**WORLD METEOROLOGICAL ORGANIZATION**

COMMISSION FOR BASIC SYSTEMS
OPAG DPFS

**MEETING OF SEVERE WEATHER FORECASTING DEMONSTRATION PROJECT STEERING GROUP**

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# WORKSHOP ON SEVERE AND EXTREME EVENTS FORECASTING

## TOULOUSE, FRANCE, 26-29 OCTOBER 2004

## FINAL REPORT

WORLD METEOROLOGICAL ORGANIZATION

## COMMISSION FOR BASIC SYSTEMS

### OPAG ON
### DATA PROCESSING AND FORECASTING SYSTEM

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### Regulation 43

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

## EXECUTIVE SUMMARY

The Workshop on Severe and Extreme Events Forecasting took place, at the kind invitation of Météo France, in Toulouse from 26 to 29 October 2004. There were thirteen participants including representatives of all WMO Regions. The CBS-Management Group suggested a demonstration project on forecasting of severe weather, involving EPS, NWP models, nowcasting, interpolation techniques and involving, through voluntary participation, global NWP model producer(s), RSMC(s), developing NMS(s) and disaster management agencies. Such a demonstration project would use a cascading approach to provide greater lead-time for severe weather and would contribute to capacity building and improving links with disaster management authorities. This workshop had to further develop the details of the project and identify resources required. The workshop agreed on a generic terminology for defining severe weather. The severe weather would be: *"a hazardous meteorological or hydro-meteorological phenomenon, of varying but short duration (minutes, hours, days to a couple of weeks) and of varying geographical extent, with risk of causing major damage, serious social disruption and loss of human life, requiring measures for minimizing loss, mitigation and avoidance, and requiring detailed information about the phenomenon (location, area or region affected, time, duration, intensity and evolution) to be distributed as soon as possible to the responsible authorities and to the public."*

The workshop discussed the necessary cascading process with the information required at various steps for severe weather forecasting. It was agreed that a sequence of processes was necessary for the forecasting of severe weather and that sub-processes could also be defined. For example EPS based guidance could be used to identify several days in advance potential areas for severe weather. Then higher resolution models would be used to refine the forecasts in the shorter range. Finally in the very short term (few hours), nowcasting techniques or extrapolation techniques could be used to provide more up-to-date information. In case of severe weather, it is necessary to provide the users (Disaster Management and Civil Protection Authorities (DMCPA), for example) with meteorological information as simplified as possible. With this respect, the colored charts indicating the degree of risk for geographical areas, which are currently elaborated by several NMCs give a good example of the way to present the information. The forecaster's work for nowcasting is very much dependent on the use of observations, radar and satellite information and model output: it consists of checking whether the actual behaviour of the atmosphere agrees with the forecast one. As nowcasting results require to be communicated to the DMCPA without delay the common way to work together with the user is at least issuing warning and using visualization system implemented in the office of the DMCPA. The task of the forecaster is also to provide the DMPCPA advice about the visualized information. In the framework of a coordinated cascading system it seems essential to define simplified products summarizing the results of Medium-Range Forecasting (MRF) on one side and Short-Range Forecasting (SRF) on the other side to be transmitted *"downwards"*. The workshop agreed also that it was important to note that the implementation of a coordinated cascading system to forecast severe weather events requires also the definition of an *"upward"* flow of information (from the user to the producer). Indeed, there was the necessity to give clear information (real time feed-back) indicating the way the received information had been taken into account; and that would increase the vigilance of the various forecasters involved in the cascading process.

The use and application of EPS products and in particular of probabilistic information for severe weather forecasting was considered by the workshop. EPS provides a quantitative measure of uncertainty or probability faced with multiple forecast scenarios. The extreme value index, mean/spread in precipitation amounts, spaghetti plots for critical precipitation thresholds are a few examples of products to be used. The workshop also recommended that derived fields like CAPE; LIFT index should be generated from EPS and their usefulness evaluated. It was reported to the workshop that in some cases, for medium-range, the forecasters would give priority to the EPS products rather than the deterministic forecast, but that below 3 to 4 days they prefer to have the deterministic global forecast. EPS gives probabilities of thresholds, of extremes, which have to be related to the model climate. A forecast guidance would use the "Extreme Forecast Index" (EFI) charts for wind, temperature and rain (as provided by ECMWF). Concerning the use and value of short-range EPS, the workshop agreed that it could deserve special case studies, but that it could be considered only in a few years since these systems were still more at an experimental stage, and run in only a few countries.

The necessary interfaces with other scientific and technical groups, mainly the Hydrological Agencies, involved in Severe Weather Forecasting and Warnings was considered. It appeared that the interface with other sciences, environmental or hydrology, was presently limited, even in advanced countries. There were efforts attempting to improve coordination between the agencies, and in particular in the development of coupled atmospheric-hydrological models. For the moment many hydrologists only use observed precipitation as input to their model, but there would be benefits in using information available from an atmospheric model.

*To satisfy the requirements usually expressed by responsible authorities there were two important principles to fulfil:*

- to avoid as much as possible missed (no detection) cases of severe weather events.
- to reduce at the same time, as much as possible, useless warnings (false alarms) in order to establish some credibility.

The responsible authorities need to be warned for managing their interventions in order to be operational as quickly as possible. However too many useless warnings might compromise the credibility of the warning system itself. The workshop agreed that it was fundamental to discuss first with the authorities to define what they required as warnings and then analyze their requirements (which might depend on the specificity of the country), and then one had to derive the implications for the work of the forecaster. The authorities should also understand the distinction between warnings and awareness. At the medium-range stage, in many cases, only an awareness message might be given to the authorities. To give probabilities to authorities would require some training to be dispensed to them, and the actual understanding and implementation might take quite some time.

The meeting defined the broad goals for the demonstration project and the roles of the participating centres. It agreed on a three-level approach involving Global NWP producer, Regional Specialised Meteorological Centre and NMC(s). The goals of the project need to be clearly stated. The workshop agreed on the following broad goals:

- to improve the ability of NMCs to forecast severe/extreme weather events
- to improve the lead time of alerting of these events
- to improve interaction of NMCs with DMCPA before and during events
- to identify gaps and areas for improvements

In addition, the demonstration project will allow the assessment of the value of probabilistic forecasts and the skill of EPS products, and enhance the capacity of NMCs (training, capacity building).

This project will only succeed if there are clear commitments from all participant to fulfill their roles as described above, as well as commitments to participate in the evaluation of the project (lessons learned, identify gaps, and make recommendations). The project will build on existing capabilities and be developed with a view to ensure sustainability. Performance measures will need to be established prior to the start of the project. A process will be established to ensure that all severe weather events are documented. It is recommended that at the end of the project, there will be an in depth analysis, including the feedback from all parties including disaster management and civil protection agencies involved. It was proposed that project duration should be of one year to ensure that sufficient severe weather events are analyzed. It was envisaged that two types of project could be developed, one that is aimed at improving severe weather associated with Tropical Cyclones, and another project focusing on improving heavy precipitation/strong wind forecasts (not associated with tropical cyclones).

