fishery management and mariculture***
- ***Renewable energy resources (wind, currents, waves, bioproducts, etc.)***
- ***Storm surges and coastal defense communities,***
- *Offshore resource exploration,*
- *Military and defense operations,*
- *Marine engineering,*
- *Sub-surface communications,*
- *Tsunami prediction and warning systems,*
- *Storm surges and coastal defense communities,*
- *Ship routing and navigation,*

- *Operations in the marginal ice zone,*
- *Pollution monitoring prevention and clean-up,*
- *Marine and coastal environmental management,*
- *Space weather impacts on safe navigation*
- *Synoptic, seasonal and other long-term forecasting,*
- *Climate prediction at different time scales,*

Many of these, if not most will require crosscutting collaborations between programs of WMO and IOC but also others: a recent example is the WMO coastal inundation forecasting demonstration project (CIFDP) which was initiated jointly by JCOMM and the Commission for Hydrology.

4.1.3.3 Ms Ciliberti highlighted the need to incorporate aspects related to Copernicus (Marine, Climate Service, Land, Atmosphere, Emergencies, etc.) in the requirements of other International Organizations' section of the draft White Paper (item 2.3). The meeting agreed that Copernicus is an important aspect to consider within the framework of the seamless GDPFS, noting that the delivery of direct services made available through Copernicus may undermine the traditional role of the NMHSs.

4.1.4 CHy

4.1.4.1 Mr Jan Danhelka (Czech Republic, CHy representative) presented CHy and its activities relevant to GDPFS since the February 2016 meeting. The meeting was informed that the GDPFS vision was presented to the third session of the CHy Advisory Working Group (AWG-3, April 2016), who decided to include GDPFS as part of the CHy work plan for the next inter-sessional period. The meeting noted that the GDPFS vision has also been introduced to the WMO RA VI Hydrology forum, and there have been personal discussions of the CHy representative, Mr Danhelka, with the Global Flood Awareness System (GloFAS) team.

4.1.4.2 The meeting noted that the 15th session of the Commission for Hydrology would be held in December 2016, where there would be a presentation about the GDPFS and potential contributions by CHy. A pre-session discussion on this issue is ongoing at http://www.whycos.org/wordpress/?page_id=828, and feedback so far has been ~50% think that this is a brilliant idea, and other ~50% expressed concerns about it.

4.1.4.3 The meeting was pleased to note that a document was prepared to CHy-15 session with a short background information on the GDPFS, and a draft Resolution, which (a) recognizes and notes the existing Cg and EC-68 Resolutions, etc.; (b) decides to actively contribute to the development and implementation of a Seamless Data-Processing and Forecasting System and to include these activities accordingly in its future work plan and activities; (c) requests to ensure that all hydrological aspects and specifics and in particular the needs and concerns of NHSs are properly reflected in the development of the new seamless Data-Processing and Forecasting System; (d) requests to consider reviewing the definitions of forecasting ranges in hydrology; and (e) requests to develop a proposal of a comprehensive structure for hydrology within the new seamless GDPFS and appropriate criteria and functions. In this context, post-CHy-15 session activities may include the inclusion of Hydrological Centres into the Manual on the GDPFS (WMO-No. 485) and the contribution to the implementation of the Seamless GDPFS, as needed. The meeting recommended the participation of a CBS Expert or the Secretariat in the CHy-15 session to present the GDPFS.

4.1.5 CAgM

4.1.5.1 Mr Jaiho OH (South Korea, CAgM representative) presented the climate service innovations through AgMet Federation under the Korea Institute of Science and Technology Information (KISTI) with WMO. For climate service to agricultural community, several applications in Agrometeorology on ICT sharable platform under cloud computing environment have been introduced. It was noted that a promising way of resolving this obstacle is to secure virtual computing resources with collaborative middle wares including GIS tools and easy access to RS data on (semi-) real time basis. To estimate a prospect of crop yield high resolution seamless, daily information on the necessary variables to be used in AgModels, such as temperature, precipitation, humidity, solar radiation, surface pressure, surface winds, etc., are provided by downscaling from both observations and prediction for the period from sowing to harvesting with QTM, QPM and QWM, which are diagnostic model for downscaling. These downscaling methods calculate the temperature, rainfall, and winds at a spatial resolution of 1×1 km by considering the effect of small-scale topography, which is not treated in the GCM as well as mesoscale model. The daily ultra-high resolution both synthetic data and prediction data for the crop model might be useful to the crop scientist as well as plant pathologists. The set of variables is flexibly selected according to user's needs. The results provided are highly useful in seasonal prediction, particularly in data sparse regions.

4.1.5.2 Following discussions on the future seamless GDPFS, the meeting noted that CAgM expects a high resolution information production (downscaling of climate/observation/forecast and projection data) for Agriculture and food security, which is one of early warning targets for climate extremes. To estimate a prospect of crop yield agricultural communities, CAgM requests to consider within the framework of the seamless GDPFS, the provision of high resolution seamless daily information on the necessary variables to be used in AgModels (such as temperature, precipitation, humidity, solar radiation, surface pressure, surface winds, etc.) by downscaling from both observations and prediction for the period from sowing to harvesting. The meeting also noted that CAgM also needs some ICT sharable platform under cloud computing environment for developing countries to support enhanced national AgMet services.

4.1.6 CCl

4.1.6.1 Mr Jean-Pierre Ceron (France, CCl representative) provided an update on CCl activities in the area of data-processing and forecasting since the February 2016 meeting. The meeting noted that the content of the White Paper was presented at the CCl Management Group meeting (September 2016) and no specific comments were raised. The meeting agreed that it is worth to consider that the White Paper reasonably capturing the CCl view about the GDPFS evolution and that what is already written is relevant for CCl.

4.1.6.2 Mr Ceron reminded the meeting that the Climate Services Information System (CSIS) was identified as the top priority at the 16th session of CCl (CCl-16, 2014) and that it would continue very likely in the top priorities to be identified by CCl-17, planned to be held in 2018. As a consequence, the Climate Services Toolkit (CST) is also in the top priorities. In complement and related to, the data management evolution would be an important issue as for the Climate Service provision, there would be a need to manage large and diverse variety of data (including some data from the user community). In addition, such data issue would very likely be a cross-cutting issue to all technical commissions. The meeting also noted that the emergence of Copernicus has highlighted the convergence of goals and objectives between the WMO framework, especially the CSIS. A close collaboration with Copernicus should be beneficial to both entities, especially in the preparation of consistent specifications, standards, documentation, interfaces, etc. In this respect a White Paper on the Copernicus contribution to the CSIS was being developed, which was a collaborative effort of WMO/CLPA and Copernicus.

4.1.6.3 In relation to the White Paper on seamless GDPFS and the associated implementation plan, Mr Ceron provided some complementary information in relation to:

a) **Specialized centres**: Regarding the specialized centres (especially RCCs) it is schedule to provide guidance documents including operations and best practices. Such deliverables would be available also for RCOFs and NCOFs. The Standardization of Products and Services should come a bit later on (including WIS compliance, etc.). The support in using products and services should become a priority quite soon with the provision of tailored climate services, especially thought not only the implementation of help-desk like functionality.

b) **Climate Services perspective**: Likely the evaluation and monitoring of the Climate Service activities would come at the front quite soon. In this respect some work has to be done on the relevant matrix to be used and the establishment of Key Performance Indicators. Obviously the issues related to Tailored Climate Information (the impact-based forecast being part of this) have to be considered. The TT-TCI (from CCl/Opace 3) worked on the framework necessary to provide such information and plan to provide a need assessment by the end of 2017. The incorporation of partners' specificity (who are not necessarily operational in the meteorological sense) would remain a challenge, especially when moving to co-production and co-design processes.

c) **Climate Service Toolkit**: A lot of different tools are already available but there is still a need to define the "box" to integrate all these different tools. So the Climate Services Toolkit (CST), is conceived as a suite of guidance, data, software tools, training resources, and examples for enabling climate services at global, regional, and national levels, and it is considered to be a major enabling factor for the CSIS implementation, particularly at the national level. In this framework, it is relevant to quote the Copernicus initiative which is developing very similar elements to be incorporated in its toolbox. So again, it is very beneficial to both entities to collaborate and share knowledge and experience on the different interfaces, standards, specifications for the different considered tools including the data management side. One important CCl initiative is a dedicated workshop to CST developers which would be held at WMO Headquarters, in Geneva, from 6 to 8 December 2016. The expected outcomes of this workshop are:

- A CST prototype with demonstrated core capabilities using web portal for data and tools as well as stand-alone tool-set comprising software and data;
- Recommended actions for sustainable long-term development, maintenance and updating of the CST through institutional collaborations, expert engagement;
- Infrastructural requirements for deployment of GFCS-relevant CST components;
- An active network of climate data and tool experts for CST demonstration for GFCS partners and priority countries;
- Action Plan for accelerated CST deployment in GFCS priority countries;
- Design of an International Workshop on CSIS, which would focus on establishing the institutional architecture and cooperative relationships needed to make GFCS relevant data and products systematically available through the CSIS.

d) **Feedback processes**: The feedback processes are not very effective (when in place) mostly in relation to the lack of visibility of WMO structures activities (like RCCs or RCOFs). In this respect, giving more visibility could strengthen the feedback processes. In this context, one can quote quite obviously the communication and outreach issues; but also elements giving more visibility to products like the WIS compliance.

e) **Verification**: There are 2 different approaches on this topic. The first one is the verification that the service is provided timely with an expected quality. The response is given by a quality management like approach (which is quite obvious in a world of services). The second one is more oriented toward the verification of the impact of the use of the provided information. It's really a more complex issue which needs further developments even with directions identified on how to proceed (e.g. placebo protocol).

f) **Climate Change information**: The agreed definition of the time scales related to the seamless aspect is covering from hours to Near Term Climate Prediction (Decadal). In this respect the Climate Change information is not inside this definition thought it remains an important component of Climate Services. CCl invested a lot of effort to convince partners and stakeholders that the adaptation to the current climate variability and to climate change is very similar and that the adaptation to the current climate variability should be understood as the first step to the adaptation to climate change. So in this respect, CCl would advocate to keep in mind the Climate Change issues so that likely at a later stage (e.g. when incorporating the Decadal specific issues) discussions on how to incorporate the Climate Change time scales to reach a full seamless definition be held.

g) **New GDPFS**: likely we should extend the described functionalities across all the time scales (trying to preserve/ensure consistency within the seamless provision of information).

h) **Additional points**:

- Data management evolution (see comment above): The dedicated ET from CCl/Opace 1 (Inter-Programme Expert Team on Climate Data Modernisation Programme (IPET-CDMP) CCl, CBS, JCOMM, GCOS, WCRP are members. CCl and CBS co-chairing) is starting to work on these issues and will continue very likely for the next intersessional period. Again the collaboration with Copernicus should be very beneficial and could accelerate the different outcomes on this topic.
- Capacity Building: In relationship with the co-production and co-design concepts, there are clear needs of CB, which should focus on the building of a shared knowledge within the Providers/Stakeholders community. CBS would be crucial for the success of tailored climate services efficiently feeding into decision making processes.
- Climate Watch System: They are good examples of the seamless approach already done at the RCC level. However, there are various uses of the term watch. CCl has defined it at CCl-14, but still focusing on its proper domain; e.g. providing climate advisories based on monitoring and forecasting from few weeks to a season. Other entities use the watch to reflect the long-term monitoring (and in some cases long-term predictions) of the elements of the earth system they are dealing with. For example Cryosphere watch, Atmospheric Watch, etc. This creates confusion in terminology and may need to be standardized.

i) **Relevant CCl Agenda**:

- CST workshop : 6-8 December (see CST section for details)
- International CSIS workshop : likely 21-24 March 2017. The concept note is drafted. The participant list is to be discussed soon (some draft available). The workshop is expected to deliver a set of recommendation which should help enhancing the resources for climate service delivery through CSIS operations. The workshop outcomes would include:
  - Recommended plan for CSIS near- and long-term activities
  - Refined scope and components of CSIS implementation approach
  - Recommended approach to ensure CSIS long-term sustainability

- Validated requirements on tailoring of climate information to meet the needs of downstream CSIS entities such as RCCs and NMHSs or wider groups of targeted CSIS users
- Produced statement of needs for training events supporting the deployment of the Climate Services Toolkit as well as accelerated usability of information provided by the CSIS.

To be noted that the date was chosen with respect of the date of the next EC. So an opportunity for CBS and CCl to convey at least some consistent or even common messages to the EC level.

- CCL Management Group Meeting: beginning of July 2017. Important step as we should get a consolidated view on the CCl-17 (next session) priorities and structure. In this perspective to be quoted the work on SOP documents (especially ERs) targeting the 2020-2023 period.
- RCOF Review: in September 2017. Focus on operations and processes especially those necessary to make more objective products.
- Workshop on Operational Climate Predictions: Q4 2017. Jointly organized by CBS and CCl. This workshop should be open beyond the GPCs and RCCs community.
- Workshop on global pratices for coding, reporting and managing information on extreme events, Q4 2017
- CCl/CBS Workshop on Data Management Practices, July 2017

4.1.7 CBS

4.1.7.1 WIGOS

4.1.7.1.1 Mr Lars Peter Riishojgaard, the Director of the WMO Integrated Global Observing System (WIGOS), provided an overview of the WIGOS. The meeting noted that WIGOS is a WMO foundational activity addressing the observational needs of the weather, climate, water and environmental services of its Members; and provides a framework for integrating all WMO observing systems and WMO contributions to co-sponsored observing systems under a common regulatory and management framework. The meeting was informed of the WIGOS implementation and pre-operational phases, and noted their five main priority areas:

a) WIGOS Regulatory Material, supplemented with necessary guidance material;

b) WIGOS Information Resource, including the Observing Systems Capabilities analysis and Review tool (OSCAR, http://oscar.wmo.int);

c) WIGOS Data Quality Monitoring System (WDQMS);

d) Regional Structure, including Regional WIGOS Centres;

e) National WIGOS Implementation, coordination and governance mechanisms.

4.1.7.1.2 The meeting noted that the WIGOS Implementation Phase (2012-2015) was approved by Cg-16 (2011), which was too ambitious as the implementation phase would last 8 years, not 4 years as originally planned. The primary focus of the WIGOS Implementation Phase (2012-2015) was development of WIGOS Regulatory Material, including Metadata Standard, and Regional Implementation Plans for all WMO Regions. Plan for the WIGOS Pre-operational Phase was developed by a Task Team under ICG-WIGOS, with broad representation from both technical commissions and regional associations. This Plan was approved by ICG-WIGOS in Jan 2016 and approved by EC-67 in June 2016.

