World Meteorological Organization
Weather • Climate • Water

CHy-XIII/Doc. 8

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COMMISSION FOR HYDROLOGY

THIRTEENTH SESSION
Geneva, 4 to 12 November 2008

HYDROLOGICAL FORECASTING AND FLOOD MANAGEMENT

Addresses Expected Result 3: Enhanced capabilities of Members to provide better hydrological forecasts and assessments

AND

Contributes to Expected Results No 6*

SUMMARY

ISSUES TO BE DISCUSSED:

1. Strategy and Action Plan of the Flood Forecasting Initiative
2. HelpDesk for Integrated Flood Management
3. WMO statement on the scientific basis for, and limitations of, hydrological modelling
4. Drought monitoring and prediction

DECISIONS/ACTIONS REQUIRED:

Adoption of Resolution 4 (CHy-XIII) – Hydrological Forecasting and Flood Management

REFERENCES:

1. *Abridged final report with Resolutions of the Fifteenth Congress* (WMO-No 1026, p 204, Resolution 21 (Cg-XV) *Strategy for the enhancement of cooperation between National meteorological and national hydrological services for improved flood forecasting)*
2. *Abridged Final Report with Resolutions of the Sixtieth Session of the Executive Council* (WMO–No. 1032)
3. *Abridged Final Report with Resolutions of the Twelfth Session of the Commission for Hydrology* (WMO-No. 979)

CONTENT OF DOCUMENT:

Appendices for inclusion in the final report:

A. Draft text for inclusion in the general summary of CHy-XIII
B. Resolution 4 (CHy-XIII) – Hydrological Forecasting and Flood Management

Appendix for information:

CHy-XIII/BM. 8: Background material on hydrological forecasting and flood management

*ER 6: Enhanced capabilities of Members in multi-hazard early warning systems and disaster prevention and preparedness

DRAFT TEXT FOR INCLUSION IN THE GENERAL SUMMARY OF CHy-XIII

8. HYDROLOGICAL FORECASTING AND FLOOD MANAGEMENT *(agenda item 8)*

8.1 The Commission welcomed the progress made under the WMO Flood Forecasting Initiative, and the development of the "Strategy and Action Plan for the Enhancement of Cooperation between National Meteorological and Hydrological Services for Improved Flood Forecasting" (http://www.wmo.int/pages/prog/hwrp/documents/FFInitiativePlan.pdf), which was endorsed by Cg-XV.

8.2 The Commission expressed its satisfaction at the efforts being made to improve collaboration between the meteorological services and the hydrological services, particularly in the area of flood forecasting as outlined under agenda item 5 while reviewing the ongoing activities.

8.3 The Commission recognized the increasing responsibility that hydrological communities and meteorological communities share to reduce the loss of life that takes place due to flash floods around the world. It expressed satisfaction with the development of the Flash Flood Guidance System, in collaboration with NOAA and Hydrologic Research Centre (HRC), San Diego, USA, at the global level and the plans to implement the regional components. The Commission appreciated the financial support provided by NOAA and USAID for the Flash Flood Conferences in Costa Rica and China, the support of the government of Japan for the Regional Flash Flood Workshop in Tsukuba and the support provided by the Government of Spain for the professional network of Ibero-American experts in hydrological forecasting (PROHIMET).

8.4 The Commission recognized the important work being carried out by the Associated Programme on Flood Management in the form of providing flood management policy guidance and tools and welcomed the move to set up a HelpDesk for Integrated Flood Management. It appreciated the substantial support provided by the governments of Japan, The Netherlands and Switzerland to the success of the Programme. It also expressed its appreciation to the Government of Spain for providing financial support for the training workshop in Cochabamba, Bolivia, under the Programme.

8.5 The Commission noted that during the past intersessional period, as part of the drought activities, a low flow manual had been produced. The Commission expressed the need for developing seasonal and inter-annual hydrological predictions for monitoring droughts and establishing best practice guidelines for drought monitoring. It noted that the Commission for Agrometeorology (CAgM) which is charged with the activities of drought management and prediction has established a group on Drought Management. The Commission saw merit in closely collaborating with CAgM and CCl to work towards developing tools and best practices guidance for drought monitoring and prediction.

