WORLD METEOROLOGICAL ORGANIZATION

Weather, Climate and Water

EXPERTS MEETING
EXTENDED HYDROLOGICAL PREDICTION

MELBOURNE, AUSTRALIA
7-9 JULY 2011

FINAL REPORT

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ANNEXES

1. OPENING SESSION

1.1 At the kind invitation of the Government of Australia, the Experts Meeting on Extended Hydrological Prediction (EHP) was held at the headquarters of the Australian Bureau of Meteorology in Melbourne, Australia from 7 to 9 July 2011.

1.2 The meeting was opened by Dr Dasarath Jayasuriya of the Australian Bureau of Meteorology who welcomed participants on behalf of the Director of Meteorology, Dr Greg Ayers. Dr Jayasuriya outlined the development of the extended hydrological prediction services in the Bureau and stressed the potential benefits of such services to water resources management. He noted that various agencies around the world are engaged in EHP activities and are using a variety of approaches and that this meeting gave the Bureau an opportunity to learn from what is happening overseas and also to showcase the processes and procedures established in Australia to deliver an operational extended hydrological prediction product.

1.3 The WMO Secretariat welcomed the participants on behalf of the Secretary General of WMO, Mr Michel Jarraud. The Secretariat explained the background to this meeting, including the previous Expert Meeting held at the International Research Centre on El Niño (CIIFEN) in Guayaquil, Ecuador, in South America in January 2010 and the training meeting held at the International Research Institute for Climate and Society (IRI) in the United States in September 2010.

Objectives

The objectives of the Expert Meeting were to:

- Present and discuss approaches to extended hydrological prediction and their related practical applications (to user sectors);
- Collect information on the benefits and value of extended hydrological predictions;
- Identify the requirements (common and diverse) and limitations (gaps) of the methods currently available for extended hydrological prediction;
- Identify guidance material that can be prepared by WMO for NHSs to guide their use and application of extended hydrological predictions; and
- Establish an action plan for the preparation of this guidance material.

Participants

1.5. Invited experts were drawn from those countries that have developed or are developing extended hydrological prediction capabilities in both developed and developing countries. The meeting was attended by 16 participants from 10 countries. A list of participants is at Annex I. As part of the introductory activities, the experts introduced themselves and outlined their backgrounds.

Agenda

1.6 The Agenda of the meeting was adopted by the participants once it had been adjusted to reflect the participants who had been able to attend the meeting. A copy of the Agenda is at Annex II.

2. MEETING EXPECTATIONS

2.1 The WMO Secretariat made a presentation on the role and responsibilities of the WMO in the field of hydrology and water resources, with a focus on the expectations of the meeting and how they would fit into the development of the programme of work for the WMO Commission for Hydrology (CHy) to be established at the 14th Session of CHy in Geneva in late 2012. The objectives of the meeting were reiterated and stressed (see above). In discussions, the possible role of the Guide to Hydrological Practices and the Hydrological Operational Multi-purpose System (HOMS) in providing guidance and tools with respect to extended hydrological prediction were raised. A copy of the WMO presentation was included on memory stick provided to meeting participants and is contained in Annex III.

3. CASE STUDIES

International Research Institute for Climate and Society (IRI) – USA (Andrew Robertson)

Dr Robertson made a presentation on the activites being undertaken within IRI with respect to extended hydrological prediction. He focussed on the training activities they had undertaken with the support of the WMO and the application of both statistical (regression) downscaling approaches and the generation of daily weather sequences. Dr Robertson stressed the importance of the ENSO signal in seasonal climate forecasts and the need to provide probabalistic forecasts. Case studies from many regions of the globe were presented, including Chile, the Philippines and Ethiopia. Issues raised during the discussion included the impact of the IPO and thus the definition of climate normals (the basis for the presentation of the predictions) and the strength/skill of using the ENSO signal both spatially and temporally. Dr Robertson made the following conclusions:

- Downscaling methods for EHP can range from simple regression models that predict seasonal or monthly streamflow as a function of climate predictors or antecedent flow, to resampling or weather generator methods for daily rainfall to drive hydrologic models; it is important to assess the value added by the more complex methods through intercomparison in test cases;
- Integration of probabilistic seasonal forecasts of inflow within the Angat (Philippines) reservoir water allocation process provides an example of how EHP can potentially be of direct and actionable benefit to reservoir managers;
- An example from central Chile illustrates how snowpack storage can lead to highly skillful forecast of spring melt flow through monitoring of precipitation in the previous winter, while seasonal climate forecasts have the potential to increase the lead time further;
- Through integrated modeling, it can be shown that multi-model ensemble approaches that combine empirical and GCM climate forecasts can lead to enhanced predictions and financial benefits in some cases.