4.1.7.1.3 The meeting noted that WIGOS is supported by three key databases of OSCAR (Observation System Capability And Review): (1) OSCAR/Requirements, in which "technology free" requirements are provided for each application area; (2) OSCAR/Space, listing the capabilities of all satellite sensors, whether historical, operational or planned; and (3) OSCAR/Surface, which lists surface-based capabilities, developed by MeteoSwiss for WMO (which is operational since 2 May 2016). Comprehensive metadata for all stations/platforms is under WIGOS. The WDQMS (WIGOS Data Quality Monitoring System) will provide a complete description of how well WIGOS is functioning. A number of pilot projects are now under way (ECMWF, JMA, DWD, NCEP, etc.) to test components of the observation monitoring system (e.g., surface pressure, etc.), regionally and globally.

4.1.7.1.4 The meeting noted that the WIGOS global framework was currently in place and would be further developed during the Pre-operational Phase (2016-2019), including (a) increased emphasis on regional and national activities; (b) OSCAR/Surface and the WIGOS Data Quality Monitoring System (WDQMS) being the two most important technical elements, and both being of strategic importance to WMO; (c) OSCAR/Surface providing a quantitative, comprehensive online description of all observing platforms and stations of WIGOS; and (d) WDQMS being the primary WIGOS performance measuring tool (this was still in development, with pilot and demonstration projects underway, and Operational host still to be found).

4.1.7.1.5 The meeting noted that analogies of the WIGOS implementation and development tools, and agreed to consider some of the methods used by WIGOS in the implementation of the seamless GDPFS (e.g. working with a global centre or an NMHS to test components; developing a user interface platform for the GDPFS, etc.). The meeting agreed to incorporate this approach while developing the implementation plan for the seamless GDPFS.

4.1.7.2 WIS

4.1.7.2.1 Mr David Thomas, the Chief of the WMO Information and Telecommunication System Division, delivered a presentation on the WIS 2.0 strategy and drivers. The meeting noted the status of WIS, which is an evolution of the GTS and opening to all programmes, however it is still difficult for new contributors to benefit. New functionality of WIS is discovery metadata drive, implemented, and needs better and more diverse metadata entries, and knowledge of how to use and benefit from WIS (still too low). WIS provides a platform for information management, which is very relevant for the GDPFS.

4.1.7.2.2 The meeting noted the drivers and challenges for WIS 2.0 as follows:

(a) User expectation – easy to access, familiar interfaces, new dynamic ways of making data available, user's expectations driven by services provided buy large global companies such as Google and Amazon, increasingly challenging for Members to deliver services in expected ways;

(b) Data volumes and complexity – Satellite, model output, radar, public and private data sources, social networks, crow sourcing, etc.;

(c) Costs – WIS 2.0 should reduce overall costs by reducing budgets, altruistic policies on data availability, exchange of best practices, etc.;

(d) Technology trends (big data, cloud, search engines, messaging and social networking, internet of things, application programming interfaces (APIs) and web services, and open data);

(e) Cyber security – GDPFS and WIGOS, like WIS, is increasingly relying on automated systems connected to open networks, with millions of devices access points. It is difficult to maintain patches across broad observing networks, which are vulnerable as likely targets for cyber-attack.

4.1.7.2.3 The meeting noted however a number of opportunities with WIS, such as (a) increasing use of the Web as an information sharing platform; (b) commercial infrastructure providers offer; (c) search engines (Google, Bing, Yahoo etc.) remain the common entry point for consumer discovery of information; (d) Application Programming Interfaces (APIs) and Web Services are now very common solutions for information exchange; (e) messaging services and protocols offer new opportunities for sharing meteorological information in real-time based on common industry practices; (f) use of analytics and user feedback to drive improvement of user experience; and (g) applications such as Dropbox indicate that file distribution services have become commoditized and are no longer the domain of specialized applications such as GTS message switching.

4.1.7.2.4 In summary, the meeting noted that WIS 2.0 would: (a) provide users with seamless access to diverse information from a wide range of sources; and (b) enable weather, water and climate information to be related to socioeconomic and other contexts. Through an open eco-system of tools, applications and services, WIS 2.0 would allow (1) all information providers to manage, publish and share their data, products and services; and (2) users to develop value added services and new products. The meeting also noted that previously, the hardware and IT components were very closely linked to GDPFS, and wondered whether this was the case nowadays and would be in the future. The meeting therefore decided to evaluate the possibility of transferring ICT aspects to CBS/OPAG-ISS, while addressing seamless GDPFS.

4.1.7.3 PWS (on impact-based forecasting & risk-based warning)

4.1.7.3.1 Mr Paul Davies (UK, chairperson of the Task Team on Impact of Multi-hazard Prediction and Communication (TT-IMPACT)) noted that TT-IMPACT is all about Information, Modelling and Prediction (which are part of the GDPFS), and Accessible, Clarity and Targeted (which are Service Delivery aspects). He reported that in recognition of the importance of partnership working and stakeholder engagement, the inaugural meeting of TT-IMPACT (Geneva, February 2015) comprised representatives from a cross-section of stakeholders in impact-based forecast and warning service delivery including NMHSs, the health sector, the Global Facility for Disaster Reduction and Recovery (GFDRR)/ World Bank Group, humanitarian agencies (the United Nations Office for the Coordination of Humanitarian Affairs (OCHA)), private consulting service providers, social sciences, and communication. Among the main outcomes of the meeting was the emphasis on a pragmatic approach toward promoting impact-based forecast and warning service delivery in NMHSs. This approach would be characterized by practical implementation activities such as region- or country-specific pilot projects that would be scalable to other countries and regions, an example of which was Myanmar. The meeting noted that the WMO Guidelines on Multi-Hazard Impact Based Forecast and Warning Services (WMO-No. 1150) have been developed and approved by CBS-Ext.(2014) and subsequently by Cg-17 (2015).

4.1.7.3.2 The meeting recalled the Typhoon Haiyan and its impacts. noted that stimulating the need for action and attracting the required decision makers may be the hardest part of integrating an impact-based forecast and warning service into disaster risk reduction management. This would require evidence of recent hydrometeorological events that have had negative impact on people, the economy or reputation of the country, and perhaps more importantly, would require a good understanding of the needs and expectations of the user community. The meeting acknowledged a need to provide additional guidelines in dealing with uncertainty and exploitation of ensemble forecasting as well as addressing the need to express the uncertainty emanating from the hazard-to-impact translation and how best to communicate this uncertainty to users. This would involve training, and, in the context of impact-based forecasting, a review of the underpinning competency framework that enables the delivery of an impact-based forecasting service.

4.1.7.3.3 Mr Davies emphasized that there are a myriad of technological challenges in dealing with big data in a meteorological context, but how best to utilize big data for improved services would become an increasingly important topic as more sophisticated impact-based related services are developed. These considerations might include the necessary visualization systems if a forecaster is to make sense of the vast amounts of information now available; the optimum use of probabilistic information from Ensemble Prediction Systems; the evolving role of the forecaster who has to deal with increasing amounts of information and mould it into improved products and services; e.g. combining forecasts with exposure and vulnerability data (in a rigorous manner) to generate impact-based services. While noting the complexity of impact modelling, the meeting agreed that the role of the GDPFS is to facilitate impact forecasts, e.g. either through partnerships with other technical commissions (e.g. CHy and CAgM) or twinning arrangements with advanced GDPFS centres. The meeting agreed that impact-based forecasting needs to be part of the future seamless GDPFS, including in relation to recommended practices for collection and storage of vulnerability data, use of GIS tools, and exploring and establishing the required partnerships. The meeting noted that CHy and CCl are dealing with hydrological- and climate-related impacts and therefore suggested strengthening relationships between TT-IMPACT and CHy and CCl teams dealing with these subject.

4.2 Updates on WMO Programmes not supported by TCs and Partners – Activities/needs

4.2.1 WMO Space Weather Programme

4.2.1.1 Mr Toshiyuki Kurino, the Chief of the WMO Space Programme Office, provided an overview of the Space Programme activities, as well as background information on the establishment of the Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWISS), to complement what was discussed under agenda item 3.2.3 above. The meeting noted that the WMO Space Programme has four main components: (a) the space-based observing system; (b) access to satellite data and products; (c) awareness and training; and (d) space weather coordination. WMO Space Programme's objectives are achieved through strong partnership with the Coordination Group for Meteorological Satellites (CGMS) and co-sponsoring international science groups. The meeting noted that CGMS is a technical coordination body of satellite operators, including space agencies, focusing primarily on weather and climate satellite programmes in response to WMO requirements.

4.2.1.2 The meeting noted that in 2014, CGMS decided to include objectives related to space weather monitoring into its multi-year High-Level Priority Plan (HLPP) and agreed on Terms of Reference for CGMS Space Weather Activities. It is anticipated that CGMS would soon extend the scope of its activity towards space-based observation of space weather variables. The meeting was informed that a Space Weather Task Team (SWTT) was organized to define the methodology for the implementation of space weather into CGMS. The meeting was also informed that within the WMO framework, an Inter-programme Coordination Team on Space Weather (ICTSW) was established in May 2010 following a proposal from CBS-14, supported by CAeM and approved by EC-61. The ICTSW has two co-chairpersons nominated by CBS and CAeM, respectively. The team works primarily by teleconferences and holds one or more face-to-face meetings per year. The meeting noted that initial achievements by ICTSW include:

- Formulation of the “Observation Requirements”,
- Drafting the “Statement of Guidance” on space weather observation,

- Establishment of a Space Weather Product Portal,
- Supporting CAeM to review the ICAO concept of future space weather services to aviation.

4.2.1.3 The meeting noted that Cg-17 agreed that WMO should undertake international coordination of operational space weather monitoring and forecasting. In providing a global intergovernmental framework, WMO would facilitate international commitments and enable the establishment of operational space weather services, in particular in the context of the support to the International Civil Aviation Organization (ICAO). Cg-17 requested (a) that space weather observations be integrated into the WMO Integrated Global Observing System (WIGOS); and (b) CAeM and CBS to consider existing responsibilities, working mechanisms, expert teams and integration within relevant WMO programmes in finalizing a draft "Four-year Plan for WMO Coordination of Space Weather Activities (the Plan)". The CBS Management Group meeting (February 2016) decided that ICTSW should become an Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWISS) and would report under the OPAG-DPFS. The meeting highlighted the predictability aspects in Space Weather and therefore agreed that Space Weather is part of the seamless GDPFS, however it noted the budgetary and staff resource constraints of this decision, as explained under agenda item 3.2.3. The meeting also highlighted the need for strong partnerships in promoting WMO Space Weather, including with IUGG, as detailed knowledge of the Earth's surface geomagnetic properties is also required for power line blackouts. The meeting also noted the ICAO's requirement for designating operational centres for Space Weather, and this issue is aligned with the establishment of the seamless GDPFS.

4.2.2 *DRR*

4.2.2.1 Mr Alasdair Hainsworth, the Chief of the WMO Disaster Risk Reduction Services Division, provided an overview of the Disaster Risk Reduction (DRR) related activities. He highlighted the key thrusts of the Sendai Framework for Disaster Risk Reduction 2015-2030, which includes: (a) preventing new risks – shifting from disaster management to disaster risk management and a articulation of disaster risk governance; (b) strengthening the use of science and technology in policy-making; (c) strengthening of MHEWS and developing/investing in regional multi-hazard early warning mechanisms; (d) focusing on the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of disaster ("Build Back Better"); (e) including hazards not addressed previously such as biohazards, slow-onset disasters; (f) integrating disaster risk reduction in the sustainable development strategy of the UN; and (g) maintaining and strengthening in situ and remotely sensed Earth and climate observations. The meeting noted that the Sendai Framework tasks UN system entities and other international organizations to support countries within their respective mandates through UN Plan of Action on DRR for Resilience, UN Development Assistance Framework, International Health Regulations (2005), and other frameworks.

4.2.2.2 The meeting noted that in "Priority for Action 4", WMO can make significant contributions to the implementation of the Sendai Framework through the four components of a MHEWS, including (a) analyses and assessment of risks involved; (b) detection, monitoring, analysis and forecasting the hazards; (c) dissemination and communication of timely, accurate, actionable, inclusive and authoritative warnings; and (d) preparedness and response capabilities. While the first component of a MHEWS is addressed under the first Priority for Action, the second component of a MHEWS is supported by the GDPFS as it involves the WMCs, RSMCs/RCCs and Regional Drought Management Centres. The meeting highlighted that the Severe Weather Forecasting Demonstration Project (SWFDP) is a major contribution to DRR. Mr Hainsworth pointed out that one of the seven global targets of the Sendai Framework is "substantially increase the availability of and access to MHEWS and disaster risk information and assessments to the people by 2030".

4.2.2.3 In the context of the Sendai Framework, the meeting noted that Cg-17 noted the need (a) to assist Members in implementing the Sendai Framework through provision of guidance, capacity-building and facilitating implementation of projects at the national level; and (b) for an holistic and integrated multi-hazard approach to EWS as a strategy to streamline such systems, to apply lessons learned from their operations, and to contribute effectively to disaster risk reduction. The meeting was also informed that Cg-17 decided to: "standardize weather, water, climate, space weather, and other related environmental hazard and risk information and to develop identifiers for cataloguing extreme weather, water and climate events" in a form that allows data on losses and damage to be cross-referenced to these phenomena. These are seen as extremely important in WMO Members' ability to demonstrate their progress against the Sendai Framework goals and targets. DRR Division is working towards developing the required identifiers with contributions by CCl, CAgM, CHy and CBS, and would provide guidance and recommendations on: (a) activities on the development of hazard definitions and a classification of hazards, hazard data/metadata and modelling requirements to support loss and damage data collection and risk assessment; (b) explore and discuss the challenges and opportunities for developing international guidelines, manual and standards for NMHSs in the development of standard identifiers for cataloguing extreme weather, water, and climate events; and (c) explore the challenges and opportunities for linking such an identifier and catalogue system to the numerous hazard and loss and damage databases that exist in countries, UN organizations, and the private sector. The meeting noted that this work is well connected with the seamless GDPFS.

4.2.2.4 The meeting was informed that the DRR Roadmap is a coordinated organization-wide plan of action that can be used by both WMO and the external side to understand how NMHSs can contribute to reducing disaster risk and increasing the resilience. It serves to guide WMO Members, NMHSs, RAs, TCs, and the Secretariat to support DRM decisions in partnership with each other and external partners at all levels. It would eventually lay out prioritized activities and deliverables required to address DRR in line with the Sendai Framework for DRR 2015-2030 and other post-2015 frameworks. The Roadmap requires continuous updating and consistency with the Strategic and Operating Plans of WMO, its constituent bodies and related WMO programmes and projects. The draft DRR Roadmap is available http://www.wmo.int/pages/prog/drr/.