## AGENDA / REPORT CONTENTS

1. OPENING OF THE WORKSHOP

2. ORGANIZATION OF THE WORKSHOP

2.1 Approval of the agenda

2.2 Working arrangement for the meeting

3. ESTABLISH GUIDELINES FOR IMPLEMENTATION OF A DEMONSTRATION PROJECT OF SEVERE WEATHER FORECASTING:

3.1 Definition of severe weather

3.2 Detail cascading process from medium-range to nowcasting

3.3 Use of EPS and probabilities

3.4 Sharing information between forecasting offices

3.5 Interface with other sciences (e.g Hydrology)

3.6 Requirements of responsible authorities

3.7 Guidelines for the Demonstration Project.

4. DEMONSTRATION PROJECTS

5. NECESSARY RESOURCES

6. CLOSURE OF THE WORKSHOP

ANNEX TO PARAGRAPH 1.1:
LIST OF PARTICIPANTS

ANNEX TO PARAGRAPH 3.7.6:
DEMONSTRATION PROJECT

ANNEX TO PARAGRAPH 4.1.3:
DEMONSTRATION PROJECT ON TROPICAL CYCLONES

ANNEX TO PARAGRAPH 4.2.2:
DEMONSTRATION PROJECT TO IMPROVE FORECASTS OF HEAVY RAIN AND STRONG WINDS

**REPORT OF WORKSHOP ON**
**SEVERE AND EXTREME EVENTS FORECASTING**
*(Toulouse, 26-29 October 2004)*

## 1. OPENING OF THE WORKSHOP

1.1 The Workshop on Severe and Extreme Events took place at the kind invitation of Météo France in Toulouse from 26 to 29 October 2004 (the participants' list can be found in the Annex to this paragraph). The Workshop was opened on Tuesday 26 October 2004 at 9.30 a.m. by Mr Bernard Strauss, Director of Forecasting in Météo-France, who welcomed the participants. The Representative of the WMO Secretariat thanked Météo-France for their excellent hospitality and the local organisers, especially Corinne Mithieux and Isabelle Varin. He recalled that the CBS-Management Group suggested that a demonstration project, involving EPS, NWP models, nowcasting, interpolation techniques and involving, through voluntary participation, a major RSMC, developing NMS(s) and disaster management agencies would contribute to capacity building and improving links with disaster management authorities. Such a demonstration project would use a cascading approach to provide greater lead-time for severe weather. For example EPS based guidance could be used to identify several days in advance potential areas for severe weather. Then higher resolution models would be used to refine the forecasts in the shorter range. Finally in the very short term (few hours), nowcasting techniques or extrapolation techniques could be used to provide more up-to-date information. Such a project would help demonstrate how NWP products and nowcasting/extrapolation techniques can be applied to improve severe weather forecasting, to help in decision-making, identify issues and gaps, and provide recommendations for future work. This workshop with the participation of the rapporteur on severe weather and representatives from both developed and developing countries had to further develop the details of the project and identify resources required. This project will be further discussed during the ICT meeting prior to being presented at CBS XIII for further consideration. The WMO representative wished the workshop would elaborate a comprehensive and realistic plan for the implementation of a good demonstration. his workshop should establish general principles and define processes to be followed, and if necessary, conceptualise new tasks or processes for operational forecasting of extreme and severe weather events. These activities are already performed in advanced countries, and the project should be a demonstration for the benefit of all countries, and in priority, of the less advanced countries, which hopefully would be able later to implement also these processes.

1.2 Mrs Angèle Simard, Chair of the OPAG on Data Processing and Forecasting System, welcomed the participants and stressed that CBS has requested to give priority to three categories of severe weather events:

*(a)* Enhance extratropical storms over ocean or over land;

*(b)* Large-scale heavy precipitation and high intensity precipitation over small area for short duration (heavy rainfall or snowstorm);

*(c)* Active convective events with associated phenomena (heavy precipitation, hail, lightning, gusts, tornadoes);

She also stressed that the Commission emphasized the need for collaboration between meteorological and hydrological services to optimise use of meteorological forecasts and warnings on intense precipitation in assessment and prediction of severe hydrological events such as floods. It further agreed to encourage the implementation of forecast guidance related to tropical cyclones and to follow-up the new development in this area. Over the years, the Commission has encouraged NWP centers to produce additional or specific products that could bring valuable assistance to NMHs such as stability indices for example.

The development of a demonstration project(s) on severe weather forecasting would go in the direction defined by CBS. She noted that CBS-MG agreed that heavy precipitation, and strong winds are potential areas for such project. The main task of this workshop was to try to discuss the features of such project(s).

## 2. ORGANIZATION OF THE WORKSHOP

### 2.1 Approval of the agenda

The participants agreed to the content of the agenda as proposed (see Agenda/Report contents page).

### 2.2 Working arrangements

The participants agreed on their working time and arrangements. Mrs Angèle Simard, chair of the CBS OPAG on DPFS, then led the workshop with diplomacy and efficiency.

## 3. ESTABLISH GUIDELINES FOR A DEMONSTRATION PROJECT ON SEVERE WEATHER FORECASTING

The main task of the Meeting was to establish guidelines for a demonstration project on severe weather forecasting. It considered the various technical steps and information exchanges necessary for efficient severe weather forecasting, with a view to implement a demonstration project.

### 3.1 Definition of severe weather

The workshop started to discuss a possible general definition of severe weather applicable worldwide. The meeting agreed on a generic terminology for defining severe weather. Given the difficulty due to the variety of local phenomena depending on the latitude, the altitude and the topography and the different vulnerability of the countries depending on their level of development, an attempt to define severe weather by the implications for the activities of the forecasting centres was proposed. This definition will cover all the types of "severe weather". The severe weather would be: "**a hazardous meteorological or hydro-meteorological phenomenon, of varying but short duration (minutes, hours, days to a couple of weeks) and of varying geographical extent, with risk of causing major damage, serious social disruption and loss of human life, requiring measures for minimizing loss, mitigation and avoidance, and requiring detailed information about the phenomenon (location, area or region affected, time, duration, intensity and evolution) to be distributed as soon as possible to the responsible authorities and to the public.**" That concept defined generically the severe weather. It could be linked to the forecasting process, which depends in detail on the scale of the considered phenomenon.

