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WMO FLOOD FORECASTING INITIATIVE

REPORT ON THE TECHNICAL CONFERENCE ON IMPROVED METEOROLOGICAL AND HYDROLOGICAL FORECASTING

Geneva, Switzerland, 20-23 November 2006

OPENING SESSION

The Synthesis Conference of the WMO Flood Forecasting Initiative was held at the WMO Headquarters in Geneva, Switzerland from 20-23 November 2006. It was attended by 28 participants from the National Meteorological and Hydrological Services (NMHSs) of 22 Member Countries and 4 Participants from regional and other, water and weather related agencies. The list of attendees is provided in Annex 1.

2. The meeting was opened by the Secretary-General of WMO, Mr Michael Jarraud. Mr Jarraud stated that the WMO had launched the Flood Forecasting Initiative in 2003. He indicated that, up to now, the major activities within the scope of this initiative had included an overall analysis of the weaknesses and strengths of current flood forecasting systems and the organization of a series of regional workshops. The objective of these workshops had been to further improve the capacity of NMHSs to deliver timely and more accurate flood forecasting products and services through the enhanced cooperation between National Meteorological Services and National Hydrological Services. Likewise, capacity building activities, in collaboration with disaster managers have been performed through these workshops.

3. Mr Jarraud stressed that improved cooperation between National Meteorological and Hydrological Services on national, regional and global levels is a core interest of WMO. Foremost, it serves to improve forecasting and warning services to enable responsible authorities to take preventive actions against the impacts of extreme hydrometeorological events and to prevent disasters.

4. The President of the WMO Commission for Hydrology (CHy), Mr Bruce Stewart undertook the duties of Chair of the Conference and welcomed the participants. Mr Stewart thanked the WMO Secretariat for initiating and supporting the Flood Forecasting Initiative and pledged the support of the Commission in advancing the recommendations to flow from the Conference.

5. The WMO Secretariat, through Mr Wolfgang Grabs, provided a presentation on “The Status of Early Warning and Forecasting in National Meteorological and Hydrological Services”. Mr Grabs noted that the principal benefits to be gained from improved cooperation between meteorological and hydrological services are improved accuracy and timeliness of forecasts, extended warning times and the development of a framework for integrated, multi-hazard forecasting capabilities.

6. In his presentation, Mr Grabs highlighted the status of flood forecasting in member countries of WMO. Based on the experience of 86 countries that had participated in the six regional workshops that had been organized as part of the WMO Flood Initiative it was recognized that: Almost 50% of all countries have no or insufficient flood forecasting capabilities, most of the other countries provide basic/intermediate flood forecasting services with some countries providing advanced services. In this respect, most European countries have fully advanced, high quality forecasting products, while most African countries lack flood forecasting systems. In the other regions and in Asia in particular, a large diversity between high quality products and basic or non-existent services can be observed. Only 33% of countries have institutional cooperation agreements for flood forecasting and warning when more than one agency is involved in providing these services. However, 70% of the countries use meteorological information for flood forecasting purposes and another 33% of the countries undertake activities to improve/modernise national flood forecasting services. Despite these recognized deficiencies it can be stated from evidence, that the observed losses of lives and livelihoods would be manifold larger without the dedicated forecasting services of hydrological and meteorological services worldwide. Common needs observed in all regions and across the NMHSs include:

- On-going efforts to upgrade existing data collection and transmission systems;
- Improved data management and modelling systems;
- Encouraging data exchange in particular meteorological data as input for flood forecasting models;
- Promotion of dialogue between meteorological and hydrological communities;
- Improved institutional cooperation; and,
- Enhancement of technical capabilities (technical and institutional capacity building).

7. The draft strategy and action plan for the improved cooperation between NMSs and NHSs provides a blueprint to overcome these deficiencies in a pragmatic way.

8. The meeting adopted its Agenda (Annex 2). This report of the meeting follows the structure of the agenda. Full PowerPoint presentations from the Conference are provided on the CD delivered together with this report and can be also accessed through the following web-page together with this Report and the Strategy and Action Plan.

SESSION 1 WMO FLOOD FORECASTING INITIATIVE: PROCESSES AND OUTPUTS

9. The WMO Secretariat, through Mr Wolfgang Grabs made a presentation on “The WMO Flood Forecasting Initiative: Purpose and Objectives”. The overall objective of the WMO Flood Forecasting Initiative is to:

Improve the capacity of meteorological and hydrological services to <u>jointly</u> deliver timely and accurate flood forecasting & warning products and services.

10. Therefore, this Conference aimed to synthesize technical know-how and expertise and requirements for improved cooperation between hydrological and meteorological services and to agree on a Strategy and Action Plan to implement recommendations on national, regional and global levels. The principal mid-term expected results of the WMO Flood Forecasting Initiative are the generation of improved quantitative and qualitative weather forecasting products that are available in such a way that these can be directly used for flood forecasting; the availability of medium-range weather forecasting and climate prediction tools that can be applied to extend

warning times and produce pre-warning information. Furthermore, it is expected that NMHSs will have improved their capacity to cooperate in delivering timely and accurate flood forecasting information. In order to reach the user groups, decision-makers and the general public, it is also envisaged that integrated weather, climate and hydrological forecasting information is available in a relevant format for use by civil organizations responsible for disaster preparedness and mitigation.

11. Major elements that need to be recognized in this process are the diversity of the development status of NMHSs worldwide, the user expectations from hydrological forecasting systems as forecasting services need to be user-driven and the state of the art of methods of observations, network configuration, capabilities of meteorological and hydrological forecasting models and the actual state of observations, data management, data sharing mechanisms and the use of models especially in the developing world.