4.2.3 ECMWF

4.2.3.1 Mr David Richardson (ECMWF representative, Head of Evaluation at the ECMWF) provided an ECMWF update on the seamless GDPFS, which included aspects related to the ECMWF Strategy 2016-2025 (available at http://www.ecmwf.int/en/about/who-we-are/strategy) and a roadmap to 2025, the 4-year and 1-year plans, open data, and training – WMO fellow. The meeting noted that the ECMWF main strategic goal is to provide forecast information needed to help save lives, protect infrastructure and promote economic development in Member and Co-operating States through: (a) research at frontiers of knowledge to develop an integrated global model of the Earth system; and (b) ensemble-based analyses and predictions that raise the international bar for quality and operational reliability reaching a 5 km horizontal resolution. Forecast targets by 2025 include: (1) ensemble predictions of high impact weather up to two weeks ahead; and (2) seamless approach, aiming towards predictions of large scale patterns and regime transitions up to four weeks ahead and global-scale anomalies up to a year ahead. The goals of the ECMWF Strategy are consistent with the vision of the however, white paper. However, the meeting noted that ECMWF considers this to be an ambitious target that depends on scientific, computing and scalability advances. At ECMWF, research activities in advancing weather science would focus on Earth system modelling, and improving forecast skill. In terms of operations, ECMWF would deliver global predictions by creating a fully integrated ensemble system, and evaluating the quality of the forecasts. Issues related to sustaining high-performance computing are also included in the

ECMWF Strategy 2016-2025, including scalability of computer codes, and providing a high-performance computing facility. Scalable code is required in all parts of the forecasting process, from observation inputs through forecast modelling, product generation and forecast delivery to Member State users. Within the Scalability Programme, ECMWF also has partners from the national meteorological services (NMSs) as well as the computing technology industry. The implementation plan for this Strategy covers a rolling four-year period (the Four-Year Programme of Activities), updated every year and reviewed annually by ECMWF's advisory committees and Council. Reporting and planning is organised with respect to the 5 key themes of the strategy.

4.2.3.2 The meeting noted that in addition to delivering forecast products, providing expertise and training, the ECMWF offers to its Member States the possibility to calculate their specific user-tailored output quantities at ECMWF. Within the WMO framework, ECMWF enables some of the poorest countries in the world to have access to life-critical data and products, and participates in collaborative activities both in research and in operational weather prediction. ECMWF also supports WMO training and capacity development activities, including the WMO fellowship programme in association to its support to the SWFDP. The meeting noted that some WMO aspects are included in the ECMWF annual plan 2017, such as

- WIGOS Data Quality Monitoring. Make monitoring inter-comparison between centres more generally available within ECMWF;
- WMO Lead Centre for Wave Forecast Verification. Establish LC-WFV at ECMWF;
- Year of Polar Prediction;
- WMO products:
  revise (with the agreement of Council) the sets of products available to WMO members and provide the required documentation and verification;
  review with WMO how best to continue the support for Severe Weather Forecasting Demonstration Projects (SWFDPs) as some of these move towards an operational phase;
- Operational implementation of the Global Flood Awareness System (GloFAS);
- S2S: explore the use of products to represent risk of extreme events at the extended range (weeks 2-4).

4.2.3.3 The meeting noted that the ECMWF is organizing an Open Data Week at ECMWF, from 28 February to 1 March 2017. This week would have a series of events that focus on freely available climate and weather data from ECMWF/Copernicus. The week is part of the International Open Data Day 2017 on 4 March 2017, which aims to promote the benefits and potential of open data. The series of events include:

- Data Policy Workshop (28 February - 1 March 2017) – to discuss the opportunities and consequences for ECMWF, National Meteorological Services and the private sector of introducing an open data policy for ECMWF forecast data.
- Workshop on Meteorological Operational Systems (MOS) (1 - 3 March 2017) – to review current and future developments of operational systems at ECMWF and National Weather Services. How (open) data can be best brought to users and aims at reviewing current pull services, such as standardised web services (OGC, INSPIRE) and push services, such as product generation and dissemination.
- OpenDataHack - "Discover the potential of weather data" (4 - 5 March 2017) **–** a two day hackathon for developers, (technical) data experts and everyone interested in freely available weather data. The goal is to discover and unleash the potential of open weather and climate data and to come up with innovative ideas how ECMWF/Copernicus data can be used to develop services for climate monitoring and high impact weather. Showcase how standardized web services can be beneficial to serve large volumes and a high variety of weather and climate data.

4.3 Finalizing the white paper

4.3.1 The meeting prepared a draft GDPFS Imperative document, as given in Annex III, which follows the approach of the WIGOS documentation, and agreed that the long version of the draft White Paper should be its annex.

4.4 Discussion on the Implementation Plan

4.4.1 The meeting reviewed the draft outline of the implementation plan and prepared two tables that would be attached to it; one describing the areas of improvement, benefits and related WMO expected results; and a second table listing the tasks, priority, nature (business as usual/transformations), responsibility, areas of improvement, deliverables, milestones and timelines, and performance indicators. The revised draft outline of the implementation plan and tables are provided in Annex IV. The meeting decided to present the draft GDPFS Imperative document and the draft outline of the implementation plan (except the tables) to CBS-16 session (November 2016) as an INF document and make it available for consideration of CHy-15 session (December 2016).

4.5 Key recommendations to CBS-16

4.5.1 Finalization of CBS-16/Doc. 5.6(1) on Seamless GDPFS

4.5.1.1 The meeting reviewed the CBS-16/Doc. 5.6(1) on seamless GDPFS, and suggested a few changes as provided in Annex V.

5. ANY OTHER BUSINESS

5.1 The Steering Group recommended changing the name of GDPFS to clearly reflect the evolution the system towards seamless global data-processing and forecasting system, while it recognizes the concern that the Manual on the GDPFS is being replaced by a new one aiming at expanding its scope beyond the World Weather Watch (WWW).

5.2 Identified actions/timelines include:

- To present the draft GDPFS Imperative document and the draft outline of the implementation plan (except the tables) to CBS-15 session (November 2016) as an INF document and discuss it at CHy-15 session (December 2016).;
- To present the draft GDPFS Imperative document and the draft outline of the implementation plan (except the tables) to PTC/PRA meeting, in January 2017;
- To conduct Mambers’ review before RC-69;
- To hold a Webex call with the Steering Group members by end January/early February 2017, to review the outcomes of the CBS and CHy sessions, as well as of the PTC/PRA meeting.

6. CLOSING

6.1 The meeting of the Steering Group of the Seamless Global Data-processing and Forecasting System (GDPFS) closed at 14:50 hours on Friday, 4 November 2016.

Annex I

AGENDA

1. OPENING OF THE SESSION

2. ORGANIZATION OF THE MEETING
2.1 Adoption of the agenda
2.2 Working arrangements

3. INTRODUCTION
3.1 Review of minutes of the February 2016 meeting
3.2 Status of the "Seamless GDPFS" project
3.2.1 EC-68 decisions
3.2.2 Draft White Paper
3.2.3 IPT-SWISS

4. WAY FORWARD
4.1 Updates on TCs' activities related to GDPFS
4.1.1 CAS
4.1.2 CAeM
4.1.3 JCOMM
4.1.4 CHy
4.1.5 CAgM
4.1.6 CCl
4.1.7 CBS
4.1.7.1 WIGOS
4.1.7.2 WIS
4.1.7.3 PWS (on impact-based forecasting & risk-based warning)
4.2 Updates on WMO Programmes not supported by TCs and Partners –Activities/needs
4.2.1 WMO Space Weather Programme
4.2.2 DRR
4.2.3 ECMWF
4.3 Finalizing the white paper
4.4 Discussion on the Implementation Plan
4.5 Key recommendations to CBS-16
4.5.1 Finalization of CBS -16, Doc 5-6(1): Seamless GDPFS

5. ANY OTHER BUSINESS

6. CLOSING

Annex II

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Annex III

FUTURE SEAMLESS DATA PROCESSING AND FORECASTING SYSTEMS:

THE GDPFS IMPERATIVE

1. The proposed vision for the Future GDPFS is:

- The GDPFS will be an effective and adaptable monitoring and prediction system enabling Members and partners to make better-informed decisions.
- The GDPFS will facilitate the provision of impact-based forecasts and risk-based warnings through partnership and collaboration.
- The GDPFS will do so through the sharing of weather, water, climate and related environmental data, products and services in a cost effective, timely and agile way, with the effect of benefitting all WMO members, while also reducing the gaps between developed and developing Members.

The GDPFS will become increasingly integrated and seamless - following the discussion at the WWOSC (Montreal 2014) seamless spans over several dimensions including:

- Space and Time (nowcasting, through weather and ocean forecasts for days and weeks ahead to long-range forecasts on seasonal and up to multi-annual scales);

- Disciplines and socio economic applications (hydrology and oceanography: flood, inundation, and water management; ocean forecasting, marine and coastal: wave and storm surge, sea ice; air quality and sand and dust storm; natural resources, energy, tourism, transport, etc.);

- Prediction of non-weather-related elements, including the assessment of likelihood and probabilities of impacts and risks associated with hazards taking into account vulnerability and exposure information to support risk-based decision-making;

And finally GDPFS will facilitate the transition of capability from research to operations and minimizes the gaps between prediction skills and user’s needs. One may imagine the GDPFS in 2031, 16 years later, with the following characteristics:

- The overall accuracy of state-of-the-art global prediction models have improved enough to add 1.5 days of overall predictability, if the historical rate of progress of one day per decade is sustained: The goal set by Jule Charney and others when they launched GARP in the 1970s was achieved. Global models have resolutions below 5km, and mesoscale-to-submesoscale models significantly below 1km, down to a few tens of meters in urban and coastal areas for example.

- The sub-seasonal time scales are achieved, ensembles have routinely hundreds of members, shared between many global centers, and forecast products provide accurate and detailed information on such things as closed water budgets over most watersheds, wind, temperature and air quality information, including global greenhouse gases emissions information, from urban street canyons and outwards to the surrounding country side, regions and countries, finely detailed agrometeorological information from hourly cycles to seasonal, precise storm surges and wind damage estimates for cyclone landfall, sea state, including rogue waves, and dangerous shore currents, telecommunications and electricity blackouts from solar eruptions form the surface to satellites orbital heights, toxic algae blooms , pest migrations, etc.

- Most or even all this information is accessible as a public good product to all WMO Members, and their partners, and most of this information is available either in raw format, or directly as impact information. It is disseminated and presented in accordance with users formats, and using point-to-point or, increasingly, cloud to point communication broadband technologies. It is quality controlled, validated and have metadata information associated, and in the case of forecast information, it is verified. Imbedded in the design of the system is a two-way feedback real-time communication capacity between the provider and the receiver of the data.

- The system has evolved through partnership agreements that allow it to absorb or carry information produced either by the private sector, academic institutions or by other closely related organizations to the traditional NMHSs.

2. Drivers – System and Service Requirements for Members

The requirements associated with this exercise can be framed as follows:

- The need to support and enable enhanced Service Delivery by Members' NMHS/Partners to their countries and customers;
- The need for NMHSs/partners/users to access GDPFS data, products and algorithms through a common user interface platform with information on quality and performance
- The need to devise a system that would be flexible and easily adaptable;
- The need to expand collaborations with many other partners;
- The need for a clear focus on high impact products;
- The need for effective feedback mechanisms from users for quality management purposes;
- The need to involve users in product development;
- The need to enable NMHS's and other institutions with different levels of capabilities to share, discover and leverage each other's data resources;
- The urgent need to transit the GDPFS towards a system capable of producing impact-based forecasting and risk based-warning (IBF & RBW);
- The need to facilitate technological advances and science pull-through to operations;
- The need to enhance global efficiency by wider exploitation of collective capabilities;
- The need to increase the capacity development and training of the users in order to make the optimal use of the products of the seamless prediction system;
- The need to address policy issues associated with the seamless GDPFS.

3. Scope

To achieve its objectives GDPFS will:

- Build upon the existing network of GDPFS systems, services and centres to span the wider, seamless operational activities of WMO;
- Improve access to and utilization of seamless monitoring and prediction systems, products and data;
- Improve WMO's ability to support Impact Based Forecasts and Risk-Based Warnings through enhanced collaboration through partnerships;
- Enhance integration between seamless monitoring and prediction capabilities of the TCs;

- Provide a mechanism to meet new predictive requirements of its Members;
- Make a major and unique contribution to United Nations agencies that are focused on protection of life, property and the environment;
- Improve the quality, interoperability, diversity and relevance of GDPFS information, data and products;
- Transit towards a new optimized global, regional and national production infrastructure;
- Provide multi-disciplinary training and capacity building;
- Consider policy and open data considerations;
- Consider of the role of the private sector and academia;
- Develop methodologies for assigning quality and performance assessment.

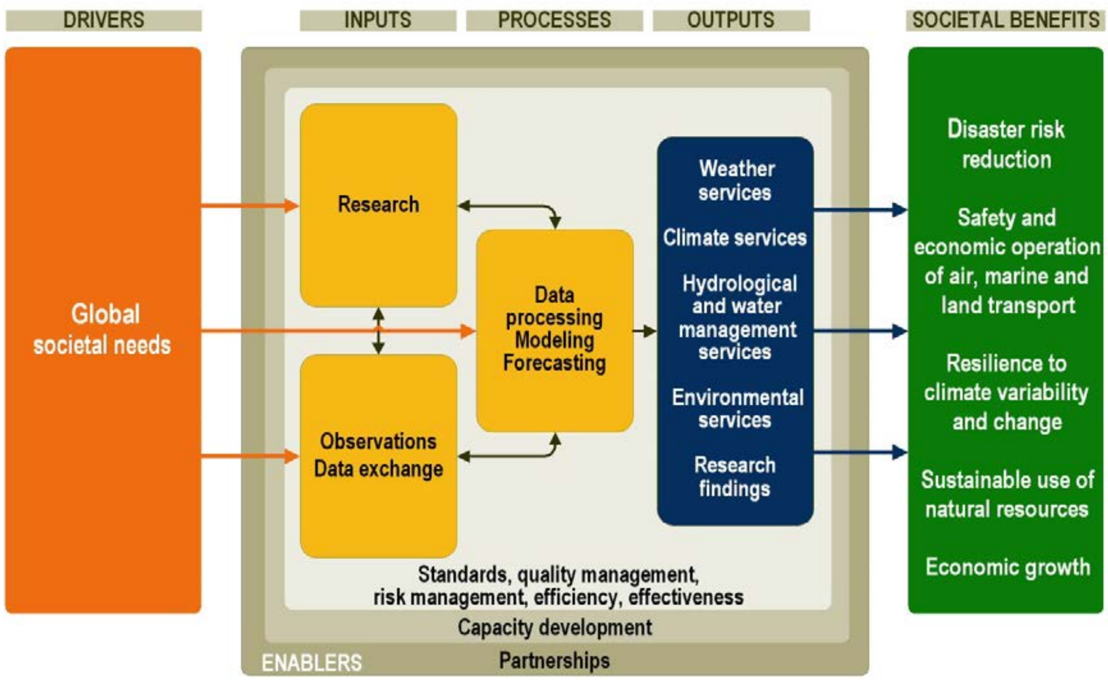


Figure 1: WMO Operational System (from WMO Strategic Plan 2016 -2019) – GDPFS, the Heart of the System.