### 3.2 Detail cascading process from medium-range to nowcasting

The workshop discussed the necessary cascading process with the information required at various steps for severe weather forecasting. It was agreed that a sequence of processes was necessary for the forecasting of severe weather and that sub-processes could also be defined. For example EPS based guidance could be used to identify several days in advance potential areas for severe weather. Then higher resolution models would be used to refine the forecasts in the shorter range. Finally in the very short term (few hours), nowcasting techniques or extrapolation techniques could be used to provide more up-to-date information.

Presently, only a few Meteorological Centres have technical facilities to run models at different time ranges. For this reason, it seems logical to benefit from the resources provided by the various NMCs to implement a coordinated system aiming at providing forecasters with information as comprehensive as possible about the possibility of development of severe weather. So it was relevant to examine how to implement a cascading procedure based on splitting up forecast procedure into separate processes, which can be carried out by different Centres. According to the methods and tools that are currently used, it seems logical to divide the whole forecasting procedure into three main processes: Medium Range Forecasting (MRF), Short Range and Very Short Range Forecasting (SFF/VSRF) and

Nowcasting (NC). The workshop considered the content of each process and the flow of information to be exchanged between them.

3.2.1 Medium Range Forecasting (MRF)

A limited number of Meteorological Centres runs Ensemble Prediction Systems (EPS) for MRF purpose. They use various techniques and provide the forecaster with a set of possible evolutions of the atmosphere. This enables to assess, for each meteorological parameter, a finite sample of its probability density function (PDF) and not a unique deterministic value. Knowledge of PDFs allows to compute probabilistic forecasts for all the model parameters and to quantify the uncertainty.

For the case of severe weather events, it is possible to forecast the probability for a given meteorological parameter to exceed a specified threshold. It is worth noting that even a low probability attached to the forecast scenario leading to severe weather may have value. The corresponding evolution should not be excluded from the various possibilities given by the ensemble.

A large amount of data could be generated from EPS: mean value and standard deviation of the meteorological parameters for the ensemble or for clusters resulting from an automated classification, probability of the occurrence of several weather events. It would thus be useful to define diagnostics and synthesized products that summarize the assessment of severe weather potential in the medium range.

3.2.2 Short Range and Very Short Range Forecasting (SRF and VSRF)

From a practical point of view there was no need to distinguish between SRF and VSRF because forecasting is a continuous process. SRF and VSRF differ by the respective weights the forecaster gives to the model output on one side and to the observations on the other side. As the forecast range shortens, the importance of observations increases. SRF and VSRF activity can be viewed from the forecaster's point of view as a sequence of several processes: analysis that leads to understanding of the present meteorological situation and the recent past at the synoptic scale, assessment of the pertinence of the analysis, examination of the model output and identification of the key elements of the meteorological situation according to the conceptual models, choice of the most likely scenario, determination of the consequences of the chosen scenario for smaller scales and specific areas, description of the expected weather in terms of weather elements. The decision to issue severe weather warning results from the comparison of specific forecast weather elements with agreed thresholds, adopted in cooperation with the responsible authorities. But it is important to note that it is not possible to define standard thresholds for each category of severe weather phenomena (the values or the thresholds may depend on the level of protection against the possible damages and the decision to issue warnings does not only depend purely on the expected value of meteorological parameters).

As MRF, the SRF and VSRF activity also requires accessing a rather large amount of data. The evaluation of model output with help of workstation requires the ability to display all the 4-D meteorological parameters (allowing cross-sections, animation, overlaying). Nevertheless in case of severe weather, it is necessary to provide the users (Disaster Management and Civil Protection Authorities (DMCPA), for example) with meteorological information as simplified as possible. With this respect, the colored charts indicating the degree of risk for geographical areas, which are currently elaborated by several NMCs give a good example of the way to present the information.

3.2.3 Nowcasting

The forecaster's work for nowcasting is very much dependent on the use of observations, radar and satellite information and model output: it consists of checking whether the actual behaviour of the atmosphere agrees with the forecast one. This process needs to compare the model fields (or model synthetic images) with the actual state of the atmosphere indicated by real time satellite images or/and radar echoes. When the actual evolution differs from the model one, the forecaster should be able to adjust his/her forecast and to amend the products delivered toward the end-user. This task becomes particularly critical when a severe weather event is taking place. In the case of heavy precipitation, adjustment of forecast precipitation over small areas can be done with help of the nowcasting tools (mainly radar echoes extrapolation). Although automated tools have been developed to try to minimize the subjective decisions of the forecaster, a clear specification of the way to properly achieve nowcasting is far from simple. It seems difficult to specify a final product summarizing the result of the nowcasting activity to be communicated to the user. As nowcasting results require to be communicated to the DMCPA without delay the common way to work together with the user is at least issuing warning and using visualization system implemented in the office of the DMCPA. The task of the forecaster is also to provide the DMPCPA advice about the visualized information.

3.2.4 Exchange of information in the cascading process

For MRF it is necessary to examine several cases from the ensemble(s) and a lot of probabilities corresponding to several thresholds. For SRF the interpretation of the model needs to have the complete 4-D description of the model parameters. In addition, in the framework of a coordinated cascading system it seems essential to define simplified products summarizing the results of MRF on one side and SRF on the other side to be transmitted "**downwards":**

- the summary of the MRF process (consisting of evaluations of the risk of selected hazardous weather events) which has to be communicated to the NMC in charge of SRF and VSRF;

- the summary of the SRF process (consisting for example of simplified charts indicating the areas where severe event is likely to occur). An example of such charts was presented by Australia showing the areas threatened by different types of thunderstorms and their expected degree of severity.

These summaries should be easy to use in order to avoid increasing the workload of the forecaster, but they should trigger subsequent actions to be carried out after reception. What are the follow-up actions to be performed by the short range forecaster after reception of the MRF summary? What are the consequences of the SRF summary for Civil Security activities?

The workshop agreed that it was important to note that the implementation of a coordinated cascading system to forecast severe weather events requires also the definition of an "**upward"** flow of information (from the user to the producer). Indeed, there was the necessity to give clear information (real time feed-back) indicating the way the received information had been taken into account; and that would increase the vigilance of the various forecasters involved in the cascading process. Moreover such upward information (feed back) would be also an essential tool to assess the efficiency and the performances of the system. This feedback process should be activated every time a severe weather event was forecast.

### 3.3 Use of EPS and probabilities

The use and application of EPS products and in particular of probabilistic information for severe weather forecasting was considered by the workshop.

