WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

IMPLEMENTATION COORDINATION TEAM ON DATA-PROCESSING AND FORECASTING SYSTEMS (ICT-DPFS)

TOULOUSE, FRANCE, 29 MAY – 2 JUNE 2006

FINAL REPORT

Executive Summary

The Implementation Coordination Team reviewed the work and outputs of all its Expert Teams, Coordination Group on Nuclear Emergency Response Activities, the Rapporteur on Application of NWP to Severe Weather Forecasting, as well as the Severe Weather Forecasting Demonstration Project Steering Group.

Guidance on the use of EPS products entitled: "Guidelines on Using Information from EPS In Combination with Single Higher Resolution NWP Forecasts" developed by the ET-EPS should be made available on the WMO Web site. As products from EPS systems evolve, guidance materials should be developed to facilitate their implementation and use, such as in severe weather forecasting. A guide on EPS was proposed. Training on EPS products continue to be in high demand and the ICT suggested that various complementary approaches could be used to effectively meet the demand.

The Severe Weather Forecasting Demonstration Project's first regional subproject is being organized for the south-eastern region of Africa with the anticipation to commence the field phase of the subproject by November 2006. Participating centres include NMCs of Botswana, Madagascar, Mozambique, Tanzania and Zimbabwe; and RSMC Pretoria, RSMC La Réunion, ACMAD, ECMWF, Met Office UK, and NCEP.

Producing centres of global long-range forecasts expressed the importance of facilitating the development of multi-model ensembles. The ICT encouraged the Global Producing Centres (when designated by CBS) to interact with Regional Climate Centres and NMCs to determine and confirm their needs. The list of Observation Data Needs for Producing Global LRF was reviewed and will be conveyed for consideration by the CBS/OPAG on IOS, CCl, and GCOS.

The ICT considered the importance of data-processing aspects including those relevant to "nowcasting" as part of the weather forecasting process. The complementary mix of the observations and high-resolution NWP to support nowcasting depends on the phenomenon, the lead-time, and actual events.

Specialized meteorological support to nuclear emergency response is a commitment of WMO to the International Atomic Energy Agency, and has continued to be carried out under the Regional and Global Arrangements and routinely tested through exercise. The WMO Technical Note No. 778 entitled: "Documentation on RSMC support for Environmental Emergency Response (targeted for meteorologists at NMHSs)" is the technical guide to the ERA programme and needs to be maintained. Operational atmospheric transport modeling at WMO centres has evolved to include a backtracking capability, which has proven to be a very useful for determining the possible source of an airborne tracer. RSMCs are prepared to expand their ATM capabilities to include this aspect.

Cooperation with the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) has reached a point where operational arrangements between WMO and CTBTO were developed and are recommended to CBS.

In relation to the application of atmospheric transport modelling for non-nuclear emergency response the ICT agreed that because of the predominately “localized” and short-lived nature of environmental emergencies related to chemical incidents, that the strategy and plan of action should be concentrated on developing the necessary capabilities at the NMHSs. In the case of smoke from large fires, a regionalized approach would be appropriate, where designated RSMCs would provide emergency support to NHMSs and at the same time build capacity at the national level. There is also potential for a similar concept of operations to be applied to major sand and dust storms, although more investigation into the level of need for Regional/Global arrangements was required.

Regional aspects of the DPFS were presented. Aspects related to the status of implementation of NWP and training needs were discussed and incorporated into the future work programme where appropriate.

The ICT recommended amendments to the WMO Manual on the GDPFS (WMO-No. 485) that will be carried forward to CBS-Ext.(06), in the areas of EPS, LRF, and ERA. The recommended amendments are found in the Addendum to this report.

The future work programme of the OPAG on DPFS was developed, including a revised team-structure and terms of reference. The following new structure for the OPAG on DPFS will be recommended to CBS:

- Implementation Coordination Team on Data-Processing and Forecasting System;
- Coordination Group on Forecast Verification;
- Expert Team on Ensemble Prediction Systems;
- Expert Team on Infrastructure for Numerical Weather Prediction;
- Expert Team on Very Short-range Forecasting;
- Expert Team on Extended- and Long-range Forecasting;
- Coordination Group on Nuclear Emergency Response Activities
- Expert Team on Modelling Atmospheric Transport Modelling for Non-nuclear Emergency Response Activities;
- Rapporteur on the Application of NWP to Severe Weather Forecasting

The ICT stressed that strong liaison with the PWS programme would be required in several areas, in particular in the area of EPS and of very short range forecasting because of the wide range of end users who could benefit from their development.