12. Following this presentation, there was discussion on the major outcomes from the regional expert meetings. During this discussion, the following issues were raised:

- In many countries, the existing institutional arrangements, operational customs and procedures and capabilities hinder cooperation between NMSs and NHSs. For example, the agencies work on diverse temporal and spatial scales, often from different agencies located in different parts of the country. The outputs/inputs from the various agencies are not necessarily correctly aligned and the staffs often come from different educational and training backgrounds.
- The status of development of the services also varies considerably from country to country depending on the issues of relevance to each country and the positioning of the agency within the government and/or private sector. The sources and levels of funding are therefore also highly variable.
- The focus for each agency also varies depending on the needs of the country and the legislation under which they operate.
- The provision of flood forecasting services needs to be user driven, but supported by sound science and able to be operated within the prevailing environment. It is therefore essential to identify who the products are for, for example, emergency services, water resource managers, academics, policy makers and to identify their needs and strive to meet these where feasible. In this regard countries will have varying needs for flood forecasting services depending on amongst other factors, their geography, weather, population distribution, etc.
- It is essential that both meteorologists and hydrologists understand and communicate their strengths and weaknesses, including the capabilities and limitations of their various monitoring systems, models and forecasting systems. This requires strong communication skills.
- One of the key issues that must be addressed by NMSs and NHSs is that of connections between their models. This can be through alignment of outputs/inputs, coupled models and other statistical and/or downscaling techniques. An emerging need is for skills and expertise in hydrometeorology.
- One additional requirement is that related to the validation/verification of the outputs of the modelling activities and the expression of uncertainty of the outputs.
- NMSs and NMSs often use different data formats and data collection standards and have different access regimes to their data. Close cooperation is essential to address issues of data sharing and exchange.

13. The discussions also raised a number of possible initiatives that would assist in cooperation and collaboration between NMSs and NHSs, including:

- Using opportunities for the free interchange of ideas in support of strengthened cooperation. It is essential that we learn from each other.
- Ensuring that a multidisciplinary, multisectoral, multinational approach is adopted by involving all of the stakeholders.
- Where they are available, or can be developed, integrated solutions involving all inputs (meteorological and hydrological) should be adopted.
- Pilot projects are one way of focussing actions and providing operational examples of what can be achieved on the ground.
- NHSs and NMSs must develop techniques and processes that enable them to understand the needs of the users and their associated expectations.
- Agreement on roles and responsibilities of each of the agencies involved in the provision of flood forecasting and warning services is essential.
- NMSs and NHSs must be encouraged to share data, work together in setting standards for measuring, storing, disseminating and exchanging data (The interoperability of observing networks and data management is a pre-requisite in this respect.).
- Modelling advances should evolve in a cooperative and collaborative manner, with due consideration to each others capabilities and limitations.
- Training and capacity building is an essential requirement for improved flood forecasting services and provision of an integrated service.

14. During the discussion, a number pf positive statements were made, including:

- The current global, regional and national interest in disaster mitigation can be used as a catalyst to support recommendations that flow from the initiative.
- Both NMSs and NHSs recognise the potential benefits of closer collaboration and cooperation.
- The signs are there that the technology and capabilities are there in some instances to technically improve cooperation, but much more work is required to gain maximum benefits.
- Modelling capabilities are increasing at a rapid rate.
- It has already been demonstrated that regional approaches to improved cooperation can work.

15. The participants then discussed and identified the main focus areas to improve cooperation between meteorological and hydrological services for forecasting purposes. A survey of participants identified the list of focus areas below.

Institutional:

- Policy for flood forecasting – roles/responsibilities
- Legal Framework;
- Regional level cooperation;

Data/Information:

- Data/information/knowledge sharing/exchange/access;
- Data needs/requirements – spatial/temporal;
- Network design;

Modelling – Meteorology:

- Improved meteorological forecasting (QPF);
- Improved access to forecast products;
- Validation of forecasts;
- Information on uncertainties;
- Interpretation of radar data;

Modelling – Joint Meteorological/Hydrological:

- Integration of forecast models;
- Extend multi-model forecasting experiments from met to hydro models;

Modelling – Hydrological

- New methods/techniques for hydrological forecasting;
- Flash flood forecasting models;
- Urban flooding;

Dissemination:

- Awareness raising;
- Communication;

Benefits:

- Socio-economic value of joint meteorological/hydrological forecasts;

Capacity Building:

- Education and understanding of capabilities and value/benefits of working together;
- Joint training initiatives;
- Equipment and modelling training and capacity building;
- Team building - trust;

Tool development:

- Decision support systems.

16. During further discussion on this item, the importance of flood forecasting as a component of Integrated Water Resources Management was stressed. The value of the development of risk-based systems to address flood forecasting processes and applications was strongly supported, noting however that many services are at different levels of capability.

SESSION 2 FOOT PRINTS OF COLLABORATION: Experiences of Current Practices

17. During this session, three presentations were made on three current flood forecasting case studies showing different levels of capability and cooperation. The session served to demonstrate various states of development of hydrological services and different levels and mechanisms of cooperation with meteorological services. The following discussions highlighted various aspects of delivery of products and services for flood forecasting recasting purposes. The paragraphs below summarize some aspects of the presentations; details are provided in the full presentations on the CD delivered together with this report.

Mozambique (M. Mustafa)

18. In Mozambique, INAM and DNA are members of Disaster Management Council at National Disaster Management Institute (INGC) and they are responsible for the warning system and alerts section. The cooperation between the INAM and DNA is based on exchange of meteorological information, data and research. INAM is doing research on validation of satellite based rainfall estimates over the Limpopo River Basin and the result of the study will benefit the two services by improving rainfall forecasting and flood forecasting.

19. At the regional level, the South Africa Weather Service (SAWS) and Water Research Commission under the Spatial Interpolation and Mapping of Rainfall (SIMAR) project, developed a model that integrate rainfall data from radar, satellite and rain gauges.

20. SAWS is developing a model for quantitative precipitation forecast (QPF). This project is being carried out in collaboration with the International Precipitation Working Group (IPWG). The result of the project will be integrated in the regional flood warning system. The five-year plan includes the establishment of regional flood warning systems with neighbouring countries and the development of modern system to monitor the river catchments and increase the hydrological network by implementing the second phase of SADC HYCOS project.