3.3.1 EPS provides a quantitative measure of uncertainty or probability faced with multiple forecast scenarios. The probability can be wisely used in decision making under uncertainty to yield the most desirable outcome if the economic consequence of each decision could be evaluated in monetary values and the relationship between a forecast scenario and the corresponding decision were well established. The severe weather is generally highly dangerous weather affecting local society in aspect of loss of human lives and damage to properties. The decision to prepare in advance against the severe weather requires the probabilistic forecasts for the risk associated with the severe weather concerned. EPS provides extreme scenarios feasible in the given synoptic setting. The severe weather event is rare, unique, and difficult to classify with conventional concepts, and often misleads even experienced forecasters on the likelihood of the event to occur. The EPS alerts forecasters to the possibility of the severe weather event regardless of the high or low value of probability. The synoptic pattern of severe weather could be represented in some member forecasts of EPS, which would be most valuable to forecasters to develop various weather scenarios well ahead of time, and to prepare for further monitoring and investigation on mesoscale developments along with, as the target time become closer to 1-2 day leadtime. The extreme value index, mean/spread in precipitation amounts, spaghetti plots for critical precipitation thresholds are a few examples of products to be used. The workshop also recommended that derived fields like CAPE; LIFT index should be generated from EPS and their usefulness evaluated.

3.3.2 It was reported to the workshop that in some cases, for medium-range, the forecasters would give priority to the EPS products rather than the deterministic forecast, but that below 3 to 4 days they prefer to have the deterministic global forecast. EPS gives a probabilistic information. It gives probabilities of thresholds, of extremes, which have to be related to the model climate. A forecast guidance would use the "Extreme Forecast Index" (EFI) charts for wind, temperature and rain (as provided by ECMWF).

3.3.3 However it was also reported that EPS has failure, and may generate false alarms, but comments were expressed saying that false alarms were better than missed events. EPS results need also to be interpreted, before issuing a forecast for the external user, especially the responsible authorities. However, some user may want to use a products based only probabilities (e.g water resources management). It depends on the ability of authorities to use this information. Reports and advice are sometimes better appreciated. The workshop considered it might be good to use the EFI in a demonstration project. Every countries would need different calibration for thresholds for warnings.

3.3.4 In the demonstration project, the NMC would have to analyse the products, starting with a guess forecast at the medium-range stage, and then refine the possible scenarios, eliminating what appears to be wrong. One has to reduce the uncertainty as time range shortens, and increase the accuracy of the forecast. Consultation and feed-back between centres would be necessary in that process. These steps would be important especially for heavy convection forecasting.

3.3.5 The workshop considered that EPS could have a great role for Tropical Cyclone forecasting, with the track plumes and the strike probabilities. The possible use of probabilities for wind and precipitation intensities would have to be evaluated. The demonstration project for Tropical cyclone prone areas should focus on the applicability of EPS to tropical cyclone forecasting.

3.3.6 The workshop agreed that the following points were crucial for the use of EPS by forecasters: they had to:
- Understand where to find and how to build a range of scenarios, alternatives, and extremes based on various EPS charts for varying synoptic setting (stamp maps, spaghetti charts, ensemble mean and spread, cluster/ tubes, EPS grams and plumes, EFI index, etc.);
- Understand how to interpret various probabilistic EPS products for confidence assessment, risk management and communication of uncertainty to users (including PDFs/CDFs, stacked probabilities, storm track and strike probability charts);
- Understand how to combine EPS products (regional EPS in particular) with deterministic forecast charts and nowcasting information to add values, to develop scenarios on mesoscale details and to make decisions on severe weather warnings in a seamless manner;
- Appreciate the capabilities and limitations of EPS products compared with deterministic products.

3.3.7 Some participants of the workshop considered that at the medium-range stage it was still not possible to be fully automated, especially for severe weather, since forecasters have to evaluate the risk of severe weather and express the possibility in writing, and in consultation with responsible authorities. The workshop agreed that the severe weather forecasting would require two stages; (1) pre-alert stage for synoptic condition, and (2) downscaling to meso-scale details. Extratropical cyclone, tropical cyclone, polar lows are considered in the former, and severe thunderstorm, heavy rain or snow, dust storm, cold surge imbedded belongs to the latter. Concerning the use and value of short-range EPS, the workshop agreed that it could deserve special case studies, but that it could be considered only in a few years since these systems were still more at an experimental stage, and run in only a few countries.

### 3.4 Sharing information between forecasting offices

The required exchange of information, in particular NWP products and warnings between forecasting offices of same or different countries was considered by the group.

3.4.1 Existing systems in Europe were described. Warnings of severe weather are exchanged between partner countries by different means, e.g. fax is used to pass a special bilingual form between Germany and France or Germany and the Czech Republic. Text bulletins (with WMO header) are used by München to inform Austrian regional centres. Also a forum on the Internet has been used to discuss complex weather situations. The forecasters had reported that these exchanges were found useful. NMHs should be encouraged to exchange such information.

3.4.2 The European EMMA project was presented and its primary objective consisted of providing a coloured map of various degree of vigilance to the public and other NMCs in different areas over several European countries. The group felt it was a good system, but that it was more a Public Weather Service issue, and not an objective of the demonstration project. Although, ultimately, it would have to be considered as a mean of conveying the information to the end user.

### 3.5 Interface with other sciences (e.g Hydrology)

The necessary interfaces with other scientific and technical groups, mainly the Hydrological Agencies, involved in Severe Weather Forecasting and Warnings was considered.

3.5.1 It appeared that the interface with other sciences, environmental or hydrology, was presently limited, even in advanced countries. There were efforts attempting to improve coordination between the agencies, and in particular in the development of coupled atmospheric-hydrological models. For the moment many hydrologists only use observed precipitation as input to their model, but there would be benefits in using information available from an atmospheric model.

3.5.2 As an example of the current development, the group examined what was being done in Europe. There were several Projects of interface of meteorological models with hydrological models on several basins. The operational implementation is expected to come very soon for some of these systems (perhaps 2005). There were however still difficulties in obtaining high-resolution precipitation data. High computer capabilities were required to run these systems. There was a need to structure the real time operation between communities. EPS could be used for interfacing with hydrology.

3.5.3 The problem of large basins flooding is quite different from that of flash floods. The conditions of the previous days or weeks give the levels of risks for some parameters in the large basin's flood. Meso-scale high-resolution models would be useful for flash floods. For nowcasting, RADAR information would be fundamental. The forecasters as well as the hydrologists have to learn how to make best use of probabilistic information. Some methodology and standards would have to be developed in this area.

3.5.4 The workshop recognized that the European projects potentially fit well with the expressed interest in the field of interface between meteorological and hydrological forecasting, and the workshop suggested that the CBS be informed of the outcome of theses projects.

### 3.6 Requirements of responsible authorities

The requirements usually expressed by responsible authorities and their implications on the forecasting process were considered by the group.

3.6.1 To satisfy the requirements usually expressed by responsible authorities there were two important principles to fulfil:

- to avoid as much as possible missed (no detection) cases of severe weather events.