A copy of the presentation was provided to meeting participants on a memory stick and is contained in Annex III.

US National Weather Service (NWS) – USA (Geoffrey Bonnin)

3.2 Mr Bonnin outlined the role and services provided by the US National Weather Services in extended hydrological prediction. The activities are provided in support of the objectives of the NWS which are to provide river and flood forecasts and warnings for the protection of lives and property and hydrologic forecast information for the nation's environmental and economic well-being. He described the Hydrologic Ensemble Forecast Services (HEFS), an end-to-end hydrologic ensemble forecast service which is currently under development. Comprehensive planning began in 2007 and it is based and built on leading-edge science and technology, collaborating domestically and internationally through the Hydrologic Ensemble Prediction Experiment (HEPEX) and the Observing-System Research and Predictability Experiment (THORPEX). The HEFS will be field deployed via the Community Hydrologic Prediction System (CHPS) and prototype components are under test at some River Forecast Centers (RFCs).

3.3 Mr Bonnin described the results from a Distributed Model Intercomparison Project, led by the Office of Hydrological Development (OHD) with international participation. Discussion following the presentation focussed on the benefits of extended hydrological prediction services and how these could be better presented and described to the stakeholder community. Mr Bonnin reflected on the fact that people tend to remember and respond to your prediction failures and that trust was difficult to re-build. The use of historical information via regression techniques introduces unknown bias (e.g. the impact of an early spring melt). In developing extended hydrological prediction services we need to look at the decision making processes and ensure that the products are designed to fit the process or the process can be adapted to take advantage of the information. As an example there is a need to persuade reservoir operators to change their operating rules from using deterministic to probabilistic forecasts. A copy of the presentation was provided to meeting participants on a memory stick and is contained in Annex III.

India (Chetan Pandit)

3.4 Mr Pandit made a presentation on hydrological predictions in India. He described the hydrological characteristics of India and the role and functions of the Central Water Commission, including the provision of flood forecasting and inflow forecasting services in most places in India (Flood forecasting at 147 locations and inflow forecasting at 28 locations). He described advances proposed for the future as being the use of rainfall-runoff models for flood and inflow forecasting and the introduction of the use of QPF to extend the hydrologic forecasts. Mr Pandit stressed that the social cost of incorrect forecast was high in a country where a large proportion of the population relied on agriculture for their livelihood. He also made the point that it is important to show that the "with forecast" operation is better than "without forecast" operation. He described the proposed use of the Narmada Basin as a pilot study. A stakeholder group comprising basin managers, hydrological experts, meteorological experts, software and modelling experts and academics has been established to guide the pilot project. The following discussion focussed on the strategic versus tactical use of extended hydrological predictions and the implications of poor forecasts. A copy of the presentation was provided to meeting participants on a memory stick and is contained in Annex III.

CIIFEN – Ecuador (Juan Jose Nieto)

3.5 Mr Nieto described the activities in the field of extended hydrological prediction being undertaken within the International Research Centre on El Nino (CIIFEN). The presentation focused on extended hydrological prediction in the West Coast of South America and the Regional Action Plan. Mr Nieto identified the lesson learnt as:

- A regional process must be understood as the result of strengthening of national institutions involved;
- Need to share a minimum common vision;
- Must build and sustain mutual trust and commitment;
- Must work on reducing regional asymmetries;
- Must invest in consistent training processes;
- Must decide, adjust and refine at least one common methodology;
- Communications should be kept flexible, sustainable, and efficient;
- A regional coordinating body is required for the additional workload.

3.6 Mr Nieto described some good practices regarding relationship with users as:

- Learning from the users "profile";
- Identifying the users market;
- Encouraging concrete responses from Governments;
- Generating trust with users;
- Knowing what can be forecast and what cannot be forecasted.