21. Expansion of flood forecasting systems into other river basins including the installation of modern equipment including telemetry and rainfall radars. Improved modelling using quantitative rainfall forecasting, enhancing technical capacity of staff are amongst the challenges in the near future to match the country's demand for efficient flood forecasting systems.

Viet Nam (D.N. Tinh)

22. The National Hydro-Meteorological Service of Viet Nam is a combined service with close collaboration in flood forecasting. Flood forecasting is carried by the National Centre for Hydrometeorological Forecasting (NCHMF) at the central, regional and provincial level in all major river basins. Empirical models are used and increasingly conceptual models and, as a new development, hydraulic models that also use rainfall forecasting inputs from NWP. Besides the data from hydrological stations, meteorological data and information from synoptic, meteorological stations and rain gauges are transmitted directly to NCHMF for common use. All near-real time observed meteorological and hydrological data are archived in an operational database at the NCHMF server that permits direct access for all forecasting divisions. Meteorological divisions make special rainfall forecasts for hydrological forecasting as inputs to hydrological forecasting models/schemes. Other meteorological data as satellite images, radar images, storm tract, synoptic map, etc. also are available for forecasters-hydrologists. In storm and flood situations, hydrologists can get additional consultation/guidance from meteorologists about forecasted weather conditions above forecasted river basins or regions.

23. There is also close cooperation between meteorological and hydrological services. In operational work, meteorologists provide special rainfall forecasts required by hydrologists for each river basin as main input for their forecasting models/schemes. Meteorologists receive feedback from hydrologists on their weather forecasts accuracy for adjustment. In flood situations, a joint forecasting discussion is organized to clarify or emphasize the forecasted weather phenomena. Results of rainfall forecasting by HRM are used in operational hydrological work. The use of NWP for flood forecasting purposes is still mostly at an experimental stage but with the objective of using these techniques operationally as soon as the have been proven to be reliable.

24. There are many development opportunities; the mid-term challenges are to improve network and modelling practices as well as technical capabilities to allow the establishment of a functional decision-support system. A particular challenge is the improvement of flash flood forecasting and warning services.

France (C. Wittwer, Mizzi)

25. Traditionally, the National Meteorological Service of France and the national Hydrological Service have been responsible for the provision of adequate flood forecasting services through cooperation. However, to improve information, communication and warning services and with a view to provide improved flood forecasting services including flash floods and an extended warning lead-time, a new institution, the national Hydrometeorological Flood Forecasting Centre, was created. Experienced staff from the meteorological and hydrological services is seconded to the Centre. Hydrological observations as well as rainfall observations - by improving the national radar network – are being upgraded and unified to consolidate real-time availability of crucial data and information at the national scale. Since July 2006, a web-based flood vigilance system is on-line that allows the public access to real-time gauge station data and warning/alert information. The provision of warnings and alerts is not only based on model results and automatic analysis procedures but is essentially backed up intense consultation mechanisms at central, regional and provincial levels using the local expertise of forecasters.

26. An important lesson is that a strong legal and regulatory framework improves efficiency and effectiveness of forecasting services. Challenges for the mid-term future include works towards a common Decision Support System; providing tools and cooperative mechanisms between meteorologists, hydrologists and civil defence authorities to arrive ultimately at a unified hydrometeorological vigilance procedure.

27. Additional presentations were also made by the representatives from China and Thailand. These are summarized below:

China (C. Sun)

28. According to the flood prevention law of China, NMS and NHS are both members of the Flood Prevention & Drought Relief Headquarters: NMS is responsible for meteorological information and prediction; the NHS is responsible for hydrological information and forecasting.

29. Major achievements have been the establishment of the cooperation and coordination mechanisms; sharing and integration of the information from NMS and NHS and the use of QPF/QPE for flood forecasting. Aside from flood forecasting for riverine floods, the Bureau of Hydrology and the China Meteorological Administration focus on flash floods as flash floods are responsible for over 70% of loss of lives as a result of floods. In addition to the necessity to improve now-casting and also to further improve the telemetry and communication system, the major challenge is the acquisition of Quantitative Precipitation Forecasts to effectively improve flash flood forecasting services throughout the country.

30. The main requirements in the near future are: To obtain more accurate QPF from CMA and others; to establish a QPF base and integrate it with the flood forecasting system and research on coupling of meteorological and hydrological models to improve flood forecasting and in particular flash flood forecasting.

Thailand (S. Insawang)

31. In Thailand, five major agencies are historically concerned with flood forecasting for various purposes and sectors, the Thai Meteorological Service provides hydrological forecasting by directly using own weather forecasting and prediction capabilities coupled with a national hydrometric network and forecasting procedures. Coordination between major water-related agencies is sought through the National Water Council, mainly for planning purposes. Flood forecasting services directly use NWP products and quantitative precipitation estimation from satellites as well as the radar system in Thailand. The exchange of data is facilitated through an internet protocol and by using the GTS of WMO. Major challenges are the coordination of networks and exchange of early warning information. A particular challenge is the improvement of flash flood forecasting which requires further improvements of NWP-derived QPF information as well as assimilation of precipitation information from multiple observation platforms including satellites.

SESSION 3 PROJECTED PATHWAYS FOR FUTURE COLLABORATION: Improving Meteorological and Hydrological Forecasting Practices

32. The Conference discussed the main focus areas for collaboration (see para 15) and agreed that having defined and agreed responsibilities was a key requirement for future collaboration. Also, it was agreed that sharing of data, in particular rainfall data and the integration of this information was a catalyst for future collaboration, particularly when related to the needs for disaster mitigation. There was further discussion on the requirement for training and capacity building in the area of Quantitative Precipitation Forecasts (QPF), particularly with respect to magnitude and uncertainty.