- to reduce at the same time, as much as possible, useless warnings (false alarms) in order to establish some credibility.

The responsible authorities need to be warned for managing their interventions in order to be operational as quickly as possible. However too many useless warnings might compromise the credibility of the warning system itself. Therefore, when new procedures of warnings were implemented (e.g. Meteo-France's vigilance charts), following the requirements of the DMCPA, the thresholds for several parameters were increased (e.g. by Météo-France) in order to focus on extreme events only.

3.6.2 Distinction had to be made between two types of meteorological weather events:

1) Severe events with important spatial or temporal amplitude (for example a moving storm or heavy continuous precipitation over a large area).

2) Very local event but nevertheless extremely severe with very devastating phenomena (for example stationary thunderstorms over Mediterranean areas).

The first case concerns large-scale meteorological systems, which were generally well forecast by operational models. The models were able to describe correctly the state and the behaviour of synoptic scale weather systems up to three days. In the case of large cyclogenesis, even if some uncertainty about the trajectory and the value of the minimum of pressure is possible, a good confidence in the main scenario was there. Then early warning (24 h ahead and even more) was useful for the authorities because this kind of event needed to mobilize important means, which could not be managed by local authorities. For shorter range (< 24 h), a warning could give more details about the location of the low and the strongest expected gusts in order to specify the more exposed areas and to allow DMCPA to target their intervention means.

The second case particularly concerned severe convective events for which such anticipation could not be expected. It was only possible to know whether the synoptic environment would be favourable to the development of very strong activity and therefore it was more difficult to produce accurate early warning. Moreover, issuing systematically early warnings lead to increase the false alarm rate. Indeed the experience showed that for this kind of event, even if the risk decreased for short range, it did not disappear totally and it could be hazardous to terminate the warning. New problems arose with the mesoscale features produced by the models: often convection parameterisation schemes tend to produce wrong features, which perturbed many meteorological fields at the synoptic scale. This was the reason why numbers of warnings were issued less than 24 h ahead and were then updated in accordance with the extrapolation, which could be assessed by using nowcasting tools.

3.6.3 It was also important to consider the situation where hazardous events happened without any warning having been issued. In this case the forecaster had to react very quickly, use all the available nowcasting tools and products available and produce information about the expected duration of the event and the possibility of similar events in the near future.

3.6.4 The workshop agreed that it was fundamental to discuss first with the authorities to define what they required as warnings and then analyze their requirements (which might depend on the specificity of the country), and then one had to derive the implications for the work of the forecaster. The authorities should also understand the distinction between warnings and awareness. At the medium-range stage, in many cases, only an awareness message might be given to the authorities. To give probabilities to authorities would require some training to be dispensed to them, and the actual understanding and implementation might take quite some time. Preliminary discussion with the authorities was a must. One had to explain that at the Medium-range stage, it is a risk management approach that the user has to take. For the forecaster, giving a warning is a deterministic decision, which requires some certitude, that cannot be offered, in most cases by medium-range EPS or deterministic models. High-resolution models might be able to help this process with downscaling. Experience would have to be gained in the use of short-range EPS models (e.g COSMO-LEPS might demonstrate that there is a possibility of forecasting convective precipitation), which might provide probabilities on the intensities of the events.

3.6.5 In tropical countries, convective phenomena would require different thresholds. The availability of observations would be crucial for nowcasting and also for the usefulness of the models results. The physical limitation of the forecasting systems might be more serious in the tropics. Pre-warning in the short range could be given while warnings could be sent only few hours or less before the events.

### 3.7 Guidelines for the demonstration project

3.7.1 The meeting defined the broad goals for the demonstration project and the roles of the participating centres. It agreed on a three-level approach and provided guidelines on the implementation of a cascading process. It considered several aspects essential to the success of the project.

3.7.2 It was important to consider the capacity of the forecasters to receive and use the available products and to ensure that the approach considered was sustainable. It was noted a number of products were available and accessible but were not used to their full extent, and that some training would be required to improve that situation. Another important aspect was the capability of the users to apply the information. For example, it was important to work with end users and in particular governments in the development of policies related to the use of information on severe/extreme weather events which often translate into disasters. There was a need for governments to factor weather information as an essential component of the management of natural disasters. There was a need to establish stronger links with disaster management and civil protection organizations.

3.7.3 The demonstration project will require the involvement of a global NWP centre, a regional centre and an NMC referred to as a three-level approach. It will be used to demonstrate the kind of cascading process described in 3.2. The roles and capacities and commitments of each participating centres need to be defined.

3.7.3.1 The goals of the project need to be clearly stated. The workshop agreed on the following broad goals :

- to improve the ability of NMCs to forecast severe/extreme weather events
- to improve the lead time of alerting of these events
- to improve interaction of NMCs with DMCPA before and during events
- to identify gaps and areas for improvements

3.7.3.2 In addition, the demonstration project will allow the assessment of the value of probabilistic forecasts and the skill of EPS products, and enhance the capacity of NMCs (training, capacity building).

3.7.4 Three-level approach: Roles and commitments of participating centres

3.7.4.1 One or more global NWP Centres will be committed to provide information, model output and products relevant to the area covered by the project and for the duration of the project. The information provided could be e.g. gridded output and derived products (e.g CAPE, stability indices, etc. ) from deterministic model, EPS output such as extreme weather index, probability of precipitation/wind exceeding a certain threshold. The information provided will be agreed upon prior to the beginning of the project and would be generally composed of existing products but provided for a specific area. The global centre would provide a contact person for the duration of the project to facilitate exchange of information. This would facilitate feedback from users to the global NWP centre on the usefulness and skill of the products and help improve global model and products.

3.7.4.2 The role of the regional centre would be to interpret the information received from global NWP centres, use that information to develop guidance /diagnostic products on potential for severe weather and make that information available to participating NMCs. This would provide indication of potential area for severe weather 3 to 5 days ahead of time. As it gets closer to the event, 36 to 72h prior to event, the regional centre would run a mesoscale model to refine products, confirm potential for severe/extreme weather and make information available to NMC. It will provide advice to NMC as required. It would provide feedback to global NWP centres concerning usefulness and skill of products and participate in the evaluation of the project from a regional centre perspective.

3.7.4.3 The NMC will use and interpret guidance from regional centres. It will be responsible for establishing contacts with disaster management and civil protection agencies, understand their needs and provide advice to them. It will issue alert, advisory and warnings as appropriate. It will actively participate in the evaluation of the cascading process from an NMC perspective, provide feedback to the regional centres on usefulness and skill of diagnostic products. It will monitor in real-time, using all data available, the evolution of meteorological systems as compared to NWP and other guidance. It will use nowcasting techniques in the last 12 hours to give best information to decision makers as it gets close to the event. The NMC will play a key role in developing linkages with the disaster management and civil protection agencies.