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Philippines (Margaret Bautista)

3.7 While the focus of Ms Bautista's organization (PAGASA) is flood forecasting not extended hydrological prediction she made a presentation on two case studies being undertaken in the Philippines. Case Study one was a statistical model for the prediction of Angat Dam inflows (National Hydraulic Research Centre (NHRC), University of the Philippines). The project is entitled - Angat Reservoir Monthly Operations with Optimization Simulation Model and Autoregressive Model to forecast Inflow (July 2009). This work involved collaboration with the National Water Resources Board and the Dam Authorities. The second case study focused on the availability of monthly rainfall predictions derived from the disaggregation or downscaling of Global Climate Models output (PAGASA). The project is entitled Monthly Rainfall Prediction Derived from Global Climate Models (Climate Monitoring and Prediction Section (CLIMPS), Climatology and Agrometeorology Division in collaboration with IRI). A copy of the presentation was provided to meeting participants on a memory stick and is contained in Annex III.

AGRHYMET - Niger (Abdou Ali)

3.8 Mr Ali made a presentation on hydrological seasonal forecasting in West Africa. His presentation addressed the importance of seasonal forecasting in West Africa, the predictors and methodology used in the West-African hydrological seasonal forecasting and the results and applications. He pointed out that the seasonal forecasting in West

Africa, which consists of forecasting the global characteristics of the rainy season, plays a major role in:

- Food security (crop yield et famine early warning, advice the choice of seed variety, advice the choice of shallow or plateau area for agricultural activities);
- Water resource management (flood risk forecasting, water availability for dam, Hydro-electrical energy, etc.), and
- Navigation, fishing.

3.9 The West African Hydrological Seasonal forecasts are based on SST as a quantitative predictor and precipitation forecast of the climate centre as qualitative predictor.

Mr Ali made the following conclusions:

- Hydrological seasonal forecasting forum is becoming a strong component of the PRESAO process in West-Africa;
- Various users are now participating to the hydrological seasonal forecasting;
- The forum is led by AGRHYMET in collaboration with river basin authorities and national hydrological services;
- There is a need to improve the methodology, e.g. to take into account the non-stationary relationship between discharge and rainfall.

A copy of the presentation was provided to meeting participants on a memory stick and is contained in Annex III.

New Zealand (Roddy Henderson)

3.10 Mr Henderson made a presentation on the production and use of seasonal hydrological outlooks in New Zealand. His presentation covered the National Climate Centre, the Climate Outlooks (including Influences on them) and Hydrology Outlooks and their applications (including Water Supply and Hydro-electricity Supply).

Mr Henderson stated that the following are required for making good forecasts:

- Knowing who wants outlooks;
- Good monitoring and information systems – Knowledge of the current status of water systems;
- Interpretation by hydrologists of climate and weather outlooks;
- Translation to water outlooks - *Action: simple, reliable methods;*
- Communication of outlook to stakeholders (government, decision makers, communities);
- Checking how good the outlook was - Know limitations, uncertainties;
- Scheduled and regular communications between hydrologists and climatologists.

A copy of the presentation was provided to meeting participants on a memory stick and is contained in Annex III.

Peru (Waldo Lavado Casimiro)

3.11 Dr Lavado made a presentation on hydrological forecasting in Peru. He described the hydrological characteristics of Peru. He described the applications of a statistical model and of a hydrological model. The statistical approach has not shown good results, except within the lagged rainfall, other models and predictors will be investigated. The Hydrological Model approach has shown good results at times in representing discharge. It is proposed to look for better methods for deriving the ensembles and this may include the use of rainfall forecasts. A copy of the presentation was provided to meeting participants on a memory stick and is contained in Annex III.

Brazil (Eduardo Martins)

3.12 Mr Martins made a presentation on Hydrological Forecasting in the Cearà region of Brazil. He described the hydrological characteristics of the Cearà region, ephemeral rivers which run for the first few months of the first semester. Dynamical and statistical approaches have been employed for seasonal prediction. Four key factors make Ceará an appropriate site to develop and implement an integrated approach to dealing with the high climatic variability:

- High skill in forecasting climate variability;
- High vulnerability of a large segment of the population;
- Need for adaptability of the socioeconomic and water management system;
- The political will and technical skill to implement policy measures toward adaptability.