4. Benefits

The benefits of the future GDPFS can be articulated along three axis: contribution to the UN and WMO agendas, the quality, diversity and relevance of GDPFS information and furthering existing and developing new partnerships. Improved seamless monitoring and prediction capabilities in a more cost effective manner to enable improved service delivery because:

- GDPFS will enable the wider exploitation and service delivery of science through seamless prediction capabilities, including ensembles, among WMO Members and enhance collaboration with its partner organizations for improved decision-making;
- This will allow access to an expanded set of predictive data and products resulting in wider protection of life and property in a cost effective manner;
- GDPFS will better enable NMHSs to meet expanding national mandates and achieve higher national visibility. In doing so, WMO Members will be able to better respond to natural hazards, improve environmental monitoring, and adapt to climate change and man-made environmental impacts. In this regard, GDPFS will greatly enhance operational components

of WMO Programs, especially in Developing and Least Developed Countries and contribute to UN Agendas and international agreements;

- Integration will lead to efficiencies and cost savings that can be reinvested to focus on Impacts and Service delivery.

Members will be able to better access information from TCs with predictive capabilities including CBS, JCOMM, CCL and CHy in a consistent and seamless network of systems, centres and services and an improved pull-through of science from CAS and CCl. As well it will better enable users to access and select the most appropriate data sources and algorithms to meet their requirements. Finally, TCs with a strong application focus such as CAeM, CAgM and CHy will benefit from better access to quality assured seamless products, services and data.

5. Collaborative contribution to WMO Expected Results

The WMO Operating Plan 2016–2019 provides details on key outcomes, deliverables and activities to be implemented to achieve results defined in the WMO Strategic Plan, with the resources provided under WMO Results-based Budget. It is organized around 8 Expected Results

- Improved service quality and service delivery: Enhanced capabilities of Members to deliver and improve access to high-quality weather, climate, hydrological and related environmental predictions, information, warnings and services in response to users' needs and to enable their use in decision-making by relevant societal sectors.
- Reduced disaster risk: Enhanced capabilities of Members to reduce risks and potential impacts of hazards caused by weather, climate, water and related environmental elements.
- Improved data-processing, modelling and forecasting: Enhanced capabilities of Members to produce better weather, climate, water and related environmental information, predictions and warnings to support, in particular, reduced disaster risk and climate impact and adaptation strategies.
- Improved observations and data exchange: Enhanced capabilities of Members to access, develop, implement and use integrated and interoperable Earth- and space-based observation systems for weather, climate and hydrological observations, as well as related environmental and space weather observations, based on world standards set by WMO.
- Advance targeted research: Enhanced capabilities of Members to contribute to and draw benefits from the global research capacity for weather, climate, water and related environmental science and technology development.
- Strengthened capacity development: Enhanced capabilities of Members' NMHSs, in particular in developing and least developed countries and small island developing states, to fulfil their mandates.
- Strengthened partnerships: New and strengthened partnerships and cooperation activities to improve NMHSs' performance in delivering services and to demonstrate the value of WMO contributions within the United Nations system, relevant regional organizations, international conventions and national strategies.
- Improved efficiency and effectiveness: Ensured effective functioning of policy-making and constituent bodies and oversight of the Organization.

Over time GDPFS has contributed to the top 7 ERs. Over the past decade, GDPFS has contributed to improving services to NMHS through the cascading forecasting process of the SWFDP and the move to seamless GDPFS will expand the breath of services to a number of socio-economic sectors, through application of cascading process to variety of socio-economic sectors such as hydrology, transports, and energy for efficient and timely decision-making.

Seamless GDPFS will take advantage of and facilitate the synergy between a number of existing and developing activities in other disciplines such as:

- **JCOMM**

  - Lead Centre for Wave Forecast Verification (LC-WFV**).** The JCOMM Expert Team on Waves and Coastal Hazards (ETWCH) established a Lead Centre for Wave Forecast Verification (LC-WFV) at ECMWF. The project involves 17 Institutions around the world.
  - Coastal Inundation Forecasting Demonstration Project (CIFDP**).** The CIFDP aims to assist countries with issues of coastal inundation from oceanographic and/or hydrological phenomena, resulting from severe hydro-meteorological events, to operate and maintain a reliable forecasting system that helps the national decision-making for coastal management. The main focus of the CIFDP will be to facilitate the development of efficient forecasting and warning systems for coastal inundation based on robust science and observations.

- **CHy**

  FFGS Flash Flood Guidance System (FFGS) project with global coverage has been developed by the WMO Commission for Hydrology (CHy) jointly with the WMO Commission for Basic Systems (CBS) and in collaboration with the US National Weather Service, the US Hydrologic Research Center (HRC) and USAID/OFDA The collaboration between the Severe Weather Forecast Demonstration Project and the FFGS in the region of South Africa has demonstrated benefits of close cooperation among meteorological and hydrological forecasting.

- **CAgM**

  CAgM expects a high-resolution information production (downscaling of climate/observation/forecast and projection data) for agriculture and food security, which is one of early warning targets for climate extremes. To estimate a prospect of crop yield, agricultural communities have requested the GDPFS to provide high-resolution seamless daily information of the necessary variables to be used in agrometeorological models. It also needs some ICT sharable platform under cloud computing environment for developing countries to support enhanced national AgMet services.

- **CCl**

  The definition, implementation and operationalisation of the GPCs galaxy (individual GPCs and associated Lead Centres on MME and SVS on the seasonal time scales) is a very successful example of benefits gained for the entire climate community linked to CBS/CCl joint efforts, through the GDPFS. The establishment of mandatory products made available via individual GPCs web sites and LCs web sites under WMO umbrella improved significantly the access to seasonal forecasts and their possibility of post processing (especially downscaling and tailoring) at the RCCs and RCOFs levels and then consequently at the national levels. Last but not least one of additional products from the GPCs galaxy is the GSCU (Global Seasonal Climate Update), which is recognised to be a key element in support to their global, regional and national users, especially for preparation of relevant seasonal outlooks.

- **CAeM**

The ICAO Global Air Navigation Plan (2014-28) based on the implementation of the phased Aviation System Block Upgrades (ASBU) approach will require the increasing integration high-resolution meteorological data into 4-D Air Traffic Management (ATM) decision support systems to support and enable more efficient trajectory-based (gate-to-gate) operations. This transition from the traditional product-based 'briefing and advising' approach to one based on the application of best data by ATM decision support systems will inevitably result in significant changes to the current models of aviation meteorological service delivery with consequent impacts on and challenges for MET Services within the overarching framework of the WMO GDPFS. There is a significant opportunity to further enhance the relevance of the GDPFS given that high quality meteorological science, modeling, observations and interoperable data will be key enablers in ensuring the successful implementation of the ICAO GANP.

- **ECMWF**

ECMWF has been and continue to advance weather science by incorporating an increased level of complexity of physical and chemical processes and the interaction between atmosphere, ocean, sea-ice and land into the model. As a contributor to the GDPFS, ECMWF expects that by 2025 it will provide ensemble predictions of high impact weather up to two weeks ahead. It will also provide a seamless approach, aiming towards predictions of large-scale patterns and regime transitions up to four weeks ahead and global-scale anomalies up to a year ahead.

- **CAS**

CAS was the originator[1] of the decisions by EC LXI in May 2009 to implement:

(a) A unified approach to multidisciplinary weather, climate, water and environmental prediction research and to a step up in high-performance computing investments for coordinating and accelerating weather, climate, coupled chemical and hydrology model development, validation and use;

(b) Closer linkages between research, operations and users through Forecast Demonstration Projects (FDPs) that accelerate technology transfer;

(c) The review and rationalization of the roles and mandates of the WMO Commissions, and the improvement of their effectiveness in capturing optimal science input through WMO decision-making and thereby, enhancing WMO Member capabilities in research, observations, prediction and services.

CAS has also delivered the Sand and Dust Storm operational service (an example of multidisciplinary product), as well as being behind a number of significant improvement in NWP technologies. Looking forward, CAS is now ready to move up to IG3IS, HIW, S2S, GURME, Air Quality and GURME production of new products, which will have potentially large impacts on climate change mitigation policies or life shortening and illness resulting from bad air.

[1] EC-RTT report to EC LXI in May 2009, titled: Challenges facing Prediction Research: A report of the EC Task Team (EC-RTT) on Research Aspects of an Enhanced Climate, Weather, Water and Environmental Prediction Framework

ANNEX TO THE GDPFS IMPERATIVE

(DRAFT WHITE PAPER – SEAMLESS DPFS)

Preamble.

1.1 The successes of the past.

WMO, and its members have since their creation successfully met a number of major technology jumps: for example, the switch from data plotting and map drawing by hand, and more or less subjective synoptic analyses to a NWP-based system using supercomputers and automation technologies, then later on to global modeling, highly efficient and accurate numerical methods and sophisticated data analysis systems, then further on to global operational usage in data assimilation of space-based observing systems in real time, then on to ensemble methods that allowed a probabilistic estimate of the accuracy of the forecast and finally, recently, to the so-called seamless and integrated modeling approach which expands by orders of magnitude the potential applications of weather and climate modeling systems.

It is thus with a high level of confidence that we should approach the next technology transitions: correctly managed, our responses will, as in the past, result in further improvements of the excellence, relevance and impacts of our products, and thus contribute, overall, to further improvements in the security and socioeconomic progress of all our members, thus reducing further the gaps that separate some of us today.

1.2 Challenges for the future.

The World Meteorological Congress, at its seventeenth session (Cg-17), noted the rapidly evolving transformations in the practice of operational numerical weather prediction, particularly the integrated or seamless modeling approach, and recognized:

(1) That all WMO constituent bodies and numerous subsidiary expert level groups provide a complex framework for coordination and collaboration in which a large number of decision-makers and experts from virtually all Members and partner organizations address matters related to the Data-processing and Forecasting System (DPFS),

(2) That emerging requirements from the services-oriented programmes, such as aeronautical, marine, agriculture, health, and public weather services, as well as requirements from a wide range of hydro meteorological-related emergencies, or from implementing disaster mitigation strategies, require an enhanced integrated, holistic and seamless DPFSin order to be relevant to users' decision-making,

(3) That an enhanced integrated, holistic and seamless Data-processing and Forecasting System could have the potential to lead to important benefits for Members and their National Meteorological and Hydrological Services (NMHS) and the Organization as a whole,

(4) That the integration of the technical support to meet the on-going and emerging requirements from different sectors of society in a single system (in a multi-dimensional/ multi-disciplinary approach) would be more cost-effective and relevant to decision-makers and users.

Cg-17 therefore decided, through Resolution 11 (Cg-17), to initiate a process for the gradual establishment of a future enhanced integrated and seamless WMO DPFS, in light of the conclusions of the first World Weather Open Science Conference (WWOSC-2014, Montreal, Canada, August 2014), and requested the Executive Council to formulate Terms of Reference for this process, and a description of the set of products the system should produce, for consideration by the eighteen session of the World Meteorological Congress (Cg-18) in 2019. This paper responds to this request by describing (a) the requirements; (b) the reason why we are doing this; (c) the vision and scope for the future Global Data-processing and Forecasting System (GDPFS); (d) linkages with observations and data exchange, applications and services, research, regional bodies, and capacity development, (e) the benefits, (f) opportunities, success factors and challenges, and (g) the mechanism for implementation and timelines.

2. Considerations.

2.1 System and Service Requirements by WMO technical programs.

The requirements associated with this exercise can be framed as follows:

- The need for a clear vision for the future of the GDPFS that would contribute significantly to the long term positioning of the WMO as a world leader in facilitating the provision of both data and forecast products encompassing not only traditional weather related products, but also increasingly a widening spectrum of environmentally related information, in the spirit of the integrated and seamless approach;
- The need to devise a system that would be flexible and easily adaptable to the many technical and expanding service needs and requirements emerging in the user and producer communities, without necessitating a complete rebuild of the system, now, or in the future (for example, standardization on model /system output formats “or” transformation scripts to achieve transformation of standardized formats).
- The need to expand collaborations with many other partners, not necessarily in the traditional family of NMHS's, and adjust the GDPFS to facilitate this openness; for example, earth system modeling, including atmosphere, oceans, land, cryosphere, chemistry interactions, etc.
- The need for a clear focus on high impact products, whilst respecting the professionalism of some users, particularly in the marine, hydrological and agro-meteorological sectors, who are well trained and aware of the impact which certain environmental conditions create and as well, the need to have all members of WMO benefit from state of the art data and products specific to their particular needs;
- The need for a system where two-way feedback between producers and users is not only facilitated but also recognized as a key to success. This could be achieved through the creation of a User Interface Platform (UIP);
- The need to enable NMHS’s and other institutions to share and leverage each other’s data resources and to identify other sources of data e.g. Crowd Sourcing, Future mobile phone systems as meteorological observation platforms, road/rail/marine vehicles as data sources through similar systems as AMDAR on aircrafts, Nano- technology, etc. ;
- The need to clearly separate policy issues (EC and CG domains of governance) from internal operational and management issues.

- The urgent need to transit the GDPFS towards a system capable of producing impact-based forecasting and risk based-warning (IBF & RBW).

The future GDPFS system will need to be designed to help deliver in the most satisfactory and efficient way the new types of services required by the users with the overarching objective to contribute to Disaster Risk Reduction. This will necessitate a close interaction between the providers and the users of the services, and the requirement for a mechanism which strongly encourages and facilitates feedback between these two parties, such as a User Information Platform (UIP), something which is seen as lacking for now and that could be enabled by social media.

Another very important aspect to consider is the move towards impact-based forecasts and risk-based warnings, e.g., not merely providing a future state of the environment to the users, but actually providing the potential impact of this future state: and for many, if not the majority of the impacts, they will be at the State level, and will depend on socio-economic type information (preparedness, local transportation, building and power infrastructure status and disaster management rules, etc.), as on the quantitative physically-based information itself. One example that was provided is that unless one has access to hydrological reservoir management rules and practices, a global attempt to provide an operational flood forecasting service runs the risk of being seriously flawed.

In defining a future state and of the GDPFS (in connection with WIGOS, WIS) one will need to make decisions on what priorities the core services provided to WMO Members shall be addressing, and what position WMO, and its services oriented programs and commissions wish to retain for themselves and their partners.