8.6 The Commission adopted Resolution 4 (CHy-XIII) on Hydrological Forecasting and Flood Management ………………………..

DRAFT RESOLUTION

Res. 4 (CHy-XIII) - HYDROLOGICAL FORECASTING AND FLOOD MANAGEMENT

THE COMMISSION FOR HYDROLOGY,

Noting:

(1) The request of Cg-XV for CHy to implement the activities under the Strategy and Action Plan on the Flood Forecasting Initiative (FFI),

(2) The request of Cg-XV encouraging WMO's continued advocacy for a widespread adoption of an Integrated Flood Management approach at the basin, national and international levels,

Considering:

(1) The potential benefits from the Flash Flood Guidance System (FFGS), the professional network of Ibero-American experts in hydrological forecasting (PROHIMET) and the Global Flood Alert System (GFAS) in furthering the objectives of FFI,

(2) That Cg-XV welcomed the plans to establish HelpDesk Services as a mechanism for providing support on flood management policy issues in collaboration with other partners,

(3) That the technical and financial support made available by the Governments of Japan, the Netherlands, Switzerland and Spain, for APFM activities, has allowed WMO to create capacities for flood management policy advice and guidance for the benefit of its Members,

Recognizing:

(1) That the implementation of the Flood Forecasting Initiative forms a central part of the work plan of the Commission,

(2) That that the Flood Forecasting Initiative and the Associated Programme on Flood Management contribute substantially to the International Flood Initiative,

Decides:

(1) To supplement the Strategy and Action Plan of the Flood Forecasting Initiative by a detailed activity plan that will assist Members in establishing flood forecasting systems;

(2) To explore the possibility of establishing an Inter-Commission Task Team comprising of representatives of CHy, CBS, CCl and CIMO for the implementation of FFI;

(3) To endorse the WMO Statement on the Scientific Basis for and Limitations of Hydrological Forecasting as given in the Annex to this resolution;

(4) To continue promoting the activities of PROHIMET, including the development of demonstration projects in the Ibero-American region;

(5) To support operationalization of GFAS by testing and validating global precipitation products and information, suitable for various geographical regions;

(6) To establish an adequate monitoring and evaluation mechanism to keep track of the implementation of the Strategy and Action Plan on the Flood Forecasting Initiative (FFI);

(7) To support setting up of a HelpDesk for Integrated Flood Management for the benefit of Members in the areas of flood management policy and strategy, and capacity building in support thereof;

(8) To develop, in collaboration with CAgM, and CCl activities to support drought prediction capabilities of NHSs;

Requests the Secretary-General:

(1) To further undertake all necessary actions to implement the FFGS through regional projects while keeping abreast of other forecast-based approaches and methods to address flash flood issues;

(2) That while developing the regional components of FFGS, due consideration should be given to other similar initiatives;

(3) To set up a management structure of the FFGS as appropriate;

(4) To continue to promote the Associated Programme on Flood Management to attract more extrabudgetary resources for its activities.

Annex: 1

ANNEX

WMO STATEMENT ON THE SCIENTIFIC BASIS FOR, AND LIMITATIONS OF, HYDROLOGICAL FORECASTING

Introduction

1. With increasing demands being placed on our valuable water resources, the issue of scientific uncertainty in the derivation of available water resources and predictions of flood levels and inundation becomes increasingly important.

2. The WMO has issued a Statement on the Scientific Basis for, and Limitations of, Weather and Climate Forecasting. Obviously, the uncertainties in such forecasts have a direct impact on the uncertainties in hydrological predictions and forecasts. It is therefore recommended that this statement on the scientific basis for, and limitations of, hydrological modelling be read in conjunction with the weather and climate forecasting statement.

3. It is essential that the inherent uncertainties associated with hydrological modelling, both in relation to the input data as well as to the assumptions made in the modelling process, are recognized. In undertaking hydrological studies, these uncertainties should be understood, assessed and reported in a transparent fashion to enable them to be factored into the planning process.

Hydrological Analysis

4. Hydrological analysis is generally based on well-established principles of hydro-dynamics, thermodynamics, and statistics. However, the central problem in hydrological analysis is the application of these principles in a natural environment that is non-homogeneous, sparsely sampled, and only partially understood. The events sampled are usually unplanned and uncontrolled. Analyses are performed to obtain spatial and temporal information about certain variables, regional generalizations, and relationships among the variables. Often, the pertinent components are not measured directly.