3.13 Mr Martins identified the need for improvements to verification studies, suggesting the use of 12 years of Numerical Climate Prediction and the cross-validation for the statistical forecasts. He also urged improvements in the communication of the results - What is the best way to present information to water basin committees? He suggested that the weakest links are:

- Institutions involved in the process - cooperation may be intended but has to be effective!
- The relationships between the Met Service & Water Manager;
- Water Managers (WM) and Ownership of water-related products - Although, FUNCEME developed the Inflow forecast products, the results are now presented by the WM in the Climate Outlook Forums (COFs) (started 2009);
- That the information needed - exists – is useful – is used, at the right time, horizon and format.

A copy of the presentation was provided to meeting participants on a memory stick and is contained in Annex III.

4. AUSTRALIAN BUREAU OF METEOROLOGY

4.1 The presentation on the practices and procedures in the Australian Bureau of Meteorology were made by Dasarath Jayasuriya (Introduction), Jeff Perkins (the

Statistical approach), Narandera Tuteja (the Dynamic Modeling approach), Mohamed Bari (longer term hydrological prediction) and Trudy Peatey (stakeholder engagement).

4.2 Australian streamflows are among the most variable in the world. These streamflows are relied on by a range of water managers and users, including irrigators, urban and rural water supply authorities, environmental managers and hydroelectricity generators. To help water managers and users make better water availability decisions and manage risks, the Bureau of Meteorology (the Bureau) has developed an operational Seasonal Streamflow Forecasting service.

4.3 The seasonal streamflow forecasts are based on research conducted in partnership with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) as part of the Water Information Research and Development Alliance (WIRADA). The development process involved a long period of consultation and workshops with stakeholders, and from December 2009 registered users were given access to experimental forecasts. Their valuable feedback was incorporated in the development of the operational service, which was publicly launched on the 14 December 2010.

4.4 The Bureau's seasonal streamflow forecasts are issued monthly for specific sites and major storages, and are freely available online at: www.bom.gov.au/water/ ssf. The forecasts provide a three-month outlook of total streamflow volumes at a site or total inflows into a water storage. They are currently available for 21 sites in eight river basins in the southeast of the Murray-Darling drainage division. An extension of the service to other catchments across Australia is planned, driven by user need, data availability and forecast skill and accuracy.

4.5 There are two main sources of predictability in Australian streamflows: firstly, strong serial correlations in streamflows due to soil and groundwater storages extending the time between incidence of rainfall and any resulting streamflow; and future rainfall and secondly, climatic conditions influencing future streamflows. Many indices of large-scale climate anomalies, such as the Southern Oscillation Index and Indian Ocean Dipole Mode Index, show significant concurrent and lagged correlations with rainfall and streamflows.

4.6 It was found that when the skill of seasonal streamflow forecasts produced using only antecedent flow predictors is high, climate predictors tend to add little skill, however, when it is low, climate predictors tend to increase the skill of the forecasts, in some cases substantially. The Bureau's seasonal streamflow forecasts rely on data collected over many years by state agencies and other organisations, as well as climate information from the Bureau and international organisations. Most of the climate indices used in the forecasts are generated within the Bureau from raw data using a geo-processing model.

4.7 The current forecasting system is based on Bayesian joint probability (BJP) modelling. A Box- Cox transformed multivariate normal distribution is used to model the joint distribution of future streamflows and their predictors, such as antecedent streamflows and El Niño-Southern Oscillation indices and other climate indicators. A Bayesian inference of model parameters and their uncertainties is implemented using Markov chain Monte Carlo (MCMC) sampling. Joint probabilistic forecasts of streamflows at multiple sites are generated, preserving inter-site correlations and allowing the transfer of information between sites.

4.8 This BJP modelling approach is able to manage a large number of predictors, and by explicitly modelling the correlations between streamflows and climate indices all available data series can be incorporated, as long as there are some concurrent records. Data containing missing records can also be handled. Separate models were constructed for each forecast location for each month and a stepwise selection procedure was used to choose the climate predictors to incorporate in each model. A base model was first established using only streamflow data for the month preceding the forecast starting month as a predictor. The forecasting performance of the base model was assessed using leave-one-out cross validation. Candidate climate indices were then introduced, one at a time, and the skill of the forecasts made by each new model was assessed. A skill score based on mean squared error in probability (SSRMSEP), and the log pseudo Bayes factor (log PsBF) were used to assess improvements in predictions by each new model over the base model. The climate index leading to forecasts with the greatest skill was then included in the base set of predictors and the process repeated to identify the next best predictor (Robertson and Wang, 2008). To ensure consistency with current understanding of physical hydrological and climate systems, findings were compared with the reported literature and climate experts' knowledge. The selected climate predictors vary with both forecast start date and location.