The service aspects requirement is one of the fundamental dimension and reason for the existence of the GDPFS. This will define in a significant way the structure of the GDPFS itself. We will consider six of these Services area in particular, but will also discuss briefly Earth System Environmental and Socio-Economic Services.

2.1.1 Observations and Data Exchange

The GDPFS, WIGOS and WIS constitute the World Weather Watch (WWW) components and as such, evolution of GDPFS is closely linked to WIGOS and WIS. If indeed one wishes to proceed with a global implementation of the seamless and integrated forecasting system, it is necessary that access to enhanced observation data through WIGOS and WIS is coordinated with non-traditional partners.

Looking for example at the data needs for hydrological, agro-meteorological and marine forecasts, this will represent a formidable challenge, for a number of reasons. An important characteristic of these three particular applications is the need for both global, regional and very fine spatial scale data requirements for informed decision-making, and this at all time scales. Another one is the fact that these three sectors have developed their own data related processes or procedures, often quite dissimilar to traditional weather or even climate related usage. They are also very often outside the traditional world of NMHS organizationally, and have developed their own dissemination and decision processes, as well as different partner and user bases.

The rapid development of data related technology (big data, crowd-sourcing, cloud computing, etc.), which has already led to the creation by the private sector of fine scale user tailored agro-meteorological services in Africa, totally outside of the WMO program structures. We can, therefore, expect many more similar initiatives for different sectors of environmental predictions.

2.1.2 Public Weather Services (PWS):

- While the increased resolution of the Limited Area Models (LAMs) has helped to provide good information for PWS, convective weather activities remain a challenge to predict accurately. Data suites derived from radar-based nowcasting systems, merged into model output at time ranges of 2-4hrs, can address this challenge but the technology is still out of reach for many NMHSs, even in the developed world.
- Ensemble Prediction Systems (EPS) systems consume a very significant percentage of the resources of the major centers running global models, but we are not exploiting this rich information to its full extent. Many users simply do not have decision-making systems that are sophisticated enough to incorporate this probability-based information.
- User-education is needed here, and also more social-science research into how users make decisions, and to what extent they can absorb this complexity of information or sharing. In other words, training is a major gap.
- Primarily the training of front-line forecasters in, e.g. the use of RSMC products and guidance, in the proper interpretation of EPS data, etc. If the NMHSs cannot properly organize for the adequate training of their own staff, what hope is there in providing training for users?
- New requirements: The need to incorporate weather information with data from other sources (vulnerability and exposure data, crowd-sourced observations of weather itself or its impacts etc.) means that there is a need to develop visualization platforms that allows all of this diverse data to be coherently presented and examined by forecasters (or consulting meteorologists, which is what forecasters may become). These platforms will probably be GIS-based, so the meteorological world needs to get to grips with how best to incorporate this technology.

2.1.3 Climate services, including the support to GFCS

- Specialized centers: Their designation and monitoring processes should be improved and should evolve. It is important to have some clear criteria and metrics to assess the compliance of the labeled centers and their activities. It is also important to elaborate standards for operations, especially at the regional level (e.g., RCCs and RCOFs), including the need to label products and services (with WIS compliance). New functionalities should also be introduced (e.g., help desk function, user support, etc.). Last but not least, global monitoring centers do not presently exist, whereas this is the case for data and forecast products.
- Climate services perspective: There is a clear need to add this dimension within the GDPFS, especially with respect to CSIS and its interface with the User Interface Platform (UIP). In this respect, the involvement of organizations or entities, which are not operational (in the NMHS sense), but are nevertheless providing information routinely should be addressed. Adaptations will be necessary for tailored information for decision making (especially impact forecasts). And of course, these should be evaluated and monitored.
- Climate service Toolkit: The development of such tools should be conducted in close collaboration with CBS and have strong linkages with the GDPFS (functionalities, standards, etc.), noting that the necessary downscaling/upscaling functions should be part of the process.
- Feedback processes: Some feedback processes are missing or are not efficient, particularly with people outside our traditional climate community, and for the RCCs and GPCs.

- Verification: It should be adapted to the service provision, especially beyond the products themselves, focusing on the impact of the use of the information (e.g., demonstrated value of the services provided).
- Climate Change information and the new GDPFS: It should be integrated in the functionalities described in the GDPFS. Likewise, we should extend the described functionalities across all the time scales (making sure we preserve and ensure the consistency within the seamless provision of information).
- Additional points: Using a system approach will allow a full picture to emerge, and the possibility of assigning the necessary priorities and importance for each component of the system. There will be a need to create and monitor relevant labels for the tools used, and the provision of the information (e.g., clear identification of authoritative voices on internet, labels for candidates to the CST, etc.).

2.1.4 Hydrological services

The Commission for Hydrology (CHy) shapes the water related activities of the WMO and addresses issues related to the basic hydrological observation network, water resources assessment, flood forecasting and management, adaptability to climate variability and change and promotes exchange of technology and capacity building. In particular the outcomes of its deliberations provide guidance to WMO Member countries and WMO Secretariat for the implementation of the Hydrology and Water Resources Program of WMO.

- Its major activities are: 1) Quality management framework, 2) Data operations and management, 3) Water resources assessment, 4) Hydrological forecasting and prediction, and 4) Water, climate and risk management.
- The responsibilities of NHSs are: 1) Observation of surface waters (stages and discharges), 2) Data quality control and primary processing, 3) Hydrological balance and water resources management, 4) Hydrological forecasting, and 5) Water quality, ground water monitoring and assessments, etc.
- Concerning runoff or flood generation processes, one needs to consider initial conditions (soil moisture, groundwater, snow, reservoirs) are very important), the high spatial variability, and the temporal and spatial development of floods (basin-scale determines a forecast lead time).
- The forecast ranges in hydrology extend from hours to years. Whilst flood forecasting is a national responsibility, depending on the basin scale, it often requires international and regional cooperation (for example, in Europe, EFAS), and also GloFAS (GFP), and G-WADI (UNESCO-IHP).
- NHSs are users of meteorological and climatological services (data, forecasts) usually not within one NMHS. Also, levels and ways of cooperation between NMSs and NHSs differ significantly among countries and regions.

The needs of CHy and NHSs are: 1) Observations and short term forecasts (basic), 2) Service delivery as a tailored product for hydrological application (no GRIB), 3) Bias corrected and downscaled to the resolution of the hydrological model, and Verification, preferably from an authoritative source.

It is unclear at this time what form the contributions of CHy and NHSs should or would be: developed hydrological services typically provide observations in near real time, flash flood guidance, short to medium-range flood forecasting, and seasonal runoff prediction, with an aim to provide these in a seamless way to users.

2.1.5 Marine meteorological and oceanographic services

The long-term objectives of WMO Marine Meteorology and Oceanography Program include, as a priority, enhancing the provision of marine meteorological, oceanographic and climate services. The coordination of implementation and development is made through JCOMM, primarily in generation and analysis of observations and knowledge of the marine atmosphere and ocean in support of numerous applications, including:

- Enhanced safety of life and property at sea and coastline through improved forecasts of natural and anthropogenic hazards such as storm surge, sea level rise, harmful algal bloom, tsunami, ocean acidification, and oil spill trajectory
- Contribute to the prevention and control of marine pollution, sustainable development of the marine environment, coastal area management and recreational activities, and in support of the safety of coastal habitation and activities.
- Contribute to development of ocean-based economic and industrial activities
- Contribute to coordination and enhancement of the provision of data, information, products and services required to support atmosphere and ocean weather forecasts and detection and prediction of climate variability and change.
- Advance understanding and improve predictability of the global integrated Earth system.
- Contribute to improve marine and ocean forecasting from the global to the coastal scales by incorporating research innovation in operational systems
- In doing so, JCOMM promotes a state-of-the-art, globally distributed, and fully integrated marine observing, data management, and services system based on present and next-generation technologies and capabilities. The main challenges that the Marine Meteorology and Oceanography Program (MMOP) is facing are:
- Enhancing the coordination of global real-time, near-real time and delayed-mode (up to 1 month) data acquisition of ocean data between the “oceanographic community” and the National Meteorological and Hydrological Services, including the national navies, oceanographic institutions and centers, operational and research centers, etc.
- Moving from the "full scale global operations" to the regional and national implementation in order to meet user needs. This may be achieved through developing a marine equivalent of the WAFC concept, where a very few Global Centers are responsible for the deep water areas, with regional and national inputs being provided for near shore and coastal areas.
- Meeting the users requirements and establishing good connections between the end product users, their producers, as well as with data providers, and observational programs. Within this, the role of governance of the safety services must be considered, where ensuring connections with, for example, the International Maritime Organization (IMO), are paramount.
- Sustaining the global ocean observing system (in situ and satellite based) in order to achieve optimal sampling capabilities for analysis, reanalysis and forecasts
- Organizing training workshops and on-line learning modules for Capacity Development at the different stages of the production line.
- Ensuring that relationships with other agencies engaged in the provision of safety information, such as IMO and the International Hydrographic Organization (IHO) are robust and resourced appropriately.

Moreover, end-users will soon require new application areas, driven both by safety at sea, and socioeconomic pressures. Some examples are:

- Offshore resource exploration,
- Military and defense operations,
- Marine engineering,
- Sub-surface communications,
- Tsunami prediction and warning systems,
- Storm surges and coastal defense communities,
- Ship routing and navigation,
- Operations in the marginal ice zone,
- Pollution monitoring prevention and clean-up,
- Marine and coastal environmental management,
- Space weather impacts on safe navigation
- Synoptic, seasonal and other long-term forecasting,
- Climate prediction at different time scales,
- Sustainable management of commercial fishing.

Many of these, if not most will require crosscutting collaborations between programs of WMO and IOC but also others: a recent example is the WMO coastal inundation forecasting demonstration project (CIFDP) which was initiated jointly by JCOMM and the Commission for Hydrology.

2.1.6 Aeronautical meteorology services

International aviation meteorological service provision is coordinated and overseen by the International Civil Aviation Organization (ICAO) and is supported by and contributes to the GDPFS. The services, underpinned and informed by the necessary guidelines, manuals and standards, are delivered through two World Area Forecast Centers, seven Tropical Cyclone Advisory Centers, nine Volcanic Ash Advisory Centers and the numerous Meteorological Watch Offices (MWO) and Airport Meteorological Offices. In addition there are plans for the development of regional hazardous (aviation) weather advisory centers for space weather, other meteorological hazards and nuclear emergencies.

The ICAO Global Air Navigation Plan (2014-28) based on the implementation of the phased Aviation System Block Upgrades (ASBU) approach will require the increasing integration high-resolution meteorological data into 4-D Air Traffic Management (ATM) decision support systems to support and enable more efficient trajectory-based (gate-to-gate) operations. This transition from the traditional product-based 'briefing and advising' approach to one based on the application of best data by ATM decision support systems will inevitably result in significant changes to the current models of aviation meteorological service delivery with consequent impacts on and challenges for MET Services within the overarching framework of the WMO GDPFS. There is a significant opportunity to further enhance the relevance of the GDPFS given that high quality meteorological science, modeling, observations and interoperable data will be key enablers in ensuring the successful implementation of the ICAO GANP.

2.1.7 Agricultural meteorology services

The Commission for Agricultural Meteorology (CAgM) is proposing an AgMet Data Collection and Production Centers (DCPC) to support climate and weather services innovations for the sector of Agriculture and Food Security.

Global centers (WAMIS DCPC) would develop:

- Operational activities for downscaling NWP outputs for applications in the agriculture and food security sectors including S2S in space, time and element,
- Operational activities for Reanalysis on historical/in-situ data including non-meteorological data (i.e. crop monitoring) from remote sensing platforms,
- Operational data services for high resolution Agro Meteorological products and supplementary RS information (on a semi-real time basis),
- Operational activities for ICT sharable platforms under cloud environments with GIS-online interfaces for agricultural and food security applications.

Whilst regional centers (WAMIS Portal) would provide:

- Operational services for Agro Meteorological Bulletin archival and dissemination,
- Operational activities for Early Warning services on Agro Meteorological hazards/extremes, based on region specific needs,
- Operational data services to support regional Agro Meteorological Outlook services,
- Training in the use of operational Agro Meteorological products and services including promising tools.

This vision will clearly necessitate significant changes in the traditional GDPFS operations, and as well in WIS and by extension WIGOS. Non-traditional data, computing needs and products dissemination and visualization will need to be addressed. For example, a specialized or dedicated GISC/DCPC of WIS to support WAMIS grid/cloud portal will be a promising solution in improving resource sharing among CAgM member countries by allowing them to make better use of remotely located ICT resources for agrometeorological services at national/regional scale, especially when it provides interactive forecast-based agrometeorological services via simple Internet access.

Also the need for very high resolution climate and weather products (obtained through downscaling or other means), spanning a time interval from minutes to years, is a challenge that present seamless modeling technology (Sub-seasonal to seasonal (S2S) is an example) has not yet successfully resolved. And many countries do not yet have the capacity or the resources to run the kilometer or even meter scale models that will be needed. Nevertheless, the modernization of agrometeorological services under a WMO leadership role, and involving evolved GDPFS, WIS and WIGOS components could be an interesting option.

2.1.8 Earth System Environmental and Socio-Economic Services.

Clearly the ability to assimilate large volumes of data and to run ever more complex earth system models has been a major achievement of the GDPFS over the past few decades. The Sand and Dust Storm (SDS) forecasting system is a good recent example. Can these models be expanded to either: 1) incorporate all natural and man-made hazards, such as Space Weather, Air Quality issues, from urban bad air events to regional events such as forest and slash and burn smoke, vector-borne diseases, toxic algae events, etc., or: 2) provide an increasing diversity of decision-making support systems in fields like integrated ecosystem management tools, food production (fisheries, agriculture), air, land and sea transport, energy production, particularly renewable in a context of a carbon-free economy, urbanization and megacities environmental management issues, and many other products, so that science can deliver to society a truly holistic multi-hazard forecast and warnings system? If this is so, then how are the other actors and partners to be brought into the picture? The organizational and technical framework that global meteorology has developed could be expanded to encompass many other hazards or decision-making aids to civil society, but is this desirable and, if so, how does WMO go about leading or sharing this development?

2.2 Regional requirements

In order to expand the scope of the GDPFS stronger linkages with WMO constituent bodies (Congress, EC, RA's and Technical Commissions) and related programs will need to be established. Therefore, a close interaction of CBS with CAS, CCl, CHy, CAEM, CAgM, and JCOMM, as well as most of their main programs (GAW, WWRP, WCRP, GCOS, GOOS, WHOS, PWS, HWRP, WSP, PWSP, WIS, WIGOS, DRR, etc.) will be necessary in order to successfully evolve the present structure of the GDPFS by ensuring all facets of requirements impacted by the GDPFS are accounted for in the design of the future system. Also, given the more local aspects of some of the new services, RA's will need to become more closely involved, depending on the specific focus and scope of the new services.