33. The Strategy and Action Plan for the Enhancement of Cooperation between NMHSs for improved Flood Forecasting was introduced by the Chairman via a short presentation which covered the background to its development and the need for the group to consider it in greater detail during the conference. The key areas for cooperation identified in the Strategy document closely reflected those identified during the discussions at the conference. It was noted that the Strategy and its associated Action Plan was a “live” document that would evolve over time. The areas in the proposed strategy are:

- Strengthening of observing and information systems;
- Data exchange at national, regional and international levels;
- Improvement of meteorological forecasting practices and products;
- Improvement of hydrological forecasting practices and products;
- Strengthening of institutional coordination, cooperation and integration between NMSs and NHSs;
- Strengthening of cooperation and coordination between countries on issued related to Flood Forecasting;
- Promoting Training and capacity building in NMHSs;
- Strengthening of institutional coordination, cooperation and integration between NMSs and NHSs;
- Strengthening of cooperation and coordination between countries on issued related to Flood Forecasting;
- Promoting Training and capacity building in NMHSs;
- Formulation of technical documentation and guidelines related to flood forecasting;
- Supporting disaster management;
- Addressing climate variability and change; and,

- Demonstrating the value of meteorological and hydrological data, information and products.

34. The Strategy included text in boxes which outlined specific actions to be taken under these areas of focus. The conference was requested to devote as much time as possible to reviewing and revising the actions contained therein.

35. During the discussions, the potential benefits of regional networks, twinning arrangements between countries and demonstration projects (pilot projects) were identified as possible pathways for future collaboration.

SESSION 4 WHAT THE USERS NEED:
Expectations from Hydrological Forecasting Systems

36. The group held a general discussion on the identification of the various users of flood forecasts and their potential needs. The user groups identified included:

- Emergency managers (civil defence);
- Water resources managers;
- Water storage operators;
- Navigation agencies;
- Hydro-power agencies;
- Power futures markets;
- Agricultural groups;
- Farmers;
- General public;
- Tourism;
- Road authorities;
- Environmental groups;
- Recreational groups;
- Insurance and reinsurance groups;
- Commodities markets (futures);
- Health services; and,
- Commercial institutions (supplies, building equipment).

37. It was noted that the requirements of users included flood risk mapping, the forecast of the peak flood level, the timing of the peak, the full flood hydrograph (giving timing to specific key stage levels), the falling limb, possible future rainfall and/or river height increases, and inundation areas (including time and depth of inundation). It was agreed that as more data and information was available, the needs of the users would evolve and become more sophisticated. It was also stated that the interests of the users can sometimes be in conflict.

38. The importance of a single authoritative source of a warning/forecast was stressed, but it was suggested that once there were commercial aspects, then other possible sources of forecasts become likely. Faith and belief in the forecast were seen as key requirements.

39. A representative from the WMO/UNESCO Joint Commission on Marine Meteorology (JCOMM) noted the importance of flood forecasts to estuarine issues, sea level rise, tsunamis, storm surges etc.

40. There was considerable discussion on the presentation of flood information, including categories of risk, specific flood levels, and a bandwidth of reliability and use of colours/numbers to express severity. It was noted that many decision makers wanted definitive estimates, not probabilistic estimates. However one needed to be careful if there was an inferred sense of certainty.

41. It was stated that hydropower production companies are important users of flood forecast, because they make important investment decisions that can have multiple purposes, not only for increased hydropower production but also for civil protection actions.

SESSION 5 WHAT CAN THE MODELS CURRENTLY PROVIDE: State of the Art Meteorological and Hydrological Forecasting Models

42. This session comprised presentations by Mr Ken Mylne on State-of-the-art Meteorological Forecasting Models in use by NMSs including now-casting, use of NWP and ensemble prediction and Mr Paulo Reggiani on Hydrological Forecasting Models in use.

43. Mr Mylne's presentation showed aspects of the time and length scales of the various meteorological forecasting models, an introduction to NWP model scales, nowcasting, convective-scale NWP, ensembles and modelling difficulties in Tropical regions.

44. Mr Mylne indicated that the different weather modelling systems should be used for different time and length scales, for example:

- Nowcasting 1-3h – local detail – Flash Floods
- Convective-scale NWP 3-~24h – local detail – Flash Floods
- Regional NWP 12-48h – sub-synoptic detail – Medium river catchments
- Global NWP 3-15 days – Synoptic evolution – Large river catchments

45. He stated that ensemble forecasting is now a mature tool for global medium-range forecasting and provided valuable additional information, including information associated with uncertainty and risks. Ensembles are a new development in the short-range and now-casting and are planned for introduction at the convective scale (~2009). He also noted the extra difficulties of unresolved scales in modelling of the Tropics.

46. Mr Reggiani's presentation addressed components of flood forecasting as a part of the operational process – monitoring, forecasting, prediction and warning and response. The aim of flood forecasting being to increase lead time. By gaining time for mitigating action through increasing forecast lead time, the population can be warned ahead of time and evacuated.

47. Mr Reggiani promoted a data-centered approach to flood forecasting which has the following advantages:

- data centered versus model centred and therefore being;
- model-independent;
- open system;
- enhances adaptability;
- no re-training of the organisation;
- user interface does not change; and,
- flexible model integration platform.

48. Mr Reggiani provided examples of a wide range of flood forecasting applications. In conclusion, he noted the inherent complexity of using different data sources in flood forecasting in a rapidly changing world and the benefits and challenges of interfacing different models (weather, hydrologic, hydraulic models). He provided examples of the hydrological and hydraulic models used at NHSs and the benefits of data transmission in real time. In his case study examples, he highlighted the uncertainty and the need for an adequate quantification in the flood forecasting process. One of the case study examples presented was for the Po River in Italy.