4.9 Investigations suggested that including more than three climate predictors did not result in substantial increases in the skill of the forecasts. The skill of the forecasts peaks during late spring and summer and is lowest during autumn, coinciding with the period when the austral autumn (boreal spring) barrier is observed in forecasting rainfall and sea surface temperature. The following definitions are used in relation to the hindcast RMSEP skill score: 0 implies the forecast provides no additional information compared with the historical reference (a probabilistic representation of the historical streamflow data); <10 implies very low skill; 10-20, low skill; 20-40, moderate skill; and greater than 40, high skill.

4.10 The seasonal streamflow forecasts can be used in conjunction with the Bureau's existing seasonal climate outlooks, which are issued monthly and are freely available While the seasonal climate outlooks use predictors that provide the best skill, on average, across the whole of Australia, seasonal streamflow forecasts are provided at the catchment scale and the predictors and modelling have been developed to maximise skill at this scale. The Bureau's seasonal streamflow forecasts thus enhance the seasonal rainfall outlooks by providing local forecasts to help water managers and users make better water availability decisions.

4.11 The Bureau and CSIRO are also investigating forcing traditional hydrologic models with downscaled rainfall forecasts from Global Climate Models to produce monthly and seasonal forecasts of streamflow. The results are looking promising with enhanced and extended services expected over the coming years.

5. DISCUSSION – NEED FOR EHP AND SCIENTIFIC BASIS

Need for EHP

5.1 The expert meeting came to the following conclusions with respect to the assessment of the need for EHP:

- Definition of exactly what is meant by EHP is essential, that is, the definition of EHP should be clear and concise, and thus well understood;
- It is essential for each country to define and identify end users and thus needs;
- The case studies presented at the meeting identified a range of needs for EHP, from improved sustainable water resources management to improved food security;
- Stakeholder consultation is a key element of assessment of the need for and benefits of EHP;
- When defining needs, a clear decision process/decision point should be identified;
- We will win the trust of stakeholders only when we meet their needs and manage their expectations and we need to provide forecasts that are consistent and reliable to maintain this trust;
- The development and uptake of EHP can be influenced by the water legal and institutional frameworks that are in place and thus be different for each country. This may include national versus local roles and responsibilities;
- The needs help frame the approach and method used; and
- There will always be new and different needs evolving over time.

5.2 On the basis of these conclusions, they made the following recommendations:

- An example set of case studies (including hindcast based analyses) which show needs and the manner in which EHP has addressed them should be compiled. The studies should show a clear linkage between the product and the benefit;
- In compiling guidance material on EHP, due care and attention should be given to the assessment and definition of needs as part of stakeholder consultation; and
- Guidance on methods that can be used to define success (meeting needs) should be prepared.

Scientific Basis

5.3 The expert meeting came to the following conclusions with respect to the current status of the science behind EHP:

- The scientific basis for EHP is framed within the context of sub-seasonal to seasonal climate prediction;
- The expectations of stakeholders and what can be delivered by the current status of the science do not necessarily match (e.g. extension

beyond 12 months, lead times as well as period of prediction for planting seasons, inflow season, etc.);

- The tools are available and they are both easy and complex, so a range of capability exists;
- Verification procedures are a gap in the scientific capability for EHP;
- While EHP is also an important activity in its own right, it is a tool of relevance to adaptation to climate change;
- We need to be transparent with respect to the skill (temporal and spatial);
- More complex methods are not necessarily better;
- There is an insufficient investment into EHP research, for example, in comparison to climate change research;
- Capacity building needs to include training on the scientific basis of the products;
- There needs to be continued and improved data collection and development of high quality/high resolution data sets in support of the scientific research; and
- Seasonal in a probabilistic space – without a forecast you are still in a probabilistic approach.

5.4 On the basis of these conclusions, they made the following recommendations:

- Clarification of the methodologies available and predictable phenomena should be undertaken;
- Intercomparison of approaches should be encouraged;
- Guidance on verification procedures should be established and standardised;
- Capacity building activities should be identified and supported, especially between research and operational groups; and
- Recommendations on the appropriateness of methods should be compiled.