3.7.5 Criteria and commitments

3.7.5.1 In order to be successful, it is important that specific criteria for participation be met. In particular participating regional centres must have the ability to interpret, use and evaluate products from global NWP centres, they must have the ability to run limited area model over the regions considered for the project and commit resources for the duration of the project. They will participate in the training of participating NMC(s) and provide a lead person for the duration of the project.

3.7.5.2 The commitment of NMCs is essential to the success of the project. Each participating NMC must provide a lead person for the duration of the project as well a senior forecaster involvement. The senior forecaster must meet WMO standards for meteorologist (university degree in meteorology), have knowledge of local weather, must have attended workshop in NWP. Participating NMCs must have as a minimum a 64 kb/s communication infrastructure, operational real time access to satellite data and products, and some ground stations for evaluation and monitoring purposes, adequate telecommunication system to receive and transmit information and appropriate workstation that meet data processing standards.

3.7.6 This project will only succeed if there are clear commitments from all participant to fulfill their roles as described above, as well as commitments to participate in the evaluation of the project (lessons learned, identify gaps, and make recommendations). The project will build on existing capabilities and be developed with a view to ensure sustainability. Performance measures will need to be established prior to the start of the project. A process will be established to ensure that all severe weather events are documented. It is recommended that at the end of the project, there will be an in depth analysis, including the feedback from all parties including disaster management and civil protection agencies involved. It is also envisaged that other centres and agencies be informed of the results. It was proposed that project duration should be of one year to ensure that sufficient severe weather events are analyzed. Further details are contained in annex to this paragraph.

## 4. DEMONSTRATION PROJECTS

It was envisaged that 2 types of project could be developed, one that is aimed at improving severe weather associated with Tropical Cyclones, and another project focusing on improving heavy precipitation/strong wind forecasts (not associated with tropical cyclones).

## 4.1 Severe weather associated with Tropical Cyclones

CBS –ext (Cairns, December 2002) noted that current arrangements for the provision of forecasts for tropical cyclone gave a good example of the benefits, which could be derived from a more structured approach with different levels of responsibilities. It further agreed to encourage the implementation of forecast guidance related to tropical cyclones and to follow-up the new development in that area.

4.1.1 It is recognized that tropical cyclones are one of the major causes of severe weather in many countries. For example, it causes the largest number of casualties in developing countries in the Asian continent and islands in Indian Ocean and Pacific Ocean. It is recognized that linkages will need to be established with the Tropical Cyclone Programme to further develop this project.

4.1.2 The objective is to bring new tools and technology based on EPS, in addition to existing products, and to help improve the forecasts of severe weather associated with Tropical cyclones. The success of EPS in the Tropics has not been demonstrated yet. Current EPS is more or less focused on the mid-latitude dynamics (beyond 20 N). Also the horizontal resolution of ensemble members (around 80 km) is not sufficient to resolve the inner core structure of tropical cyclone, but it may still provide some useful information. A range of EPS products could be made available by producing centres but they need to be evaluated during the project for use in the Tropics.

4.1.3 Track forecasting of tropical cyclone have progressed significantly over the last years due to the progress of dynamic models and data assimilation. However, forecasting the intensity of the cyclones remains a challenging subject at operational centers: heavy precipitation and strong winds, particularly associated with landfalling tropical cyclones, which significantly influence the community through storm surge, floods, and severe thunderstorms. Often it is reported that tropical cyclone interact with large-scale circulations such as monsoon trough, mid-latitude troughs, and induce heavy precipitation far off the center of tropical cyclone in mature stage or in dissipating stage. The formation and extra-tropical transition of tropical cyclone are also of interest and cover a wide range of latitudes from tropics to mid-latitudes during the life cycle of a tropical cyclone. EPS probabilistic products, high resolution deterministic NWP guidance provide an important opportunity for the improvement of tropical cyclone forecasting as demonstrated by the recent progress in track forecasting in major NWP centers. A more detailed description of such a demonstration project is included in annex to this paragraph.

## 4.2 Severe weather not associated with tropical cyclones

Africa and South America were considered as potential candidate regions as they experience several devastating events associated with heavy rain and strong wind, and also many countries have a high degree of vulnerability.

4.2.1 Most countries in these regions have knowledge in using NWP but few of them have information and knowledge about EPS. Most of these countries have satellite reception systems (e.g. MDD, RETIM, SADIS, ISCS) to allow them receiving some global products and satellite data. Most of them do not have capacities to run adaptation tools, and limited area model. Technical capacity must allow countries involved in the project not only to receive products but also to send them to emergency authorities. The cascading process is therefore an approach that could benefit several countries.

4.2.2 For the project to be successful, it is important that proper attention be given to deliverables, and indicators that will be used to determine success and sustainability of the process. Several participants were of the opinion that one year may not be a sufficient period. Nevertheless, the project should be reviewed after one year; gaps and areas for improvements identified. At this point, a decision will need to be taken as to whether there is a need to extend project longer, or should be expanded to other areas.  Further details are provided in annex to this paragraph.  A detailed project will be developed once participating countries are identified.

## 5. NECESSARY RESOURCES

One of the key criteria for the success of the demonstration project is its sustainability.  It was agreed that participating centres should be chosen on the basis of their existing capabilities.

5.1 It is anticipated that some funding will be required for the following actions:

- A consultant will likely be required to help in the further development of the project, to evaluate capabilities of participating centres, assess training requirements (one week to 10 days work in the participating countries).

- Some training will be required for participants.  Training may take different forms: e.g. train the local trainers in workshops, training at the regional centre on the cascading process, training the staff in the NMC by a consultant.

- Some help from a consultant to assist NMCs establish and/or improve links with their respective disaster management and civil protection agencies.

- A consultant may be needed to help develop the evaluation process, performance measurement and make an early assessment.  An early assessment would allow making necessary adjustments at the beginning of the project to ensure success. (one week's work)

- Two meetings are deemed necessary for each project: one meeting of experts from participating countries to develop the details of the project and a meeting after completion of the project to assess the project and make recommendations for future work.

5.2 It is anticipated that global NWP centres will contribute products on a voluntary basis.  For example, ECMWF is already making available a number of products on the GTS and the WEB for NMCs.  The ECMWF Council is very supportive of WMO Programmes in particular for severe weather.  It would be supportive of providing severe weather products based on EPS, EPSgram, for a demonstration project to well defined participants and for the duration of the project.  It would consider moving data to an external server and generate additional products such as CAPE.  Other centres may also be interested in contributing to the demonstration project(s).

## 6. CLOSURE OF THE WORKSHOP

The chairperson, Mrs Angèle Simard thanked all the participants for their contributions and closed the workshop at 13.30 on Friday 29 October 2004.