49. These presentations were followed by a discussion on the possible benefits of coupled meteorological and hydrological models. Issues that were raised during the discussion included:

- The different scales (temporal and spatial) of the two areas of modelling and difficulties of taking the outputs from the meteorological models into the hydrological models.
- The fact that every river basin/catchment is different and that this didn't bode well for coupled modelling (earth surface, soil moisture, vegetation, etc.).
- The possible benefit of developing a hierarchical approach to modelling, starting with large sized catchments and moving down towards smaller (flash flood) areas.
- Concerns were also expressed in regard to the continuous updating and improvement of the meteorological models which then required new calibration and updating of hydrological models, to allow for changed inputs.
- There was considerable technical discussion on topics such as multi-model platforms, subjective estimation of rainfall inputs, model bias, historical simulations and training requirements.
- Meteorological models still have problems in forecasting precipitation in terms of both amount and location. Rainfall forecasts are average depths across a full grid element. Downscaling procedures are required and need further development.
- Concern was expressed over the possible implications of failure of monitoring sites and the impacts this may have on the model and the forecast.
- Participants gave examples of both successful coupling of models in specific instances, but also the failure of such approach in other areas, for example flat areas versus mountainous areas.
- Combining meteorological and hydrological models can provide increased lead time for forecasts and warnings.

50. It was proposed that hydrological models coupled with meteorological ensemble prediction systems can be a good approach but they have a characteristic which may not be useful; their results are of probabilistic nature and the users, mainly the decision makers, want deterministic results. Hydrologists and meteorologists should inform the public about the uncertainties of models and forecast and initiate some kind of activity aimed to teach the users about the requirements of working with probabilistic results.

51. It was further proposed that in operational hydrology the following phases should be considered: (a) analysis of recent past information, and (b) making the forecast. The first phase is used to find the answer to the questions about what is happening and what has recently happened. Information/knowledge management of historical data is essential.

52. A further issue is the propagation of uncertainties. First, there are uncertainties associated to the past and current time (time of forecast), and secondly there are uncertainties associated with the forecasted precipitation using numerical weather prediction models.

53. The temporal ranges in hydrology may be associated mainly with the size and also with other characteristics of the specific basin (that vary across space), like the slope, which influence the response time to precipitation. The minimum lead time can be imposed by practical reasons, for example, the time needed for evacuation of people by civil protection services. The response time of river basins varies a lot, so the temporal distribution of the accuracy of the predicted precipitation is important.

54. The hydrological system allow also the isolation of a subsystem in which the influence of the uncertainties associated to the precipitation (past an future) has low influence, in comparison with the main inputs of the subsystem expressed by hydrographs in term of flows. The criteria for the isolation are the response time of the system and the required lead-time for applications.

SESSION 6 WHAT THE MODELS NEED AND HOW WE GET IT: Data and Information Requirements for Improved Forecasting Services

55. Mr Jack Hayes from the WMO Secretariat made a presentation on "How can the WMO Information System (WIS) meet the needs of forecasting and prediction services".

56. Mr Hayes's presentation provided information on what the WMO Information System (WIS) is, why it is being developed and what services it will provide. He also addressed the topics of what the NMHS will gain from WIS, the overall plan for WIS, its implementation progress and what the major challenges will be.

57. WMO Congress requested the development of an over-arching approach for solving data management problems for all WMO and related international programmes and recommended a single, coordinated global infrastructure, the WMO Information System (WIS) for the collection and sharing of information.

58. The WIS is based on an integrated approach for all WMO Programmes and includes:

- Routine collection and dissemination of time-critical and operation-critical data and products:
  - Real-time "push" through dedicated telecommunication
- Data Discovery, Access and Retrieval service:
  - "Pull" through the Internet (HTTP, FTP and other platforms)
- Timely delivery of data and products:
  - Delayed mode "push" through dedicated telecommunication means and public data networks, especially the Internet
- Unified procedures
  - More efficient data exchange
- Coordinated and standardized metadata
  - Interoperability between programmes
  - Improved data management
  - ISO 191xxx series for geographic information

59. A general discussion on data and information requirements for improved flood forecasting services and inter-operability of observational networks and observation systems, including terrestrial and space-based systems followed. Topics discussed included evolving technology and how it is accommodated in WIS, the benefits of improved communication capabilities and the need for cooperation at all levels. A special issue was the necessity to fully integrate NHSs in the development and operation of WIS.

60. One aspect of data collection that received considerable discussion was that of automation of observing sites. Comments made included:

- Some times accuracy of observations was lost, but increased numbers (temporal distributions) made up for this;
- Costs of maintenance and communications for automated sites are often underestimated and not catered for in Technical Assistance projects;
- A balance of automation and manual observations need to be established;
- Training in equipment installation and maintenance was essential; and
- Automation was good, but needed to be managed and all costs accounted for.

61. When questioned about what benefits their were to hydrologists to be involved in data exchange, reference was made to future development of earth simulations systems and that hydrological data was an important element of environmental data sets. A further benefit was improved/increased access to meteorological products such as NWP outputs.

62. It was observed that the Strategy and Action Plan contained insufficient actions in regard to the importance of and requirements for metadata. Proposals were made for additional actions.

63. It was stated that: "Early warning systems are the key to effective risk reduction". They do save lives and livelihoods (and) in the world we live in, with so much division between rich and poor, they also save an enormous amount of investments of the donor countries that will be called upon to help when people die from such disasters. It is now commonly accepted that the most effective early warning takes more than scientifically advanced monitoring systems. All the sophisticated technology need to aim at reaching communities and people. Satellites, buoys, data networks will contribute to improved forecasting and risk reduction, but it needs to be recognized that this requires substantial investment in training, institution building, and raising awareness on the ground. Participants emphasized that if we want effective global early warning systems, we must work together, government to government, federal and local officials, scientists with policy makers, legislators with teachers and community leaders. – This excerpt from the United Nations Special Envoy for Tsunami Recovery, President William J. Clinton's statement at EWC III, on 27 March 2006 was read out and fully supported in the meeting.

64. Participants called for ways have to convince the decision makers of donor countries to include assistance, training and maintenance of NMHS networks.

SESSION 7 WHAT THE FUTURE HOLDS:
Potential and Future Use of Meteorological Forecasting Products in Flood Forecasting

65. Mr David Richardson made a presentation on "Medium range weather forecasting for improved early warning and hydrological forecasting". Mr Richardson described the current ECMWF modelling activities, including the global atmosphere forecasts and ocean wave forecasts (Run twice daily to 10 days, EPS system soon to be extended to 15 days); monthly forecasts (atmosphere-ocean coupled model, run weekly, every Thursday, to 31 days); and seasonal forecasts (atmosphere-ocean coupled model, run monthly, every 15th, to six months).