To expand a bit on the links with Regional Bodies (e.g. TCP regional bodies, RAs working groups) one should note that Regional Bodies, by their very nature, represent classes of both providers and users of observational, data and forecasting products. As well, RAs provide a governance mechanism to plan and coordinate activities as well as providing a mechanism to enable supra-national discussions and decision-making. Those bodies vary immensely in their capacities and political influence, and specific products needs, this being driven by both socioeconomic, administrative and political factors, and the specific regional characteristics that weather, climate, hydrological and other environmental impacts display in the specific global areas which they cover. As the GDPFS evolves towards the provision of an expanding set of products, and focuses increasingly on forecasting impacts, close coordination with Regional Bodies will become more and more essential. Forecasting impacts at an increasing space and time resolution requires access to whole new sets of observations and data, as well as an expanding suite of numerical models, ensemble products, etc., coupled with a diverse suite of dissemination and presentation technologies: these will vary greatly between Regional Bodies. The challenge of closing the gaps between 191 NMHS's spread across the earth will require increased linkages, through better feedbacks and interactions.

2.3 Requirements of other International Organizations

Linkages with a number of other international organizations, including humanitarian agencies, some in the UN Family, UNEP, UNESCO, IAEA, WHO, some outside, like GEO, or ICSU are also required to ensure the GDPFS system of the future can respond to their needs.

2.4 Research

The value chain in meteorology is rapidly being diversified. From mainly providing weather forecasts to the general public, the NMHSs and the weather enterprise progressively develop and apply downstream models/post processing of NWP forecasts or reanalysis for a range of applications in specific societal sectors. Marine forecasts, GCM climate projections and environmental predictions are also included. Many of these have been rendered possible by adopting the seamless and integrated modeling approach.

Examples of specific applications include road traffic, aviation (civil and military), shipping, energy production and consumption (wind, solar, hydro, fossil), air quality, integrated global greenhouse gas information system, biogeochemical fluxes (ecosystem including freshwater impact), estimation of emissions of trace chemical species, agriculture, tourism, high impact weather (wind, precipitation, temperature), avalanches and mud slides, coastal erosion, storm surges, offshore weather including waves, icing on infrastructure, emergency preparedness (search and rescue), oil spill, drifting infrastructure; volcanic ash dispersion, dispersion and deposition of radioactivity, large explosions and fires, forest fires, sand and dust storms. The list can be made even longer.

The important point here is to note the foundational role of research in making this evolution possible. WMO, largely through the CAS (GAW, WWRP, GURME), CCl, JCOMM and other research programs, some of which are co-sponsored, such as the WCRP, GCOS, and others, has played a key role in making it an operational reality. It should also be noted that most of the research initiated, coordinated or facilitated through partnerships by WMO are services and policy driven, as is most of the research conducted within the NMHS's. Research activities provides an important 'sentinel' role in that it facilitates an over the horizon S&T watch, which allows better strategic planning for future operational programs and the GDPFS.

The future evolution of the GDPFS will require stronger links with research, and eventually the capacity to test novel operational products. Some examples that have been discussed are TIGGE and TIGGE LAM, S2S, Polar related experimental products, CHAMP, IG3IS. By making these prototypes available to WMO users, it will be possible to obtain feedbacks from the whole WMO community and, hopefully, their partners: these feedbacks will be essential to assess their accuracy, identify potential improvements, and in the end help tailor them more closely to their needs. In other words the new GDPFS will need to facilitate a smooth transfer of research results into operations.

2.5 Capacity development, including education and training

The evolution of the GDPFS will require a strong focus on capacity development, education, training and support to those countries facing difficulties in assessing and using the new types of products that will be made available to them. There will be a challenge in interpreting the value (accuracy, relevance and impact on decision-making processes) of specific products, as well as disseminating and presenting them to users. A key issue here will be for WMO to ensure that the progresses made in a subset of countries in providing a more diverse, probabilistic based and impact focused set of products is actually useful to those countries who presently lack the capacity to make best use of these, countries which are often those who need them most.

2.6 Why are we doing this? Evolution, instead of revolution

There are a number of reasons for re-examining the GDPFS. On the one hand, we are witnessing rapid advances in information and computing technologies (including such objects as smartphones, cloud computing and data storage and retrieval, big data and deep data analytics concepts, fast broadband links, extremely powerful computing technology (capacity doubling every 18 months), novel visualization and display techniques, etc.). On the other hand, we are seeing steadily increasing demands from users for highly-localized weather forecast data provided at a high temporal resolution (at least hourly for the first 12-24 hrs.), spanning a much broader level of dimensions than traditional weather products, and focusing on risk warnings and impact forecasts. In other words, both the "system" and the "services" aspects will need to evolve.

Moreover, with the successful introduction of the seamless or integrated approach in earth system modeling, and the possibility through coupled modeling techniques to touch many non-traditional weather related applications, there will also be a need to re-examine if, how and how much the GDPFS needs to evolve in order to interact or liaise with non-traditional providers of data and services (such as climate services, hydrological services, atmospheric air quality services, space-weather services, maritime or polar services, etc.).

Simultaneously, while adapting to these changes, the GDPFS will need to maintain its role as a global enterprise which enables NMHS's to fulfill their national obligations, keep on enhancing WMO's role in disaster risk reduction and mitigation, increasing its linkages with the Climate Services Information System (CSIS) of the GFCS, and ultimately contributing to the reduction of service capability gaps between developed and developing countries.

3. The Vision.

The proposed vision for the Future GDPFS is:

- The GDPFS will be an effective and adaptable monitoring and prediction system enabling Members and partners to make better-informed decisions.
- The GDPFS will facilitate the provision of impact-based forecasts and risk-based warnings through partnership and collaboration.
- The GDPFS will do so through the sharing of weather, water, climate and related environmental data, products and services in a cost effective, timely and agile way, with the effect of benefitting all WMO members, while also reducing the gaps between developed and developing Members.

A good way to crystalize this vision is to project us in 2031, that is, 16 years from now, and have a look at what the GDPFS might be.

At that time, the overall accuracy of state of the art global prediction models will have improved enough to add 1.5 days of overall predictability, if the historical rate of progress of one day per decade is maintained; we will finally have achieved the goal set by Jules Charney and others when they launched GARP in the 1970's. Global models will have resolutions below 5km, and mesoscale models significantly below 1km, down to a few tens of meters in urban areas for example. We will have achieved:

- Full predictive skill at the sub seasonal time scales and Ensemble Prediction Systems (EPSs) will routinely have hundreds of members and outputs shared between many global centers;
- Forecast products providing accurate and detailed information on such things as closed water budgets over most watersheds, wind, temperature and air quality information in urban street, canyons and outwards to the surrounding country side;
- Detailed agro met information from hourly to seasonal cycles;
- Precise storm surges and wind damage estimates from cyclone, sea state, including rogue waves, and dangerous shore currents and;
- Products on telecommunications and electricity blackouts due to solar eruptions and on toxic algae blooms, pest migrations, etc.

Most or even all of this information will be made accessible as a public good product to all WMO members, and their partners[2]. And most of this information will be made available either in raw format, or directly as impact information. It will be disseminated and presented in whatever medium or format the users have chosen, and use point to point or, increasingly, cloud to point

[2] The assumption here is that the public funding of computing facilities that NMHS's can use is maintained at a sufficient level; if not, the possible landscape described above may not be entirely funded or controlled by state-owned institutions

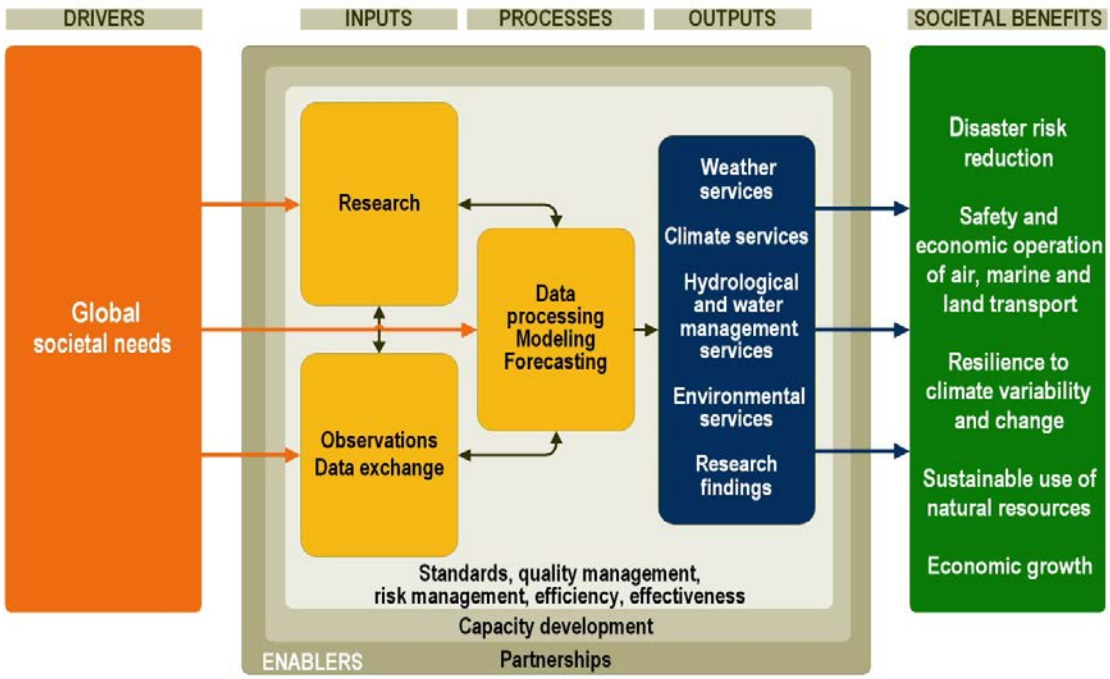
communication broadband technologies. It will be quality controlled, it will be validated and will have metadata information with appropriate publications in the peer-review literature and in the case of forecast information, it will be verified. Imbedded in the design of the system will be two-way feedback and real time communication capacities between the provider and the receiver of the data.

The system will also have evolved through partnership agreements that allow it to absorb or carry information produced either by the private sector and academia, or by other closely related organizations to the traditional NMHS's. And by using alternate and less expensive technologies, such as cloud computing, crowdsourcing, smartphones, open source software, big data storage, etc., as well as potential partnerships with private sector or other non traditional information providers, gaps between WMO members in terms of ease and cost of access and positive user impacts will have decreased significantly.

In fact, these recent technology changes open up the possibility of both NWP and GCM future development strategies (both science content and operational implementation and capacity) being "community driven", relying on distributed computing and data storage capacities, thus making relatively obsolete the need for purely national facilities. By inference, it thus follows that a potential path for the future GDPFS will be the development and provision of tools giving access to pooled resources, so that NMHS's can obtain the tailored information they need to address requirements of their users of services, thus bypassing the need to implement modeling capacities at home. An extension of this approach, is for the users to directly access the information they need to link to their decision making-processes directly.

4. Scope (integration, standardization and interoperability).

The WMO Strategic Plan 2016-2019 will largely determine the scope of the evolution of the GDPFS. It will be driven by the need to support the role of NMHSs in their response to global societal needs facing the world population at large, focusing not only on those sectors for which they traditionally have had a leading role to play, mainly in reducing the socio-economic impacts of weather and climate related disasters in their respective countries, but more broadly on contributing to an expanding number of sustainable development issues related to weather, climate, water and related environmental factors, such as contributions to a carbon-free economy. This expansion or broadening of the role of the GDPFS will be made possible by a number of factors, a key one being the seamless and integrated modeling approach, which allows the delivery of new environmental services in support of sustainable development across all timescales and disciplines (Agriculture, hydrology etc.). Standardization and interoperability of data and products will also be important factors in providing this broadening. The figure below, extracted from the WMO Strategic Plan 2016-2019 illustrates the role of the NMHSs in responding to those needs.



The GDPFS, whilst maintaining its traditional role for standards, validation, verification and overall quality management for data processing and forecast services, will expand its linkages with other WMO constituent bodies and programs, with emphasis on regional bodies (TCP regional bodies, RA's) and programs. It will also contribute to the capacity development of its client and user base, and will strengthen its interactions with research, through participation in the design and operational testing or validation of novel products emerging from RDP's and FDP's.

5. Benefits.

The benefits of the future GDPFS can be articulated along three axis : contribution to the UN and WMO agendas, the quality, diversity and relevance of GDPFS information and furthering existing and developing new partnerships.

5.1 Contribution to the UN and WMO agendas

Quoting from the 2016-2019 WMO Strategic plan (p.10, The need for Sustainable Development), the following three Global Societal needs (GSN) are of fundamental importance in defining priorities:

- **Improved protection of life and property** by mitigating the impacts of hazardous weather, climate, water and other environmental events and addressing the need for improved safety of transport on land, at sea, and in the air;

- **Poverty eradication, sustainable livelihoods, food security, sustainable access to water and energy, and economic growth** by making available weather, climate, water and related environmental services to support the post-2015 sustainable development agenda, climate risk management, climate resilience, green economy, disaster risk reduction, food security, improved health and social well-being of citizens, water management, and tapping renewable energy resources such as hydro-, solar- and wind-power;

- **Sustainable use of natural resources and improved environmental quality** by designing weather, climate, water and related environmental services to manage atmospheric, terrestrial and water resources at all time-scales, and the development and management of other natural resources.

From the preceding sections, it is clear that the proposed evolution of the GDPFS will benefit this important and central item in the UN Agenda. It also will contribute to a number of WMO priorities for 2016-2019, in particular:
Improvement of the effectiveness of high quality impact-based forecasts and early warnings for extreme weather, climate and water events for disaster risk reduction; GFCS and Aviation

5.2 Improving the quality, diversity and relevance of GDPFS information, data and products

The new GDPFS will allow testing and eventual operational inclusion of many projects, all focusing on one or more of these priorities: SWFDP expanding to other regions on the globe, GLOFAS exploring the capacity to forecast flood risks on the globe, MAP providing a successful example in a mountainous area, CHAMP looking at forecasting the hydrological budget of the North American Great lakes area, CREWS, an initiative which aims to significantly increase the capacity for seamless Multi-Hazard Early Warning System (MHEWS) in the climate realm in order to generate and communicate effective impact-based early warnings, and risk information for hazardous hydro-meteorological and climate events, IG3IS which could provide at a very high spatial resolution an integrated 4D snapshot of GHG and other related atmospheric chemical constituents budget over a given area of interest, GAMOS and ChiNAMOS, a global agrometeorological outlook system, Space Weather operational forecasting system, mitigating risks of solar eruption activity to satellites, electrical and communication networks, etc. And this list is a subset of the full number of initiatives now being examined by WMO, its members and partners.