6. DISCUSSION – SERVICE DELIVERY, STAKEHOLDER CONSULTATION, RESEARCH TO OPERATIONS

Service Delivery

6.1 The expert meeting came to the following conclusions with respect to EHP product/service delivery:

- The roles and responsibilities of all delivery institutions should be clearly and transparently defined and promoted;
- The product should be tailored to the user situation to avoid miss-interpretation;
- EHP products will become useful only when their accuracy and reliability improve to meet users' needs;
- It is essential to educate the users on the approach and ensure understanding of the product and its usability;
- Other presentations of the potential products could be considered (e.g. number of rain-days, tailored to threshold values, etc.);

- Information should be layered going from general to more deeper, specific information and data;
- Delivery mechanisms should be tailored to meet the needs and be presented in terms of the memory/understanding of the users;
- Feedback mechanisms should be linked to service delivery; and
- Web content should be developed to meet the level of the users' capability (high end and low end) – can be analyzed; can use focus groups for feedback.

6.2 On the basis of these conclusions, they made the following recommendations:

- Guidance and advice on the information required to meet user needs should be compiled;
- Guidance on the pros and cons of different communication and delivery (channel management) mechanisms should be compiled (e.g. personal briefings, websites, e-mails); and
- Guidance on web content should be developed.

Stakeholder Consultation

6.3 The expert meeting came to the following conclusions with respect to stakeholder consultation:

- Stakeholders may vary from catchment to catchment and country to country;
- The operational practices of stakeholders need to be understood;
- Stakeholder engagement could be undertaken centrally or locally and the outcomes would be different. The institutions roles and responsibilities need to be carefully and clearly defined;
- Improved communication is a key factor to successfully engaging stakeholders;
- Stakeholder consultation may include assisting stakeholders to change the way they do things;
- Education of stakeholders is essential (especially about probabilities and what they mean);
- Providers must be responsive to stakeholders;
- Some stakeholders should be selected as early adopters of the product and involved in service delivery and improvements and communicating the value to other users;

6.4 On the basis of these conclusions, they made the following recommendations:

- A check list of possible stakeholders should be compiled as part of the guidance material;
- Case studies should be prepared to enable stakeholders to see the benefits of EHP products;
- Guidance on stakeholder consultation mechanisms should be prepared; and
- Training courses and manuals to assist in educating stakeholders should be prepared.

Research to Operations

6.5 The expert meeting came to the following conclusions with respect to moving EHP research outcomes to products/services:

- Research groups should be seen as key stakeholders and thus engaged at all levels;
- Training programs should include representatives from the research environment;
- The development of easy to use/share software and hardware requirements, performance, etc, should be encouraged; and
- Local universities should be involved in the product/service development.

6.6 On the basis of these conclusions, they made the following recommendations:

- The role and function (e.g. training) of regional centres (e.g. climate) should be identified and guidance on interaction and involvement provided (e.g. with respect to the WMO Regional Climate Outlook Forums (RCOFs) and the Climate Information and Prediction Services (CLIPS) program);
- An inventory of existing training materials and tools relevant to the use of climate information and forecasts in EHP should be compiled, and the opportunities for related training workshops identified; and
- Guidance on the processes to move products from research to operations should be compiled (especially in terms of robustness).

7. ASSESSMENT OF MEETING AGAINST OBJECTIVES

7.1 In terms of the objectives of the meeting, the participants made the following observations:

- Present and discuss approaches to extended hydrological prediction and their related practical applications (to user sectors):
  The experts at the meeting were able to present the results of case studies that they had undertaken and discuss the approaches taken and the methods of presenting EHP products. All experts agreed that they had benefited from this interchange and would be able to improve their activities accordingly.
- Collect information on the benefits and value of extended hydrological predictions:
  Achieving this objective had not been a straight forward as anticipated and the experts agreed that guidance was necessary on a consistent methodology for determining benefits. While individual case studies had identified potential benefits, expressing these benefits in a consistent manner and with specific values was not easy. The recommendations therefore focussed on how better to determine the benefits of EHP products.
- Identify the requirements (common and diverse) and limitations (gaps) of the methods currently available for extended hydrological prediction:

The experts believe that for the case studies presented this objective was in the main achieved. The presentations show the methods applied and the predictors etc., used in delivering the products. The limitations of the methods were also discussed. The experts felt that there will be other groups involved in EHP and, in particular gaining knowledge of applications in Europe would be of benefit.