66. Mr Richardson stated that meteorological forecasts must be used at appropriate temporal and spatial scales and that medium-range forecasts may give good predictions of synoptic events, but not local details. It was therefore necessary to consider looking at time/area averaging or

downscaling – nested regional NWP or statistical methods. He noted that longer-range forecasts provide information on broader scales; statistics of weather for coming month or season. In using the outputs of the various models, it was important to take account of uncertainty and ensemble prediction could be used for this. He stated that there was an issue associated with model error (present predictions relative to model climate was one method of attempting to deal with this error). He concluded by stating that NWP can provide useful information if used appropriately and that on-going research into meteorology and hydrology should bring significant benefits to end users.

67. It was noted that a new web page has been created as a single entry point for all ECMWF services to WMO members:

www.ecmwf.int/about/wmo_nmhs_access/index.html

68. Following this presentation, a discussion on the future potential of national, regional and global weather forecasting products for use in hydrological forecasting and the development of integrated weather, climate and hydrological forecasting information/products was held. Points raised included:

- The limitations of the current models in tropical areas were noted.
- The potential benefits of NWP output include the provision of additional lead warning time and awareness raising of possible severe weather events. NWP modelling and forecasting of tropical cyclones also provide an opportunity to further develop improved flood forecasting and warning services.
- The importance/benefits of providing ready access to the ECMWF products to both NMSs and NHSs.
- The need to centralize the global modelling capabilities in order to gain maximum benefits from scientific advances, computer capability expansions and critical mass of expertise. However, centralization of operations at higher levels, makes better communication systems a necessity to ensure that the messages get across and are understood.

SESSION 8 HOW DO WE GET THERE (1): Capacity Building and Organizational Issues

69. A general discussion was held on capacity building in NMHSs to make use of weather forecasting for hydrological forecasting and institutional and organizational issues to foster cooperation between meteorological and hydrological services.

70. Experience following the Valencia meeting (As one of the regional meetings held during the Flood Forecasting Initiative) has shown the benefits of a regional network of experts in aiding capacity building. The regional network had organized meetings and workshops for hydrologists and meteorologists from the region and also professionals working in all aspects of the disaster mitigation area from the host country. It was noted that with additional support, the network could do more. It was also suggested that where possible, use be made of existing in region networks, such as the RA WGsH.

71. It was noted that training should focus on improving the communication between meteorologists and hydrologists, enabling them to exchange experience, knowledge and information on equal terms and in a common and consistent manner.

72. Different training approaches should be used, including distance learning, e-Learning, train-the-trainer, etc., as appropriate. Joint training initiative should be encouraged.

73. It was proposed that the areas of capacity building that could assist in improving flood forecasting capabilities include:

- Documentation/guidelines;
- Public education material; and
- Pilot projects (for example, the severe weather project in southern Africa).

74. Training should be focused around the pilot project which would provide on the group, practical experience and examples. Training should also be targeted at the level of service capable of being provided and also at improving this capability in a step wise manner. That is, different levels of training with different amounts of overlap between meteorologists and hydrologists, targeted to meet the needs of the country.

75. Training activities should also be designed to strengthen the local training capabilities. Young scientists should be a particular target group for training initiatives if changes in culture are to be achieved.

SESSION 9 HOW DO WE GET THERE (2): Strategy for Better Hydrological and Flood Forecasting

76. The Conference broke into three groups to discuss the proposed Strategy and Action Plan document. Based on these discussions, the proposed Strategy and Action Plan was amended and the final document is provided as attachment to this report.

77. Ms Maryam Golnaraghi (WMO Secretariat) made a presentation on behalf of Mr R. Dombrowsky (USA) on “Integration of early warning and forecasting services in multi-hazard disaster preparedness and mitigation programmes”. Ms Golnaraghi stressed the need to involve the users in the development of flood forecasting systems, the importance of an all-hazards approach and the benefits of end-to-end systems.

78. It was noted that the concept of an all hazards approach to disaster management comes from the emergency management community. The theory is that “all-hazards” planning can provide a basic framework for responding to a wide variety of disasters. All-hazards planning has the virtue of being cost effective in terms of time and money. It is cheaper to develop and easier to remember a single plan even if it has a number of annexes.

79. Demonstration projects at the national level are required to show benefits of multi-agency multi-disciplinary collaboration and coordination. Development of technical guidelines for improved multi-disciplinary methodologies for monitoring, forecasting and warnings would greatly assist the improved development of flood forecasting services. Further work is required to develop mechanisms for sharing of good practices among Members.

80. The points raised in the discussion of this presentation included:

- Agreement to include discussions with all stakeholders, including users, but also the need for strong leadership (including listening to the needs/ideas of all stakeholders) from the NMHSs in progressing improvements to flood forecasting systems.

- The benefits of cooperation between meteorological and hydrological services to meet the needs of disaster managers and the identification of good case studies showing these benefits (for example, the French Vigilance system).

SESSION 10 HOW DO WE GET THERE (3): Strategy for Better Hydrological and Flood Forecasting

81. The Chairs and Co-chairs of the three working groups reported on their deliberations in Plenary and the ensuing discussions resulted in the recognition of the amendments needed in the proposed Strategy document.

82. The Conference gave its support to the recommendations and actions contained in the Strategy and Action Plan as documented in the attachment to the report. The Secretariat agreed to provide a copy of the revised final draft for final endorsement by the Conference participants within two weeks. It was noted that a quick turn around was essential if the document were to be ready for presentation to WMO Congress in May 2007.