Note : The APPENDIX to this Report, contains all the recommended amendments to the Manual on the GDPFS

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1. Opening of the Meeting

1.1 The meeting of the CBS Implementation Coordination Team of the OPAG on Data-Processing and Forecasting System (DPFS) was opened at 10:00 a.m. on Monday, 29 May 2006 at Météo-France, Toulouse, France. On behalf of Météo-France, Mr Bernard Strauss, Director of Forecasting, welcomed the ICT meeting. Mr Olivier Moch, Director General Adjoint of Météo-France, later also added his welcome to the meeting.

1.2 On behalf of the Secretary General of WMO, Mr Peter Chen explained the context of the work of the OPAG in CBS that addresses the numerical weather prediction (NWP) systems that are implemented by WMO Members as part of the Global Data-Processing and Forecasting System (GDPFS) of the World Weather Watch, which includes the Emergency Response Activities programme. As well, it was noted that CBS-XIII (2005) had noted significant progress made in the areas of Forecasting Standards, EPS (products and applications), Severe Weather Events Forecasting, Long-range Forecasting (Infrastructure and Verification), and Emergency Response Activities. This meeting, in advance of the CBS-Ext.(06) will review the work of the OPAG and develop appropriate recommendations to the coming Session, including its structure and its future work programme.

1.3 On behalf of the Secretary General, Mr Chen thanked the chairpersons of the teams for their dedication and effort to the work that was assigned under their leadership, and at the same time encouraged effective interactions with the Regional programmes, in those aspects related to the implementation of the GDPFS.

1.4 Mr Bernard Strauss, Chairman of this OPAG and the ICT, made general remarks on the programme of work that was assigned to the OPAG on DPFS, the agenda of the meeting and the future direction for the OPAG, which was to be discussed in detail under Agenda Item 10.

2 Organization of the Meeting

2.1 Adoption of the Agenda
The agenda was adopted as found in Annex I.

2.2 Working arrangements
The meeting agreed to the hours of work and tentative timetable for the meeting. The list of participants is found in Annex II.

3 Forecasting Standards and Recommended Practices

3.1 The meeting noted that two recent documents have been developed and made accessible to Members via the WMO Web-site at:

http://www.wmo.int/web/www/documents.html

listed under the DPFS programme. They are:

- "A Summary of Recommended Practices for Weather Forecasting" (November 2004),

- "Guidelines on Using Information from EPS In Combination with Single Higher Resolution NWP Forecasts" (February, 2006).

3.2 The meeting noted that guidance documents should be developed and maintained on forecasting standards and recommended practices, and would be valuable to WMO Members as part of the ongoing Implementation of the GDPFS. For example, the Expert Team on Ensemble Prediction Systems (EPS) is planning to develop a Guide on EPS, and the Emergency Response Activities programme maintains an information volume on its activities and related standards in the WMO Technical Note No. 778. The meeting also noted that a review and updating of the WMO Guide on the GDPFS (WMO-No. 305) would require some experts and/or a suitable consultant, and coordinated by the Secretariat. The updated Guide would be best made available as a Web-accessible document on the WMO Web-site.

3.3 The meeting was informed of the intention within the World Weather Research Programme (WWRP) to work on the matter of "Forecast Systems", which is linked and would potentially benefit from developments under Forecasting Standards. The ICT felt that the OPAG on DPFS should participate in a joint meeting or workshop to be organized in 2007 and that the PWS programme could also be involved.

4 Ensemble Prediction Systems Products and Applications

4.1 In the absence of Mr Ken Mylne (UK), Mr Louis Lefaivre (Canada) presented the activities and future plans of the Expert Team on Ensemble Prediction Systems.

4.2 Fourteen GDPFS centres are running ensemble prediction systems (EPS), some are running multiple systems, and their products are of considerable interest to all WMO Members. The interest continues to grow, as EPS products are a realization of quantifying uncertainty in the numerical simulations and predictions of the atmosphere. The continuing development of EPS, in terms of model resolution, methods of accounting for uncertainties, forecast ranges, and applications, means it has increasing importance as a vital tool for weather forecasting, and on all time scales (short-range to long-range) of prediction.

4.3 WMO Members are encouraged to access EPS products of GDPFS centres and also invited these centres to provide the access information for their respective EPS web-sites. The concept of including uncertainty in all forecasts needs to be promoted to decision makers and managers who in turn could set new requirements for probabilistic forecasts as part of weather information, forecasts and warnings.