- Identify guidance material that can be prepared by WMO for NHSs to guide their use and application of extended hydrological predictions:
  The recommendations flowing from the meeting have identified the guidance required and thus this objective has been met.
- Establish an action plan for the preparation of this guidance material:
  The experts have identified the material required but have not gone the next step in establishing an Action Plan. The WMO Secretariat was asked to take this step in association with the CHy AWG.

7.2 The experts felt that the opportunity to interact and discuss the current status and future directions in EHP was a valuable exercise and encouraged WMO to continue the series of meetings on this topic, including in the next phase groups from Europe and other countries who may benefit from EHP products. The experts supported the continuation of the training initiatives already commenced (e.g. the IRI train the trainers). The need to have the definition of EHP in place and thus well focused (perhaps case specific) was a necessary requirement to support appropriate and targeted training.

8. CLOSURE

8.1 The WMO Secretariat thanked all of the participants for their inputs and contributions which had led to a successful meeting. The WMO Secretariat agreed to forward the report of the meeting to the Commission for Hydrology (CHy) Advisory Working Group (AWG) for consideration in developing the future programme of work for the Commission in its next session. The Secretariat and participants expressed their appreciation to the Australian Bureau of Meteorology for the support to and facilities provided for the meeting.

8.2 The meeting was adjourned at 12:30pm on Saturday 9 July.

ANNEX I

EXTENDED HYDROLOGICAL PREDICTION WORKSHOP
MELBOURNE, AUSTRALIA, 7-9 JULY 2011

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ANNEX II

EXPERTS MEETING ON
EXTENDED HYDROLOGICAL PREDICTION
Melbourne 7-9 July 2011

AGENDA

Thursday – July 7th, 2011		
9:30-10:00	Opening	
10:00-10:30	1st Session – **Meeting Expectations**	**Workshop structure and expectations**
10:30-12:30	2nd Session – **Case Studies**	**Extended Hydrological Prediction Case Studies** ➢ IRI – USA (Andrew Robertson) ➢ NWS/NOAA – USA (Geoffrey Bonnin)
	Lunch	
13:30-15:15	2nd Session – **Case Studies**	**Extended Hydrological Prediction Case Studies (continued)** ➢ India (Chetan Pandit) ➢ CIIFEN – Ecuador (Juan Jose Nieto) ➢ Philippines (Margaret Bautista) ➢ AGRHYMET - Niger (Abdou Ali)
		Coffee break
15:45-17:30	3rd Session – **Case Studies and Discussion Session**	**Focused discussion on approaches** ➢ New Zealand (Roddy Henderson) ➢ Peru (Waldo Lavado Casimiro) ➢ Brazil (Eduardo Martins)

Friday – July 8th, 2011		
09:00-11:30	4th Session – **Australian Bureau of Meteorology**	**Presentations on Australian Bureau of Meteorology approaches** ➢ Introduction (Dasarath Jayasuriya) ➢ Statistical approach (Jeff Perkins) ➢ Dynamic modelling approach (Narendra Tuteja)
		Coffee Break
11:30-13:00		**Presentations on Australian Bureau of Meteorology approaches** ➢ Longer-term Prediction (Mohammed Bari) ➢ Stakeholder consultation (Trudy Peatey)

	Lunch	
14:00-15:30	5th Session – **Needs Scientific Basis**	**User expectations of extended hydrological prediction services** ➢ Needs for EHP ➢ Scientific Basis
		Coffee break
15:15-17:15	6th Session – **Service Delivery Stakeholder Consultation**	**Focused discussion on future requirements and how to meet them** ➢ Service Delivery ➢ Stakeholder Consultation ➢ Research to Operations

Saturday – July 9th, 2011		
08:30-10:00	7th Session – **Assessment of Meeting** **Closure**	**Preparation of Final Report**
		Coffee Break
11:00-12:30		**Assessment of Meeting against Objectives** **Adoption of Final Report** **Closure**
	Lunch	

ANNEX III

CD OF PRESENTATIONS

Provided to all participants in Melbourne.