SESSION 11 HOW DO WE GET THERE (4): Strategy for Better Hydrological and Flood Forecasting

83. Possible working arrangements for follow-up activities of the WMO Flood Forecasting Initiative were discussed and the following suggestions were made:

- Regional networks that require the identification of needs and including relevant capacity building. This will require champions from the various regions and the use of existing networks where possible;
- The establishment of demonstration projects, building on existing projects where possible (for example the severe weather project in southern Africa); and
- An offer from the European Flood Alert System group to develop a proposal for a similar system for Africa. This would be a proof of concept project for data sparse/model deficient areas and undertaken in a collaborative manner with existing responsible agencies. The potential to attract external funding to support this proposal was noted.
- The group also noted the need for countries and regions to develop up Strategy and Action Plans for their own purposes, based on their own needs and targeted at their own capabilities.

84. The Conference was not able to adopt a work plan for the implementation of the Strategy and Action Plan and agreed that this was more a duty for each NMHS. It did however note the work plan set by the Secretariat to have the Strategy and Action Plan endorsed by WMO Congress in May 2007 and input to the discussions of the WMO Technical Commission of Hydrology (CHy) in preparation for the remaining time of its present inter-sessional period and as input to the work programme for the next inter-sessional period.

85. Conference participants did however express their priorities for action (Annex 4) over the initial period of implementing the Strategy and Action Plan and agreed to a survey of response actions in six months time to gauge the degree of implementation of the actions proposed.

SESSION 12 CLOSURE

86. Expressing his appreciation to all of the participants for their excellent contributions and the WMO Secretariat for the professional organization of the Conference, the Chair closed the Conference at 15:00 on Thursday 23 November 2006.

ANNEX 1

SYNTHESIS CONFERENCE OF THE WMO FLOOD FORECASTING INITIATIVE (GENEVA, 20-23 NOVEMBER 2006)

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ANNEX 2

SYNTHESIS CONFERENCE OF THE WMO FLOOD FORECASTING INITIATIVE (GENEVA, 20-23 NOVEMBER 2006)

AGENDA

Day 1, 20 November 2006

08:30 Registration

OPENING SESSION

09:00 Welcome remarks by the Secretary-General of WMO, Mr. M. Jarraud
09:20 Keynote speech: Status of Early Warning and Forecasting in National Meteorological and Hydrological Services (W. Grabs)
09:50 Adoption of the agenda
10:00 Organizational matters
10:15 Coffee break

SESSION 1 WMO FLOOD FORECASTING INITIATIVE: PROCESSES AND OUTPUTS

10:30 The WMO Flood Forecasting Initiative: Purpose and Objectives (W. Grabs)
10.45 Discussion of the major outcomes from the regional expert meetings
12:30 Lunch
13:30 Discussion of the major outcomes from the regional expert meetings
14:30 Identification of focus areas to improve cooperation between meteorological and hydrological services for forecasting purposes (Discussion)
15:30 Coffee Break

SESSION 2 FOOT PRINTS OF COLLABORATION: Experiences of Current Practices

15:45 Country experience I (M. Mustafa, Mozambique)
16:15 Country experience II (Tinh Dang Ngoc, Vietnam)
16:45 Country experience III (C. Wittwer, France)
17:15 Meeting adjourns
17:30 Reception

Day 2, 21 November 2006

SESSION 3 PROJECTED PATHWAYS FOR FUTURE COLLABORATION: Improving Meteorological and Hydrological Forecasting Practices

09:00 Summary of Day 1 and discussion of possible pathways based on the presentations and the examples presented on the previous day
10:00 Presentation of the Draft Strategy and Action Plan (B. Stewart)
10.30 Coffee break

SESSION 4 WHAT THE USERS NEED:
Expectations from Hydrological Forecasting Systems

10:45 Keynote Speech: User Requirements for Flood Forecasting Services and Products (A. Tyagi)
11:15 Current and future users requirements for forecasting services (Discussion)
12:30 Lunch

SESSION 5 WHAT CAN THE MODELS CURRENTLY PROVIDE:
State of the Art Meteorological and Hydrological Forecasting Models

13:30 Keynote Speech: State-of-the-art Meteorological Forecasting Models in use by NMSs including now-casting, use of NWP and ensemble prediction (K. Mylne)
14:00 Keynote Speech: Hydrological forecasting models in use by NHSs (P. Reggiani)
14:30 Coupling of meteorological and hydrological modeling (Discussion)
15:00 Coffee break

SESSION 6 WHAT THE MODELS NEED AND HOW WE GET IT:
Data and Information Requirements for Improved Forecasting Services

15:15 Data requirements, access and management based on forecasting objectives (Discussion)
15:45 Keynote speech: How can the WMO Information System (WIS) meet the needs of forecasting and prediction services (J. Hayes)
16:15 Inter-operability of observational networks and observation systems, including terrestrial and space-based systems (Discussion)
17:15 Meeting adjourns

Day 3, 22 November 2006

SESSION 7 WHAT THE FUTURE HOLDS:
Potential and Future Use of Meteorological Forecasting Products in Flood Forecasting

09:00 Summary of Day 2 and discussion of possible pathways based on the presentations and the examples presented on the previous day
09:15 Future potential of national, regional and global weather forecasting products for use in hydrological forecasting (Discussion)
09:45 Keynote speech: Medium range weather forecasting for improved early warning and hydrological forecasting (D. Richardson)
10:15 Development of integrated weather, climate and hydrological forecasting information/products (Discussion)
11:00 Coffee break

SESSION 8 HOW DO WE GET THERE (1): Capacity Building and Organizational Issues

11:15 Capacity building in NMHSs to make use of weather forecasting for hydrological forecasting
(Discussion)
12.00 Institutional and organizational issues to foster cooperation between meteorological and hydrological services (Discussion)

12:45 Lunch

SESSION 9 HOW DO WE GET THERE (2): Strategy for Better Hydrological and Flood Forecasting

13:45 Group discussions based on the draft Strategy and Action Plan document, including the development of demonstration projects
15.45 Coffee Break
16:00 Keynote speech and discussion: Integration of early warning and forecasting services in multi-hazard disaster preparedness and mitigation programmes (R. Dombrowsky)
16:30 Presentation of preliminary results in plenary
17:15 Meeting adjourns