5. Analyses can be performed through different approaches, such as deterministic, parametric, probabilistic, and stochastic. An analysis based on the deterministic approach follows the laws that describe physical and chemical processes. In the parametric approach, an analysis is performed by intercomparison of hydrological data recorded at different locations and times. In the probabilistic approach, the frequency of occurrence of different magnitudes of hydrological variables is analyzed. In the stochastic approach, both the sequential order and the frequency of occurrence of different magnitudes are analyzed.

6. There are variables that are measured directly, such as stage and velocity, or that are computed directly from measurements, such as discharge. There are other variables that are estimated from a sample of direct measurements, for example rainfall depth over a catchment. The estimation of some other variables, such as lake evaporation, can only be done indirectly.

7. In many cases, the measured variables are not the most relevant subject for an analysis. In the analysis of direct runoff, for example, the hydrograph is often separated into its components, so that the portion associated with a particular rainfall event is separated from the rest of the hydrograph. This separation is achieved by computation, based on analytical models, rather than by physical measurements. Analyses include case studies and statistical examination of large quantities of data. Statistical analyses include fitting of data to frequency distributions and to parametric models by regression or time-series analysis. The validity of derived relations should be tested on independent data.

8. The degree of both detail and precision of the analysis should be consistent with the quality and sampling adequacy of the available data and with the accuracy required by the application of the analysis. Consideration should be given to the relationship between the cost and time devoted to an analysis and to the benefits expected. In many instances, graphical and other relatively simple computational methods are more cost-effective than more sophisticated methods, especially when combined with local knowledge of the basin and seasonal information, and they may be sufficiently accurate for the data and purposes involved.

Hydrological Modelling

9. The term modelling of hydrological systems usually means the application of mathematical and logical expressions that define quantitative relationships between flow characteristics (output) and flow-forming factors (input). This is a very general definition that covers an entire spectrum of approaches. At one extreme are the purely empirical, black-box techniques, i.e., those that make no attempt to model the internal structure and response of the catchment but that only match the input and output of the catchment system.

10. At the other extreme are techniques involving complex systems of equations based on physical laws and theoretical concepts that govern hydrological processes — the so-called hydrodynamical models. Between these two extremes, there are various conceptual models. These models represent a logical consideration of simple conceptual elements, e.g., linear or non-linear reservoirs and channels that simulate processes occurring in the basin. Whether black-box, conceptual, or hydrodynamical, these models yield outputs without associated probabilities of occurrence. For this reason, they are often referred to as deterministic models. Probabilistic estimates can be derived through disturbing initial conditions (propagation of error).

11. However, the term modelling of hydrological systems is sometimes considered to include stochastic modelling, where the emphasis is on reproducing the statistical characteristics of hydrological time-series. While the transfer function may be a quasi input/output, no specific attempt is made to model input-output relationships.

12. Purely empirical and black-box relationships have proven and will continue to prove very beneficial under certain circumstances, but they are subject to serious error when it becomes necessary to rely upon them under conditions not previously experienced. Models that, through theoretical concepts, treat the varied and inter-acting hydrological processes are expected to be more trustworthy under such extreme conditions, and experimentation with them holds greater promise for advancing the science.

13. Developments in the complexity of modelling of hydrological systems are linked closely with the emergence of electronic computers and techniques for their application. The availability of electronic computers and the development of associated numerical methods have enabled hydrologists to carry out complex, repetitive calculations that use large quantities of data. Modelling of streamflow has become an important element in the planning and management of water-supply and control systems and in providing river-forecast and warning services.

14. In the development of water resources management plans, it is essential that the hydrological studies be based on the best science available at the time. Technical Advisory Panels are a good approach for undertaking the assessment of the degree to which the latest science and technology has been adopted.

Hydrological Forecasting

15. A hydrological forecast is the estimation of the future states of hydrological phenomena. That is, a forecast of hydrological characteristics in both space and time. A hydrological prediction is less definitive than a forecast and focuses more on the hydrological response to future conditions. The necessity for such forecasts increases with exposure of a country’s citizens,

infrastructure and properties to risk from natural phenomena and with its expanding economy and utilization of its water resources, which implies the best possible management of these resources. However, hydrological forecasts are essential for mitigating the effects of extreme events, such as floods or droughts, at all levels of national development.

16. Hydrological forecasts and warnings are issued for many purposes, varying from those for short-term events like flash floods to seasonal outlooks of the potential water supply for irrigation, power production, or inland navigation. Techniques for forecasting range from the use of simple empirical formulae and correlations to the use of complex mathematical models representing all phases of the water balance of a river basin.