**ANNEX TO PARAGRAPH 1.1**

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**ANNEX TO PARAGRAPH 3.7.6**

## *DEMONSTRATION PROJECT*

**Goals:**

- To improve the ability of NMCs to forecast severe/extreme weather events
- To improve the lead time of the alerting of these events
- To improve interaction with disaster management and civil protection agencies before and during event
- To identify gap and areas for improvements

Sub goals:

- To evaluate the value of probabilistic forecasts and the skill of EPS products
- To enhance capacity of NMCs (training, capacity building, etc..)

**Three – level approach:**

1) Global NWP Centres: producers of products;
2) Regional Centres with human and technical capability to run NWP models over a limited area, to interprete products from global NWP centres;
3) NMCs with sufficient capacity to benefit from project.

**Roles of each centres:**

1) Global NWP Centres:

- Commitment to provide NWP products over area covered by the project for duration of project(s): deterministic model, EPS output such as extreme weather index, probability precipitation/wind exceeding a certain threshold.

2) Regional Centres:

- Interpret information received from global NWP centres, develop diagnostics products/guidance material on potential of severe weather based on EPS products (timeframe 3-5 days ahead of time); make the information available to participating NMC(s);
- As it gets closer to event, run mesoscale model to refine products, confirm potential for severe/extreme weather, provide more detailed information (36-48H);
- Establish communications between regional centre and participating NMC;
- Evaluation of approach from regional centre perspective;
- Provide feedback to participating global NWP centres.

3) NMCs:

- Liaise with disaster management and civil protection agencies;
- Establish contacts with above agencies prior and during event;
- Interpret information received from Regional Centres and assess diagnostics products against available information and make adjustments as required;
- Apply nowcasting techniques;
- Issue alert, advisory, warning as appropriate;
- Evaluation of cascade approach from a forecaster perspective;
- Provide feedback to regional centre on usefulness and skill of product;
- Get feedback from users.

**Criteria for participation**

The project will only succeed if participating NMCs agree to meet certain pre-determined criteria. Participating centres must meet the requirements listed below.

1) Global NWP centres:

- Commit to provide agreed upon information during duration of project;
- Consider feedback from users as appropriate;
- Provide a contact person for the project.

2) Regional centres:

- Ability to interpret, use and evaluate products from Global NWP centres;
- Ability to run limited area model over region considered;
- Provision of training to participating NMCs as required;
- Provide a lead person for the duration of project.

4)NMCs

- Minimum communication bandwidth of 64kbps;
- Access to satellite data and some observations from ground stations;
- Provisions of senior forecaster for the duration of the project that must meet WMO standard training for meteorologist: meteorologist who acquired at the university an appropriate knowledge of mathematics, physics, and chemistry and completed a degree specialized in meteorology;
- Provision of a lead person for duration of project;
- Commitment to establish liaison with disaster management and civil protection agencies within their country.

Potential participants will have to demonstrate that they meet the above criteria.

More general criteria:

- Regional centres and NMCs would be from same region, and be able to communicate in same language;

- Must be in area where severe weather is encountered;

- Ability and commitment to participate in the evaluation of the experiment: criteria, indicators, etc..;

- The project must be sustainable: use of existing capacity, on-going commitment of participating centres, on-going assessment of usefulness and skill.

**ANNEX TO PARAGRAPH 4.1.3**

## DEMONSTRATION PROJECT ON TROPICAL CYCLONES

Specific objectives:

In addition to broad objectives described under chapter 3.7 of the report:

- To bring the available technology and tools, including EPS, to the forecasters in developing countries for the improvement of intensity forecasting. Capacity building should not be overlooked.
- To evaluate the usefulness of EPS in various aspects of intensity forecasting associated with tropical cyclone in terms of lead-time, quantitative measure of probabilistic information from both forecasters and users point of view.
- To evaluate EPS guidance against deterministic guidance including high-resolution NWP products on varying lead-time (medium to very short range).
- To promote the usefulness and value of EPS guidance particularly in the form of probabilistic guidance for the disaster mitigation from heavy rain, storm surge and strong wind from tropical cyclone, and to evaluate the effectiveness of information at three level of cascading stage including the linkage between meteorological office and disaster management authorities at national level.
- to identify limitation of the value of current EPS products particularly over Tropics, and direction for improvement.

Potential products:

In addition to existing information from Tropical cyclones program:

- Deterministic grid output (3-5 days in advance);
- Probabilistic information on track and intensity, including precipitation and wind higher than a certain threshold, EPSgram (grid point information on temperature, precipitation, wind) (3-5 days in advance);
- Some regional model output (24-72 hour in advance).

Deliverables:

At the end of the demonstration project, the expected outcome would be:

- Evaluation on the utility of EPS guidance in improving severe weather associated with tropical cyclone: timing, lead-time, location, scale of impact, and effectiveness to alarm disaster management authorities for preventive and/ or counter measures;
- Better tool to forecast intensity of tropical cyclones based on NWP guidance including EPS products;
- Identification of gaps and areas for improvement (i.e. additional products required, training needs, infrastructure enhancement such as telecommunication requirements to access the modern NWP products). This could be used in future steps e.g. to develop a proposal to enhance capabilities of NMCs in collaboration with disaster management sector.

Cascade process:

- One or more global EPS centers would provide the probability distribution of TC tracks and strength of TC intensity in terms of rain, wind, temperature, central pressure, EPSgrams along

with conventional form of NWP guidance for 3-5 days in advance through Internet or other communication means available for the target country;
- The products would be provided to the RSMC for Tropical cyclones who would interpret the information;
- High resolution limited area models may provide detailed synoptic conditions and possible some mesoscale signatures on the distribution of rainfall and wind structure, and their interaction with topography or with large-scale circulation;
- The various downscaling process will be activated to infer detailed scenarios for expected disasters associated with storm surge, floods, strong wind, and severe thunderstorms. The exchange of information among partners is requested (such as oceanographers for storm surge, hydrologist for floods, and disaster managers for evacuation, civil engineers for protection of property, etc.);
- When the threat is imminent such as TC landfall, the observation can be compared with the model guidance and corrections are made to fit with the latest observation in nowcasting range.

Three levels and roles:

- Global NWP centers provide available NWP products particularly in the form of probability;
- Regional centres provide some coordination for the definition of episode, interpretation for the guidance, collection of feedbacks, and training for facilitating the demonstration by targeted user NMCs;
- NMCs provide severe warning, evaluation of the project (the WWRP reference on the standard form for verification is desired). They are also responsible to communicate with disaster management sector, particularly for hydrology group and DMCPA component. They are requested to comment on further improvement to be carried out by advanced centers.