Day 4, 23 November 2006

SESSION 10 HOW DO WE GET THERE (3): Strategy for Better Hydrological and Flood Forecasting

09:00 Drafting session for the Strategy and Action Plan document
10:45 Coffee Break

SESSION 11 HOW DO WE GET THERE (4): Strategy for Better Hydrological and Flood Forecasting

11:00 Plenary discussion and adoption of the draft Strategy and Action Plan
12:30 Lunch
14:00 Working arrangements for follow-up activities of the WMO Flood Forecasting Initiative
15:30 Adoption of workplan for the implementation of the Strategy and Action Plan
16:00 General conclusions and closing session
16:30 Closure of the meeting

ANNEX 3

SYNTHESIS CONFERENCE OF THE WMO FLOOD FORECASTING INITIATIVE (GENEVA, 20-23 NOVEMBER 2006)

PRIORITIES FOR IMPLEMENTING ACTIONS – COUNTRY VIEWS

The conference Chair initiated a round-table survey of country priorities in the implementation of the Strategy and Action Plan. The priorities expressed by representatives of the countries present at the meeting are briefly summarized below:

Russia:

- Improved flash flood forecasting; development of guidance for observations: new instruments and organization of modern warning systems

Thailand:

- Improved rainfall estimation from radar and satellites, QPF

Vietnam:

- Priority on shift to data centred approach, coupling of models, use of radar and satellite information

China:

- Resource constraints require concentration on specific requirements, more accurate QPE, QPF, QPS also for flash floods, improved data collection, telemetry and data management. Prioritize at different levels of development, especially services in the provinces

Kenya:

- Prioritization on observation networks, data collection, real-time data collection, use of satellite data, downscaling, NWP - products for hydrological models for FF.

Peru:

- Prioritization: Use of NWP models (no or limited capabilities at present), possibilities of capacity building, Peru requires statistical hydrological forecasting for level I countries. Statistical output from weather models to statistic hydrological models. At level II: Selection of pilot basins (regional projects), work on national pilot basins (needs strategy for the selection of basins…good instrumentation historical data etc.), workshops addressing issues in pilot basins, development of methodologies to replicate projects approaches developed in the pilot projects.

Turkey:

- In general, the strategy is a good guidance. Actions: observation systems improvement, promotion of data exchange (Euphrates & Tigris), other data no problem. Improvement of meteorological forecasting, likewise hydrological forecasting practices, and priority: flash floods, institutional cooperation and coordination Capacity building: Turkey has enough capacity. action box 11: Getting better with coordination integration of civil defence authorities. The Strategy and Action Plan will serve as a guide for Turkey.

Hungary:

- Interest in transboundary basin, especially Danube (23 countries!!!) WMO could introduce/develop tools re: data exchange, modern tools for the exchange of data and information. Develop templates for hydrological flood forecasting and services. Hungary to transfer experience to other countries (Balkan etc), likewise twinning arrangements. Flash floods!!! Keen to learn from other countries, region, experiences. Reggiani: Highest priority: integration of data from different platforms on the basis of pilot projects, unified data platforms as these fosters regional collaboration. Countries should take am ore active role in showing how they want to go forward. Instrumentation and donors: More activities of countries.

France:

- Define responsibilities; define tasks within an existing national framework. Define target observation network (dedicated networks for specific purposes) resource definition and requirements. Use of demonstration projects to show what we can do for specific projects. Develop capacity-building workshops. Divide interest in cooperation: Scientific cooperation (cooperation to better include rainfall forecasting, comparing various approaches). At the national operational centre: Prioritize operational use of all methods in daily conditions. Only 10% of innovations can be really implemented in “real-life”. Put to use and demonstrate “best practices”.

Ethiopia:

- Distance between developed and developing countries and sharing experiences is large and needs improved understanding of each others’ problems especially in the developing world and improved exchange of information and know-how. Developed countries should share more effectively their experiences including transfer of know how. E&T is crucial including use of modern instruments for observations and data analysis and management.

Cook Islands:

- Networking (between experts), instrumentation, training (PACIFIC HYCOS, but no flood forecasting there yet), network design and prioritization.

Mozambique:

- Take advantage of data and modelling tools that are available now as expansion will be difficult in future, use of remote sensing crucial for country, needs training to use tools. QPF, QPE is a priority. NWP just started, long way to go on the operational use. Hydrology: expand FF-systems

Gambia:

- Usually NMS is much better equipped; to strike balance, NHS requires uplifting, deteriorating networks are a problem, requirements aim to obtain automatic recorders, expansion of network, priority: availability of modern equipments tidal rivers.

Spain:

- Proper definition of problems to make then tailor-made solutions not being imposed by donors. Combination of meteorological and hydrological models based on precipitation forecast. Implement early warning systems. Promote workshops on national and regional level also, in particular with regard to over come institutional and organizational obstacles (better cooperation). Technically: Downscaling, intercomparison of coupling of models,

improved precipitation forecasting. Find most effective way to disseminate flood-forecasting warnings and, risk based forecasting.

Argentina:

- Recognized difficulties in cooperation between NMS and NHS on local scales and also with organizations that work in irrigation, energy etc. Priorities are working with communities, pilot projects to replicate in many places.

Ghana:

- Started informal cooperation with the Department of Meteorology.

In addition to country views, the Joint Research Centre of the European Union stated on its priorities in the framework of the conference that a major issue is data accessibility! There is a strong need to establish Metadata archives and to maintenance these;

The European Centre for Medium Range Weather Forecasting (ECMWF) stated as priorities its continued service as a data resource and provider of products, additional comments included: Improve collaboration between hydrological and meteorological services, use NWP outputs but not just taking their outputs into hydrological models. Medium range forecasting aims for alerts, warnings, but not on a very local scale. Seek progress in data assimilation including soil moisture. Demonstration projects: Severe weather projects, demonstration projects are under way, others under development.