5.3 Opening a door for new partnerships

The common thread here is that the seamless and integrated modeling paradigm (with a high resolution core of atmospheric, oceanic and land surface modeling capacity, coupled with complex earth system modeling subsystems, and benefitting from powerful supercomputing capacity, broadband communication capacity, massive data storage capacity) will be easily accessible by an increasing number of non-traditional users. Moreover, using new dissemination technologies (cloud to point delivery of the information, smart phone access, emerging social media technologies), client focused adjusted means of product presentation or communication as opposed to traditional methodologies, will bring in new partners to the WMO world, including private sector operators and academia. It is unclear at this time how this will all evolve, but in the end, this transformation should yield direct benefits to decision makers or ordinary clients and users in optimizing either their business practices, risk mitigation of threatening environmental high impact events, or longer range adaptation and sustainable strategies.

6. Opportunities, Success factors and Challenges.

6.1 The context.

The business of weather, water, climate and earth system observations and predictions is, first and foremost, a science-based, high technology (largely IT-related) just in time information enterprise.

This information has global reach and relevance, and is key to countless decision-making processes, be it on: 1) global policymaking issues (UNFCC, UNCDD, Ozone, COP21, Transport of atmospheric pollutants and toxics and associated morbidity, nuclear weapons controls, etc.), 2) global weather, water and climate related disaster risk reduction, and 3) important and steadily growing socio-economic impacts.

Recently, significant scientific progresses in both observational technology (particularly space-based observing systems), as well as novel climate and weather data assimilation and modeling practices, have led us to the possibility of vastly expanding the diversity of its environmental information potential.

At the same time, it is fair to say that both the information technology and dissemination related processes are evolving at an accelerating pace (the transition of the traditional paper-based written media to a largely IT-based dissemination process (tablet, smart-phone, etc.) provides a good example of this acceleration. Given that there is a global market for the types of products NMHS's and GPC's, largely publicly funded, are on the verge of making available, it is reasonable to expect an increasing interest from the private sector with potential partnerships with the academia to take a share of the market (in fact, this has already started).

6.2 Important issues needing consideration.

Throughout this document, and in many of the discussions with the group of experts, it is possible to identify a number of important issues that need some consideration if the proposed evolution of the GDPFS is to be a success:

6.2.1 Access to data and observations.

One important consequence of moving towards a seamless and integrated modeling approach is access to new, and sometimes non-traditional observations, and at much higher spatial and temporal resolutions than has been customary. This follows from the fact that forecast products will expand to new disciplinary or thematic domains, which so far have not been part of the traditional inputs and outputs of production centers of NMHS's.

There are also other dimensions to consider: standards and formats, interoperability of the information, information storage, telecom bandwidth and downstream computing and post-processing (this may lead the GDPFS to establish globally distributed storage farms such as what CERN has done to manage the information generated by LHC; make available the basic information along with the approved piece of code to generate the post-processed information on cloud computing platform). This will require discussions on availability and data exchange protocols between WMO members and other international, national and regional organizations.

Similarly, the concept of "risk-based warnings" and "impact forecasting" requires access and sharing of novel types of data (infrastructure, emergency decision-making policies, population distribution, transportation networks, etc.), not easily amenable to present guidelines on formats, metadata, validation, etc. Moreover, some countries could be reluctant to make this data available for any number of reasons. Again, there will be a need for extensive discussions between WMO members and the other organizations controlling access to these data.

6.2.2 Future products: optimal production, dissemination and usage.

Many of the future warning and forecast data and information, such as those related to air quality, hydrological, marine, aviation, agro meteorological information, and more generally speaking socio-economic applications are often of use for organizations outside traditional NMHS's. These organizations have their own internal decision-making processes, data and forecast related protocols, partners and user bases. A good example was provided for hydrological forecasting. And similar issues exist for other services. Again, WMO will need to establish the necessary partnerships, in order expand the current GDPFS menu to these new products. In fact, concerning so-called "big data" related issues and applications; WMO has already started such a process.

Another key aspect, which requires further consideration, is user information and feedback. The creation by WMO of some form of user information platform (UIP), geographically or thematically structured is perhaps worth some further consideration.

6.2.3 Transition towards a new global, regional and national production infrastructure.

Many of the products also depend on very high-resolution observational and modeling grids, often at he kilometer size and less. A relatively small number of countries actually have the capacity (human and technical) to operate at these resolutions. And at this time, at least, it does not seem feasible to generate these products at a small number of central locations (e.g., GPC's) for global distribution. In order to help prevent the widening of a gap between the countries, which possess the capacity, and those that do not, some transitory and eventually permanent solutions will have to be found, perhaps involving private sector or academia-led initiatives, or use of new computing technologies, such as cloud-computing.

6.2.4 Training and capacity building.

The increasing complexity of many of the products will in turn increasingly require an increase in the capacity of the users (NMHS's or others) to make optimal usage of their information content. This will represent a challenge for many countries, and necessitate a strategic re-think of WMO's and its members approach to training and capacity-building initiatives.

6.2.5 Organizational impacts (impacts on GDPFS Centers).

Finally, as this expansion of the scope of the GDPFS happens, and numerous agreements and partnerships with new international, national and regional organizations are struck, there could be pressures from countries and partners to revisit the current membership structures. For example, it could be that some countries will wish to be represented by different types of managers or administrators along with the current Directors or CEO's of NMHS's.

6.3 Policy considerations.

From the preceding Sections, it becomes clear that whilst the evolution of the GDPFS proper remains an internal management and operational issue, it will also require EC and Congress to consider a number of policy issues, which will guide, clarify and facilitate this evolution.

6.3.1 Open data policies.

In order to fulfill WMO's vision, and a successful evolution of the GDPFS, free and open access to all necessary data, particularly observations, is critical. We are already witnessing initiatives, some led by the private sector, where new observations are either not shared openly, or if so, at reduced spatial and temporal resolutions, or against cost. At the same time, while most observations paid for by the public purse have open access some are not. There are also related issues linked with formats, validation and quality control. Eventually, some policy decisions will be required to clarify these issues and propose some solutions.

6.3.2 Role of the private sector and the academia.

This issue is closely linked with open data policies. However, there is also increasing evidence that some major corporations are moving towards establishing their own internal data processing and forecasting capacities, including global analyses and predictions. Given the potential value of applications derived from such capacities, mostly targeting specific socioeconomic sectors, they will in a sense potentially duplicate or compete with public good products, made available through the future GDPFS. At some point, some policy decisions might be needed to as to how the GDPFS should take these developments into account.

6.3.3 Training and capacity building.

We have already alluded to the linkages of this aspect to the evolution of the GDPFS. In the discussions leading to this paper, there was often mention of the high priority that should be given to this issue. As the products become even more complex, both in their content, as well as in their formats (ensemble products, impact based, etc.), and target many new and different non traditional sectors, training and capacity building will become essential to the success of the GDPFS evolution, unless one accepts the possibility of increasing gaps between members. Discussions between members and eventually policy decisions will probably be needed.

6.3.4 GDPFS products quality assessment.

One of the key benefits obtained by WMO members from using GDPFS products should be assurance on their quality, accuracy and reliability. Concerning weather prediction activities, for which the WMO is the UN lead agency, and which is its core business (GDPFS, WDS, etc.), there is no official external scientific assessment (produced say by an international team of experts) of these aspects. Yet, we do produce an assessment for weather modification activities, which clarifies what is scientifically validated, and what isn't.

Perhaps WMO should consider proposing to put together a core team of experts, under the leadership of its RES and WDS program, and reinstate a similar activity, which was dropped some years ago.

This would set the bar for what are good products, and those that fail to be based on good science! It would reaffirm WMO global leadership in these matters, but would also contribute very positively to the future evolution of the GDPFS, help its users in their decision-making activities, and facilitate the discussions with potential new partners.

7. Terms of Reference (ToRs) for the Steering Group on Seamless GDPFS

The Steering Group on Seamless GDPFS (following the request by Cg-17), will be chaired by the president of CBS and will comprise of representatives of technical Commissions and regional associations, with the following Terms of Reference:

(1) Provide guidance and monitor the development of the process for the gradual establishment of a future enhanced integrated and seamless WMO Data-processing and Forecasting System;

(2) Manage the integration of new components in the GDPFS, including addressing synergies with and requirements of all WMO Programmes and Regions, through active consultations with technical commissions and regional associations;

(3) Develop a description of the set of products the system should produce;

(4) Complete the White Paper along with the Implementation Plan for the process, for consideration by EC-69;

8. Roadmap (phases)

Reference

List of Acronyms

Annex: Outline of the Implementation Plan (see RA II-16 Doc 4.6(1))

Annex IV

DRAFT OUTLINE OF THE IMPLEMENTATION PLAN

1. Vision

(Excerpt from the draft White Paper on Seamless GDPFS)

- The GDPFS will be an effective and adaptable monitoring and prediction system to enable Members and partners to make better-informed decisions.

- The GDPFS will facilitate the provision of impact-based FORECASTS and risk-based warnings through partnership and collaboration.

- The GDPFS will do so through the sharing of weather, water, climate and related environmental data, products and services in a cost effective, timely and agile way, with the effect of benefitting all WMO members, while also reducing the gaps between developed and developing Members.

One may imagine the GDPFS in 2031, 16 years later:

- The overall accuracy of state of the art global prediction models have improved enough to add1.5 days of overall predictability, if the historical rate of progress of one day per decade is sustained: The goal set by Jule Charney and others when they launched GARP in the 1970's was achieved. Global models have resolutions below 5km, and mesoscale models significantly below 1km, down to a few tens of meters in urban areas for example.

- The sub seasonal time scales are achieved, ensembles have routinely hundreds of members, shared between many global centers, and forecast products provide accurate and detailed information on such things as closed water budgets over most watersheds, wind, temperature and air quality information in urban street canyons and outwards to the surrounding country side, finely detailed agromet information from hourly cycles to seasonal, precise storm surges and wind damage estimates for cyclone landfall, sea state, including rogue waves, and dangerous shore currents, telecommunications and electricity blackouts from solar eruptions form the surface to satellites orbital heights, toxic algae blooms , pest migrations, etc.

- Most or even all this information are accessible as a public good product to all WMO members, and their partners, and most of this information is available either in raw format, or directly as impact information. It is disseminated and presented in accordance with users formats, and using point to point or, increasingly, cloud to point communication broadband technologies. It is quality controlled, validated and have metadata information associated, and in the case of forecast information, it is verified. Imbedded in the design of the system is a two-way feedback real time communication capacity between the provider and the receiver of the data.

- The system has evolved through partnership agreements that allow it to absorb or carry information produced either by the private sector, or by other closely related organizations to the traditional NMHS's.

2. Scope

The WMO Strategic Plan 2016-2019 will largely determine the scope of the evolution of the GDPFS. It will be driven by the need to support the role of NMHSs in their response to global societal needs facing the world population at large. It will not only focus those sectors for which they traditionally have had a leading role to play, mainly in reducing the socio-economic impacts of weather and climate related disasters in their respective countries, but more broadly on contributing to an expanding number of sustainable development issues related to weather, climate, water and related environmental factors. This expansion or broadening of the role of the GDPFS will be made possible by a number of factors, a key one being the seamless and integrated modelling approach, which allows the delivery of new environmental services in support of sustainable development across all timescales.

3. Current state of the GDPFS, what is it, what works, success stories

- Success Stories:
    - i. SWFDP and cascading forecasting process
    - ii. Manual on GDPFS
    - iii. ERA Centres
    - iv. Designation of GDPFS Centres
    - v. LCs for verification
    - vi. LRFMME (link with CCL)
    - vii. ….

4. Role of Members

5. Role of stakeholders and partners (existing and potential)

- Constituent bodies (TCs, RAs, EC)
- GFCS/CSIS
- Humanitarian Agencies
- IAEA/CTBTO
- ICAO
- GEO
- European Commission

6. Areas for improvements

- Interoperability between legacy GDPFS and users/partners
- Services to Humanitarian Agencies
- Limited recognition of capability of GDPFS among some users (eg. Hydrology)
    - i. Hydrology cascade
    - ii. Examples of FFGS, EFAS/GLOFAS organization
- Medium and long range (Sub-seasonal gap in the Manual)
- Global centre for climate monitoring (ocean & atmosphere)
- Lack of global coverage from the cascading process (cascading applied to limited areas)
- Extension to other TCs

  i. Lack of designation criteria for some specialized centres (e.g. Agriculture, Hydrology)

- Sustaining linkage of GDPFS goals to other relevant research bodies like WWRP TIGGE (including TIGGE-LAM) and international initiatives, e.g. IAHS, HEPEX, and other water and environmental research groups (e.g. European JRC)
- Implementation of QM cycle and auditing

7. Communication & outreach strategy

- Aligned with i.e. WIS, WIGOS, GFCS, APFM, IDMP etc.

8. Capacity development & Training

- Aligned with i.e. WIS, WIGOS GFCS, and the WMO strategy for Capacity development etc.