17. The calculation of the magnitudes of specific elements of the hydrological regime for a specified time in the future is the main distinction of hydrological forecasts from statistical calculations in which the hydrologist evaluates only the expected probability of the elements. The dynamics of hydrological processes are driven by meteorological factors (see WMO Statement on the Scientific Basis for, and Limitations of, Weather and Climate Forecasting), but the changes these factors bring about in the regime do not occur instantaneously. For example, the duration of the runoff caused by precipitation is often many times longer than that of the rainfall itself, and a time lag intervenes between a causative temperature rise, the melting of snow, and a consequential rise in river level. The relatively slow rate at which hydrological processes develop and the fact that they lag behind the more rapid meteorological processes make it possible to forecast some elements of the hydrological cycle. The lead time for events such as flash floods is significantly less and they therefore require special attention.

18. The value of a hydrological forecast depends, to a large extent, upon its accuracy, its timeliness, and the purpose for which it is used. Accuracy requirements should be appropriate for the intended use. However, accuracy has to be considered along with the timeliness of the forecast. The accuracy and timeliness depend on the reliability and amount of hydrological and meteorological information (including meteorological forecasts), the speed with which that information is provided to the forecasting centre, the lag time of the river basin, the type of forecasting method or model that can be used, and the time taken to disseminate the forecasts to the users.

19. Measurement uncertainty, model limits and uncertainty, and natural variability of meteorological inputs to hydrological systems are causes of uncertainty in hydrological forecasts. Methods exist:

(a) To evaluate the uncertainty associated with traditional hydrological instrumentation and measurements;
(b) To quantify the natural hydrological variability of meteorological inputs to hydrological systems, either with probability distributions or with stochastic processes; and
(c) To assess empirically the uncertainty of hydrological model output by comparing computed results with observed data.

20. Based on these methods, the forecaster should estimate the total uncertainty and provide this information to the user. However, given user needs and difficulties in utilizing uncertainty, the major benefit of such an evaluation is to the forecaster himself/herself in suggesting possible improvements in the forecasting procedures.

21. Probabilistic hydrological forecasts are also useful to certain users for assessing the risks associated with the decisions that they may take in response to a forecast. Quantitative Precipitation Forecasts (QPFs) can also be probabilistic. The uncertainty in future conditions, especially the occurrence of precipitation, is the primary source of uncertainty in rainfall to runoff or streamflow forecasting. New techniques are being developed to make maximum use of data from all sources, e.g., radar, satellite, meteorological observations and forecasts, and surface measurements.

Conclusion

22. Skill in hydrological modelling and forecasting has increased significantly since the middle of the 20th century. This has been largely supported by the advancement of computing, observational and telecommunications systems, and the development of more complex hydrological models. This has been greatly facilitated by the vast experience of hydrologists in producing and decision-makers in using the output products. Nevertheless, each component within the science and technology of hydrological modelling and forecasting has its own uncertainties. Some of these are associated with the uncertainty in relation to observing natural phenomena and a lack of a complete understanding of, or an inherent limitation of, the predictability of highly complex processes. Other aspects of uncertainty are linked to the need for further advances in observing or computing technology, or an inadequate transfer between research and operations of improvements to measurement and modelling systems.

23. Without a doubt, significant benefits will result from continued attention to scientific research and the transfer of knowledge gained from this work into the practice of hydrological measurements (observations), modelling, and forecasting. For example, reductions in the limitations of Quantitative Precipitation Estimation (QPE) on establishing “initial conditions” for hydrological forecasting would be of significant benefit. Furthermore, recognition of the limitations of weather forecasts and climate projections as inputs to hydrological modelling and forecasts, and when possible, an estimate of the degree of uncertainty, will result in the improved understanding and use of forecasts and other hydrological information by decision-makers. Ultimately the objective is for the scientific and user communities to work better together, realizing even greater benefits. The importance of properly communicated hydrological products, including forecasts, to water resources and emergency management professionals, as well as the broad spectrum of governmental, business and recreational users, should not be underestimated.