4.4 In response to guidance that was sought by some WMO Members, the Expert Team had produced a draft text entitled: "Guidelines on using information from EPS in combination with single higher resolution NWP forecasts". This guide includes the following highlights:

- A forecaster can assess how much weight to place on a single high-resolution forecast (or on the ensemble control) from the spread in the ensemble. Small spread in the ensemble provides confidence in the single forecast, while larger spread indicates that it is essential to include information on forecast uncertainty.

- As spread increases, it is less appropriate to rely on a single forecast as the most likely scenario (be it the high resolution or the control forecast of the ensemble). All solutions in the ensemble must then be considered when weighing the likelihood of different forecast scenarios. However, until the lead time where an ensemble indicates large forecast uncertainty, a high resolution control forecast can be utilized in the formation of the most likely scenario.
- The aim of post-processing should be to produce a probability distribution function taking account of information from both single high-resolution model run and EPS members. In general it is expected that in short-range forecasts high weight will be attached to the high-resolution forecasts and lower weights to the perturbed members whereas for the longer range forecasts it is expected that similar weights will be applied to all members.

The entire text of this guidance is found in the annex to this paragraph.

Training on EPS products

4.5 The meeting noted that training on EPS is still in high demand and that while dedicated training courses should still be undertaken in the future to meet the needs, it recommended that other complementary approaches to providing EPS training could be considered. They include:

- EPS producing centres or centres that have experience in using EPS products host “international training desks” to conduct a programme of on-the-job training for forecasters from other countries or centres;
- Develop and support trainers at WMO Regional Meteorological Training Centres;
- Develop a series of questions and answers on probabilistic forecasting and EPS products;
- Develop a pool of subject experts who are particularly well suited to provide support to forecasters or to provide lectures (e.g. roving lecturer) when the opportunity arises;
- EPS and probabilistic concepts, as subjects, should be substantially included in any training event on NWP or GDPFS products;
- Develop and document, and include in a Guide on EPS, some examples of how advanced centres have implemented EPS into their operations and how they have benefited;
- Continue to use opportunities with distance-training programmes such as the COMET (U.S.A.) programme to collaborate in the development of training modules and case studies relevant to WMO Members in different regions of the world, and make such modules available in different languages.

Short-range EPS

4.6 Products from short-range EPS systems attempt to address forecast uncertainties in the prediction of localized weather parameters (e.g. precipitation) that are quite different in objectives and approach from those in medium-range EPS systems. Different perturbation methods are being developed to account for forecast uncertainties in the parameterization of physical processes that are important to the prediction of surface weather conditions in the 1- to 3-day forecast range.

4.7 There is encouraging evidence that high-resolution regional ensembles can provide useful guidance on uncertainty in the forecast of local-scale surface weather parameters of particular interest in the short-range (e.g. windspeed, precipitation intensity, visibility).

4.8 It was also noted positively that regional groupings of NMHSs are an effective approach to derive benefits from regional EPS systems for the group of countries and centres involved. Example include:

- the COSMO-LEPS which provides regional downscaling of ECMWF global ensemble;
- The EUMETNET SRNWP-PEPS project (a poor-person's ensemble combining data from different countries' regional scale models); or
- The South American centres that developed collaboration over the Plata region (MASTER Super Model Ensemble System).

This concept of collaboration could lead to the development of regional specializing EPS centres that would provide EPS products for NMHSs in a geographical region.

EPS Application to severe weather forecasting

4.9 The skill of EPS is insufficient to directly predict the probability of the intensity of severe events. Appropriate post-processing and calibration of EPS fields is required. While for specific events relevant diagnostics may be devised, a more general approach may also be useful. Although it may be difficult to predict absolute values, comparing an EPS forecast to a model climate distribution can indicate when the EPS predicts an increased probability of an extreme event.

4.10 Since EPS producing centres are developing and implementing diagnostic methods and products for severe weather applications for national requirements, it could be useful to either extend some of these applications to other NMHSs or to provide access to their EPS products or datasets and assist other NMHSs to develop for themselves suitable tools for severe weather forecasting relevant in their own regions of interest. Illustrative examples could be documented and made accessible to NMHSs. In this connection it was noted that the operational multi-centre North American Ensemble Forecasting System (NAEFS) will soon produce and distribute on its web-site weather forecast information, including end products for use in severe weather warning activities.

4.11 The EPS producing centres are encouraged to provide additional products related to severe weather forecasting such as the Extreme Forecast Index (EFI) developed at ECMWF. The team noted that such new products may require additional post-processing ("downscaling") and may not always have been fully assessed for all areas of the globe, but that producing centres are encouraged to make them available with suitable caveats, and invite feedback from users.