9. Current and foreseeable trends (external drivers of change) – (users driven and technology driven)

- Science
- Earth system modelling
- Internet bandwidth in developing countries
- Technologies (big data, cloud storage and data mining tools, cloud computing, next generation satellite systems, crowdsourcing of everything, the Internet of things)
- Emerging service needs – Downscaling
- Socio-economic trends
- Climate change, environmental changes and global security considerations
- Urbanization (Mega cities), transports, energy, etc.
- Open data
- Private sector
- Demand for accessible data and services (e.g. humanitarian agencies)
- Sendai Framework for DRR
- Cyber security
- Financial constraints

10.Success indicators

- Harmonization of regulatory materials
- Centre designation criteria & responsibilities established
- Inclusion of all WMO domains (Ag, Hydrology, marine, etc.)
- QMS including recurrent review of requirements and users satisfaction in place
- procedures for continuing evolution in place
- Cascading process implemented across all regions
- Key external stakeholders are engaged
- Members have access to sufficient information to support the issue of multi-hazards early warnings
- Engagement with all TCs and RAs

- GDPFS and NMHSs remain recognized authoritative voices
- Contributions to Sendai Framework for DRR

11. Methodology / Principles

- Engagement of TCs, RAs and Programmes
- Clarity of responsibility between WIS, WIGOS and GDPFS
- Evolution of existing system
- Cost neutral
- Don’t break anything
- Non duplication
- Leverage existing system
- Synergy between research and operation
- Clear linkages to strategic plan
- Focus on operational arrangement and coordination
- Consolidation where appropriate
- Simplification and integration
- Regional engagement and empowerment
- Strengthening application activities
- Service oriented
- Customers (NMHSs & International Organizations)

12. Policy considerations required to facilitate, enable the achievement of the vision

- Clarity of the role between WIS/WIGOS and GDPFS
- Open data
- Open source
- Mandates and legal aspects of NMHSs and partners (e.g. flood forecasting and civil protection)
- UN ISDR (e.g. Sendai Framework for DRR)
- Evolving WMO governance to enable our vision
- Role of the private sector and academia
- Training and capacity building
- GDPFS products quality assessment and external independent review
- Issues related to formats, validation, quality control and international standards (e.g. OGC)

13. How do we get there? Required partnerships, role of the private sector in supporting-enabling the vision

- Harmonization of regulatory materials

14. Roadmap, timelines, resources (high level implementation plan)

- CBS (and other sessions of TCs and RAs)
- Consultation with Members
- EC-69 and EC-70

- Cg-18, in 2019
- CBS-17, in 2020
- Cg-19, in 2023
- Cg-20, in 2027

Table 1: Areas of Improvement, benefits and related WMO ERs

Benefits	Areas for Improvements	WMO ERs
GDPFS will enable the wider exploitation and service delivery of science through seamless prediction capabilities, including ensembles, among WMO Members and enhance collaboration with its partner organizations for improved decision-making.	• Interoperability between legacy GDPFS and users/partners • Lack of global coverage from the cascading process (cascading applied to limited areas) • Availability and use of EPS • Limited recognition of capability of GDPFS among some users (eg. Hydrology)	• Improved service quality and service delivery • Reduced disaster risk • Improved data-processing, modelling and forecasting
This will allow access to an expanded set of predictive data and products resulting in wider protection of life and property in a cost effective manner.	• Lack of global coverage from the cascading process (cascading applied to limited areas) • Availability and use of EPS • Medium and long range (Sub-seasonal gap in the Manual) • Global centre for climate monitoring (ocean & atmosphere) • Limited recognition of capability of GDPFS among some users (eg. Hydrology) • Hydrology cascade • FFGS, EFAS/GLOFAS (internal WMO structure) • Services to Humanitarian Agencies	• Improved service quality and service delivery • Reduced disaster risk • Improved data-processing, modelling and forecasting
Protection of life and properties • Accuracy • Timeliness • Improved lead time • Integrated hazards • IBF & RBW • Socio-economic decision making • Relevant to other discipline	• Interoperability between legacy GDPFS and users/partners • Lack of global coverage from the cascading process (cascading applied to limited areas) • Availability and use of EPS • Sustaining linkage of GDPFS goals to other relevant research bodies like WWRP TIGGE (including TIGGE-LAM)	Improved data-processing, modelling and forecasting

	and international initiatives, e.g. IAHS, HEPEX, and other water and environmental research groups (e.g. European JRC). •	
		Improved observations and data exchange
		Advance targeted research
GDPFS will better enable WMO Members' to meet expanding national mandates and achieve higher national visibility. In doing so, WMO Members will be able to better respond to natural hazards, improve environmental monitoring, and adapt to climate change and man-made environmental impacts. In this regard, GDPFS will greatly enhance operational components of WMO Programs, especially in Developing and Least Developed Countries.		Strengthened capacity development
		Strengthened partnerships
Integration will lead to efficiencies and cost savings that can be reinvested to focus on Impacts and Service delivery		Improved efficiency and effectiveness

Gaps or Areas of Responsibilities (from WP)

- Interoperability between legacy GDPFS and users/partners
- Services to Humanitarian Agencies
- Limited recognition of capability of GDPFS among some users (eg. Hydrology)
    i. Hydrology cascade
    ii. EFAS/GLOFAS (internal WMO structure)
- Medium and long range (Sub-seasonal gap in the Manual)
- Global centre for climate monitoring (ocean & atmosphere)
- Lack of global coverage from the cascading process (cascading applied to limited areas)
- Lack of designation criteria for some specialized centres (e.g. Agriculture, Hydrology)
- Availability and use of EPS
- Atmospheric Chemistry
- Sustaining linkage of GDPFS goals to other relevant research bodies like WWRP TIGGE (including TIGGE-LAM) and international HEPEX, and other water and environmental research groups (e.g. European JRC).

Table 2: Areas of Improvement, benefits and related WMO ERs

	Tasks	Priority	Business as Usual (BaU)/ Transformation	Who	Areas for Improvements	Deliverables	Milestones & Timeline	Performance Indicators
1	**Maintaining Services**							
1a	Workshops on Operational Climate Prediction	1	BaU					
1b	Operational Emergency support for Nuclear Emergencies	1	BaU					
1c	Operational Oceanography Services for supporting safety and life in coastal and marine areas	1	BaU	JCOMM	Outreach programme to enhance the national capacity of maritime countries	Definition of a join action GDPFS-JCOMM for defining data management system abd standards		
2	**Enhancement of organizational and users' aspects of existing services**							
2a	To increase the visibility of GDPFS among Members and partners	1	BaU	CBS CCL CHy JCOMM	Increase visibility and recognition of GDPFS	GDPFS leaflet/GDPFS stand in Cancun/SDPFS imperative newsletter/twitter? training/workshops with members clear and understaandable description of NMHSs role in the GDPFS	-	number of subsribtion to newsletter
2b	Rolling review of user requirements	1	BaU					
2c	Rolling review of user requirements - hydrological applications	2	Tr	CHY	Implementation of new application areas to GDPFS / hydrology			
2d	Guidelines on procedures for generating regional seasonal forecasts	2	BaU					
2e	Designation of centres for suppport to Humanitarian Agencies	1	Tr	CBS DRR	Central point of contact for humanitarian agencies	Products for DRR Products for post-event recovery support		Agencies rely on GDPFS advice consistent with National warnings
2f	Partnerships to ensure success of integrated service delivery	2	Tr		Interoperability between legacy GDPFS and users/partners			
3	**Enhancement of technical aspects of existing services**							
3a	Expansion of the cascading forecast process and seamless approach, including broaden it to cover wider range hazards and applications	1	Tr	CBS, CHY, JCOMM	Lack of global coverage from the cascading process (cascading applied to limited areas)	New SWFDP projects Existing projects progress to Ops		Sustainable capacity development in NMHSs Improved Service Quality and Delivery, Improved Data Processing, Modelling and Forecasting, Advanced Research
3b	Delivering improved climate services, including operationalization, and the delivery to users	2	BaU	CCL CBS JCOMM External Partners	Partly represented in the GDPFS (e.g. RCCs) should Chy be included? Following an example of water users forum associated with RCOFs? Implementaiton of Climate Service Delivery	Implementation of CSIS Climate Service Toolkit Coordinated CSIS implementation	CST Workshop CSIS workshop CSIS Implementation	
3c	Support mechanism to help enable to develop processing capabilities	1	BaU	CBS	Take account of new cloud computing opportunities.	· Cloud based solutions · Big data analytics and processing · Open source software	Guidelines in 2017	Sustainability measures of solutions
3d	Implications throughout forecast chain for high-resolution NWP (Guidance on accessing hi-res NWP)	2	BaU	CBS, JCOMM, ...	Improving GDPFS capabilities for enhancing the provision of marine and oceanographic services			
3e	Verification methods for high-resolution models	2	Tr	CBS, JCOMM, ...	Improving support on coastal hazards, forecasting and management	. Comparison of modelling system performance . Multi-modeling nesting approach		
3f	Use of additional observation types for verification	2	Tr	CBS (WIGOS), JCOMM, ...	Improving observations and data quality exchange	Capitalizing JCOMM OPA expertise		Improved observations and data quality exchange
3g	Develop and test new products as well as Ensemble and Transfer Coefficient Matrix (TCM) methods for atmospheric transport and dispersion modelling	1	BaU					
3h	Continue to develop non-nuclear ERA	2	Tr					

	Tasks	Priority	Business as Usual (BaU)/ Transformational	Who	Areas for Improvements	Deliverables	Milestones & Timeline	Performance Indicators
4	**Data Distribution**							
4a	Exchange of EPS products, including:	1	BaU	CBS, JCOMM, ...				
	- Exchange of EPS products for marine users	2	Tr	CBS, JCOMM	Implementation of new application areas to GDPFS /marine			
	- Exchange of EPS products for hydrology users	1	Tr	CBS, CHY	Implementation of new application areas to GDPFS / hydrology	access to ensemble meteo forecasts for NHSs		
4b	Migration from fax to email distribution of RSMC ERA products	1	BaU					
4c	NWP/EPS data accessible and fully integrated in WIS	2	Tr	CBS				
4d	Creation of user interface platform	2	Tr	CBS (WIS)	Seamless interface for users	· Additional responsibilities to GISC · Implementation of institutional mechanism at national levels	·	
5	**Implementation of new Manual**							
5a	Implementation of new Manual of GDPFS	1	BaU					
5b	Designations of new NWP/EPS RSMC centres	1	BaU	CBS				
5c	Implement Quality Management System for GDPFS Centres	2	Tr	CBS CCL CHy JCOMM	Regular audit of Centre compliance with improvements and updated designation		·	
5d	Renew the Guide on GDPFS (WMO-No 305)	3	Tr	CBS	Description of new seamless GDPFS	Completion of the new Guide	·	
6	**Broadening Seamless Scope**							
6a	Integration of activities in other TCs into GDPFS Manual	1	Tr	CHY	Implementation of new application areas to GDPFS / hydrology	designation criteria for hydrological GDPFS centers Designation criteria for centres for aviation support Designation criteria for centres for non-aviation support Designation Criteria for global centre for climate monitoring ocean and atmosphere Designation criteria of centres for air quality Designation criteria for AgMet centres		
6b	Delivering improved Hydrological services as a component of GDPFS	1	Tr	CHy CBS CCL CAS External partners	Implementation of new application areas to GDPFS / hydrology	operational designated regional/global hydrological products available to NMHSs through GDPFS use of global/regional products at national level for enhanced services Guidelines on procedures for generating regional seasonal forecasts of streamflow	·	
6c	Delivering improved Marine services as a component of GDPFS	2	Tr	JCOMM CBS CHy CCL External partners (Copernicus etc.)	Implementation of new application areas to GDPFS / marine	Operational centres supporting Marine services	· Designation criteria for GDPF Centres · Global and Regional centres ·	Improved Service Quality and Delivery, Improved Data Processing, Modelling and Forecasting, Improved observations and data exchange
6d	Delivering improved air-quality services as a component of GDPFS	3	Tr	CBS, CAS	Implementation of new application areas to GDPFS / air quality	New modelling and guidance capabilities for air quality monitoring and prediction		
6e	Delivering improved aviation and non-aviation services as a				Implementation of new application areas to	Transition from products to data	Production of fields of upper air	
6f	Delivering improved climate monitoring services as a component of GDPFS				Implementation of new application areas to GDPFS / climate monitoring			
6g	Delivering improved AgMet services as a component of GDPFS					Establishment of new AG early warning and outlook service for sustainable high resolution in time, space and element Production of essential data for Ag. Models with appropriate high resolution in time, space and element	Global and Regional centres (WAMIS)	

	Tasks	Priority	Business as Usual (BaU)/ Transformational	Who	Areas for Improvements	Deliverables	Milestones & Timeline	Performance Indicators
7	**Pull-Through of new Science**							
7a	Improve transfer of demonstration projects and research into operational services	2	BaU	CBS CAS	Feedback to research from Ops. Developed tools integrated in WIS and		· Sharing of best practices · Role of RAs	
7b	Calibration of model output	2	Tr					
7c	Sub-seasonal forecasting to pull through research	3	Tr	CBS, CCl CAS	Medium and long range (Sub-seasonal gap in the Manual)	Operational centres supporting sub-seasonal timescale	· Designation criteria for GDPF Centres · Completion of S2S project	
7d	To bring IG3IS into operational mode	3	Tr	CBS CAS CCL External partners (GCOS etc.)	Atmospheric Chemistry & Climate change mitigation	Real time observations and analyses of greenhouse gases	· Designation criteria for GDPF Centres · Completion of IG3IS project	
7e	Polar prediction	2	Tr	CBS CAS, CCl, External	Climate Modeling & Predictions		Polar RCC establishment	
7f	impact-based forecasts and risk-based warnings: need for products, interpretation, communication, including for land transportation and megacities	2	Tr	JCOMM	Global-to-coastal ocean modeling		Decision support systems for coastal and marine hazards	
8	**Supporting Applications**							
8a	NWP/EPS data to support aviation applications in WIS	3	Tr	CBS CAeM WAFCs	Transition from products to data driven services	Fields of upper air aviation products in WIS		
8b	Guidance products for radioactive clouds for aviation	2	Tr	CBS CAeM				
9	**Policy**							
9a	Address the policy issues associated with private sectors and academia	2	Tr	CBS CAS CHy CCL JCOMM	The role of private sector is undefined within the GDPFS		· Designation criteria	NMHSs retain single authotitative voice
10	**Miscellaneous**							

Annex V

REVISIVION TO CBS-16/DOC. 5.6(1), DRAFT DECISION 5.6(1)/1 (CBS-16)

IMPLEMENTATION PLAN ~~FOR~~OF THE FUTURE SEAMLESS GDPFS

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(a) Resolution 11 (Cg-17) – *Towards a future enhanced integrated and seamless WMO Data-processing and Forecasting System*,

(b) Decision 8.1/1 (EC-68) – *Towards implementation of seamless Data-processing and Forecasting System*,

Noting with satisfaction that the work to advance this initiative had been initiated at an expert meeting held in Geneva, in February 2016, which was attended by representatives of technical commissions, who had developed the draft vision, scope and white paper,

Noting further the development of a draft GDPFS Imperative, which includes the white paper in annex, and the draft implementation plan by the Steering Group of the seamless GDPFS, who met in Geneva, November 2016,

Acknowledging that Decision 8.1/1 (EC-68) endorsed the vision for the Seamless Data-processing and Forecasting System, as provided in the Annex, and requested ~~CBS~~ Steering Group to complete the implementation plan for the process, for consideration by EC-69,

Mindful of the deadline for the submission of the implementation plan to EC-69,

Decides:

(1) To speed up the process by using the results of the first and second meetings on the seamless GDPFS (Geneva, Switzerland, February and November 2016, respectively);

~~(2) That the membership of the Steering Group for the seamless GDPFS be composed of the same representatives of the technical commission at the February 2016 meeting;~~

(3) That the Steering group first order of priority is the completion of the white paper and the development of the implementation plan for tabling at EC-69;

Urges technical commissions and regional associations to provide their full support in addressing Resolution 11 (Cg-17);

Urges further the Secretary-General to provide full support for the realization of this initiative;

Calls upon advanced GDPFS centres to assist the Steering Group with assessment of proof of concept of seamless GDPFS.