Duration:

- A whole year to sample on extreme storm events (classified as tropical storm or stronger in Pacific region for instance).

Evaluation of demonstration:

- To measure the accuracy of meteorological products using WMO standards;
- To measure the process itself, survey is recommended after each storm event towards both forecasters and end users at national level.

Preconditioning:

- The infrastructure for the communication and/or verifying ground network should be available for the participating NMC;
- The targeted user NMC have an appropriate capability for the evaluation of the cascading process and the usefulness of the processed information;
- The committed NMCs and/ or intermediate RSMCs have to identify the forecast problem (i.e., how to use the given NWP guidance on what sort of severe weather in tropical cyclone), and the way of verifying the process for all three level of cascading.

Special recommendation to CBS/WMO:

- Global NWP centers are identified as willing to provide as much EPS products as available to target user NMCs;
- Approach regional bodies such as regional association or tropical cyclone community to find appropriate regional centers that coordinate the interpretation of NWP guidance, train target user NMCs and collect feedbacks from the users;
- The participating NMCs should be identified as highly motivated to use the latest available NWP products for their forecasting process, while being committed to evaluate the accuracy of the

information, the usefulness of the information provided and the effectiveness for the disaster mitigation, from a meteorological service perspective.

Downscaling details:

- The uncertainty of meteorological information based on EPS could be further processed for refining the assessment of the risk associated with storm surge and flood, which could be handled with a coordinated effort with the hydrology community and the coastal engineering community.

Remarks:

- A tropical cyclone may hit a single country and/ or several countries on its passage. In case several NMCs may be involved in any single event, associated NMCs may participate on the demonstration. The targeted NMC may not necessarily be limited to a single country.

- Many global NWP centers including ECMWF have a plan to enhance the resolution of their EPS, which could provide additional opportunity and motivation to participate on demonstration project.

- In a sense the tropical cyclone program is well established at regional level. Some agreement or harmonization have to be developed to make the demonstration successful from the planning stage to the implementation stage. Some institutional arrangement between CBS and tropical cyclone community has to be made.

- The linkages between NMCs and disaster management and civil protection agencies need to be strengthened, as it is very weak in some countries.

- Performance measures need to be developed to verify the usefulness and the skill of the projects. There may benefits to use the scheme developed by WWRP for the demonstration project during the Sydney Olympics. The scheme should evaluate the performance from both a forecaster perspective and user point of view.

**ANNEX TO PARAGRAPH 4.2.2**

**DEMONSTRATION PROJECT TO IMPROVE FORECASTS OF HEAVY RAIN AND STRONG WINDS**

**Objectives:**

In addition to the broad objectives described under chapter 3.7 of the report

- To bring the available technology and tools, including EPS, to the forecasters in developing countries for the improvement of severe weather forecasting related to heavy rain and strong winds;
- To evaluate the usefulness of EPS in various aspects of heavy rain and strong wind forecasting in terms of lead-time, quantitative measure of probabilistic information from both forecasters and users point of view;
- To use current available products to their full capacity;
- Develop linkages with between meteorological office and disaster management authorities at national level;
- To identify limitation of the value of current EPS, diagnostic products, nowcasting techniques and direction for improvement.

Potential products:

- Identify currently available products;
- Deterministic grid output (3-5 days in advance);
- Probabilistic information such as precipitation and wind higher than a certain threshold, EPSgram (grid point information on temperature, precipitation, wind), diagnostics products (stability indices, CAPE) (3-5 days in advance);
- Some regional model output (24-72 hour in advance).

Deliverables:

At the end of the demonstration project, the expected outcome would be:

- Evaluation on the utility of EPS guidance in improving lead time for disaster management authorities for preventive and/ or counter measures;
- Better tools to forecast severe weather;
- Increase use of NWP and diagnostic products;
- Improved links with disaster management and civil protection organization;
- Identification of gaps and areas for improvement (i.e. additional products required, training needs, infrastructure enhancement such as telecommunication requirements to access the modern NWP products). This could be used for future steps (e.g. to develop a proposal to enhance capabilities of NMCs in collaboration with disaster management sector).

**Cascading approach:**

1) Global NWP centers: provision of products of interest over the area covered by the project. This will allow assessing the ability of existing products to add value to the forecasting services in the participating countries. Global NWP centers are encouraged to enhance the list of products that they make available and improve the accuracy of the existing products based on feedback from users.

2) Regional centres (belonging to target region) with technical and human potential to run numerical model and generate new product adaptation tools for their own use and for dissemination and capacity building for other countries. The role of the regional centre will be crucial during the demonstration project implementation phase. This centre through intensive discussion with the global NWP centers

has to build an evaluation/validation process/mechanism from the beginning in order to detect any added value during and after the demonstration project period.

3) NMCs provide severe warning, evaluation of the project ( e.g. the WWRP reference on the standard form for verification). They are also responsible to communicate with disaster management sector, particularly for hydrology group and DMCPA component. They are requested to comment on further improvement to be carried out by advanced centers.

**Action plan:**

During the discussion it was pointed out that the period of one year cannot be enough to show clear and strong added value. The idea to consider three phases around the demonstration project:

**A) Pre-demonstration period-Feasibility phase:**

During this phase an inventory of existing products, capacities (telecommunications, data-processing, human resources, etc…), vulnerabilities will be undertaken for potential candidate countries. This will allow selecting participating countries, ensuring that they meet criteria, and better defining problems to be addressed.

**B) Demonstration period:**

**1)** Demonstration project precision phase: as output of the feasibility phase the term of references of the demonstration project have to be well identified and detailed: general objectives, specific objectives, expected deliverables, team members, international, regional and national coordinators, time table, list of partners, list of product and processes, resources needed.

**2)** Implementation phase: during this phase one can start by generating the optimal use of existing products with the necessary adaptation. In this phase the role of the regional centre is crucial in term of product adaptation, process validation and capacity building.
The second step concerns the improvement of the existing processes even in the regional centre to engage communications with the NMCs, to ensure a mechanism for validation/feedback. The aim is to implement a pilot operational warning system in both regional centre and at least one NMC: coordination, optimization and facilitation of the exchange of information have to be considered. At the end of this phase a **dynamic warning information system** have to be implemented with easy access by the existing telecommunication tools (fax, telex, internet, satellite,…).

**3)** Sustainability phase of the warning system (Continuous evaluation/improvement): During this phase the warning system has to enter in operational suite assuring all the accompanying measures that allow robustness, maintenance and sustainability of the warning system. The Warning Information System has to be continuously updated; the interaction with the end users regularly maintained; systematic coordination assured, etc…

**Post- evaluation:**

It is proposed to assess the project after one year. Based on the assessment, it may be decided to continue the project for another period, to make some adjustment to the project or terminate the project.