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HYDROLOGICAL FORECASTING AND FLOOD MANAGEMENT

BACKGROUND MATERIAL*

SUMMARY

Reference: CHy-XIII/Doc. 8

CONTENT OF DOCUMENT:

Appendix:

- Background material on hydrological forecasting and flood management

*The text of the Background Material is not for discussion

BACKGROUND MATERIAL

HYDROLOGICAL FORECASTING AND FLOOD MANAGEMENT *(agenda item 8)*

1.0 While activities for longer term flood frequency estimation and real-time forecasting of slow rising rivers have been given considerable attention in the ongoing activities under HWRP (agenda item 5), the Flash Floods have drawn little attention. This agenda item therefore deals with new activities that are related to Flash Flood Guidance and Flood Management.

1. Flood Forecasting Initiative (FFI)

1.1 Recognizing the need to improve the capacity of NMSs in detecting flood-critical situations and to improve the capacity of NHSs in using meteorological forecasting information, the WMO Flood Forecasting Initiative was launched in April 2003 which lead to the development of a Strategy and Action Plan for Enhancement of Cooperation between National Meteorological and National Hydrological Services for Improved Flood Forecasting.

1.2 Cg-XV, through its Resolution 21 on the subject, endorsed the Strategy and Action Plan and made specific requests to the Commission:

> **“Requests** the president of the Commission for Hydrology in coordination with presidents of other technical commissions, where needed:
>
> (1) To ensure that the Commission provides the technical expertise needed in supporting the development of new and improved flood, including flash floods, forecasting products;
>
> (2) To ensure that the necessary coordination with other technical commissions be established as required to keep the Strategy in review and further development and implementation of the implementation plan.”

2. Integrated Flood Management

2.1 The Associated Programme on Flood Management with the financial support of the Governments of Japan, Switzerland, the Netherlands, and Spain has developed and advocated the development policy concept of integrated flood management since 2001 through a variety of activities. Based on a case study analysis and various regional pilot projects a robust flood management policy concept has been established and widely consulted and advocated. Various WMO Members have been supported through the Programme in form of pilot projects and training activities since 2002. The Programme continues to prepare various tools in support of the integrated flood management approach and is in the process of transforming the Programme into a fully demand-driven entity by establishing a HelpDesk on Integrated Flood Management, designed to support Members in the areas of flood management policy and strategy formulation and capacity building in support thereof.

2.2 CHy has played a crucial role in guiding and shaping the Programme by holding 2 seats in the APFM’s Advisory Committee. Cg-XV encouraged WMO’s continued advocacy for a widespread adoption of an Integrated Flood Management approach at the basin, national and international levels and welcomed the plans to establish HelpDesk Services as a tool for providing support on flood management policy issues in collaboration with other partners. EC-LX noted the role that policies based on such an approach could play in adaptation to increased climate variability and change to manage flood risks and thereby support sustainable development.

2.3 There is an overwhelming need to facilitate the adoption of the IFM approach at the field level, and the capacities at the international level to provide competent, impartial and balanced guidance backed with adequate human and financial resources needs strengthening in form of a clear and accessible mechanism – The HelpDesk for Integrated Flood Management (IFM HelpDesk).

2.4 The IFM HelpDesk is *"a facility that will provide guidance on flood-related issues to countries that want to adopt the IFM concept in a 'hand holding' mode", i.e. in close partnership and tailored to the needs of the particular partner, with the aim of helping the partners further in IFM implementation."* The HelpDesk will:

- Provide quick access to relevant flood management information;
- Provide guidance and momentum for reform activities for integrated flood management in the countries or river basins;
- Serve as a link between flood management practitioners or decision-makers in flood-affected countries and regions and required experts in various fields such as hydrology, institutional development, ecology, sociology and development economics, etc.; and
- Serve as link between various technical and financial partners.

2.5 The IFM HelpDesk, coordinated by WMO will be based on a multi-disciplinary network of institutions with required expertise in various facets of Integrated Flood Management.

3. WMO Statement on Scientific Basis for, and Limitations of, Hydrological Forecasting

3.1 The WMO Statement on the Scientific Basis for, and Limitations of, Weather and Climate Forecasting was adopted by EC-LIV for providing information to all those with an interest in the scientific foundations and limitations of weather and climate forecasting on timescales from minutes and hours through to decades and centuries. In line with this a WMO statement on the scientific basis for and limitations of hydrological forecasting was considered by the Commission during its last session. The Commission recommended that the statement should be further reviewed. The statement was placed on the CHy Web site soliciting inputs from NHSs. The revised statement is attached for the consideration of the Commission.