4.12 The idea of using Severe Weather Forecast Demonstration Projects for the demonstration of the benefits of EPS, including dissemination of suitable products, to civil protection services is strongly supported.

EPS Verification

4.13 The Lead Centre for EPS Verification is operated by JMA using two Internet sites: a FTP-site (ftp://ftpepsv.kishou.go.jp/) for gathering the statistical data of EPS verification, and a Web-site (http://epsv.kishou.go.jp/EPSproducer/) for their publication. The Lead Centre prepared and made available at the Web-site a set of guidelines on the exchange and use of EPS verification. All EPS producing centres are encouraged to register with the Lead Centre and commence providing their verification data to the Lead Centre as soon as possible. Currently, the Web- and FTP-sites are password protected and accessible only by the registered centres. The meeting recommended that access to the Web-site should be made available to all WMO Members.

4.14 The meeting decided that the details of the required verification for exchange should be posted on the Lead Centre for EPS Verification Web-site. The meeting requested the Lead Centre for EPS Verification to update the Guidelines to include the full details on how to generate the verification data for international exchange, as stated in the *Manual on the GDPFS*.

Recommended amendments to the *Manual on the GDPFS* - EPS products and verification

4.15 The Meeting recommended to add to the current paragraphs in the *Manual on the GDPFS* (Volume I, Part II, APPENDIX II-6, paragraph 4.1) the additional EPS graphical product type known as “EPSgrams”, to the present list of EPS products. The recommended amendment to the Manual on the GDPFS is found in the APPENDIX to this Report, in the EPS Section (A.1). The CBS MG-6 (2006) had noted that specific product standards should be developed for this kind of product for international exchange.

4.16 The Meeting recommended revisions to replace the entire existing text in the *Manual on the GDPFS* (Volume I, Part II, Attachment II.7, Table F) related to EPS verification. The recommended amendment is found in the APPENDIX to this Report, in the EPS Section (A.2).

5 Severe Weather Forecasting

5.1 Mr Jean-Marie Carrière, the Rapporteur on Applications of NWP in Severe Weather Forecasting, presented a summary of the background and status of the Severe Weather Forecasting Demonstration Project (SWFDP).

5.2 The motivation to organize a demonstration project on severe weather forecasting originated from the following needs:

- To demonstrate how cooperative work among meteorological centres can be further exploited in order to enhance the forecasting process of several types of severe weather and to improve warning services at the NMHSs;
- To make better use of existing NWP models and products including those derived from Ensemble Prediction Systems and train forecasters of NHMSs that have not yet used or applied them and to demonstrate their utility in decision-making;
- To prepare NMHSs and GDPFS centres to implement and benefit from the outputs of the THORPEX research and development programme;

- To improve the ability of NMCs to forecast severe weather events;
- To improve the lead-time of alerting of these events;
- To improve interactions of NMCs with Disaster Management and Civil Protection Authorities before and during events;
- To identify gaps and areas for improvements;
- To improve the skill of products from GDPFS centres through feedback from NMCs.

5.3 The Project is divided into three phases:

- Phase 1 is the overall project planning. It includes project specifications, identification by the Project Steering Group of possible participating centres and suitable regional subprojects, type of severe weather and chosen period for the experimentation, and the development of a Severe Weather Forecasting Demonstration Project (SWFDP) guidebook on planning regional subprojects;
- Phase 2 is the regional subproject(s) implementation planning and execution. It includes detailed specifications (data and products to be exchanged), planning (including training to forecasters), subproject implementation, and the demonstration and experimentation itself;
- Phase 3 is the regional subproject(s) evaluation and conclusion. It includes the analysis and evaluation of the subproject, the contribution to the evaluation of the overall SWFDP, and the identification of gaps, deficiencies and areas for improvement for other similar subprojects.

5.4 The first regional subproject will focus on severe weather (heavy precipitation and strong winds) not specifically associated with Tropical Cyclones and will be implemented in the southeastern region of Africa (RA I) in 2006.

5.5 Expressions of interest to participate in the first regional subproject has been expressed by the following centres:

- NHMSs: Madagascar, Mozambique, Botswana, Zimbabwe, Tanzania;
- Regional Centres: RSMC Pretoria (South African Weather Service), RSMC La Réunion (Météo-France), ACMAD;
- Global Centres: ECMWF, Exeter (Met Office UK), NCEP (U.S.A.).

5.6 An organizing meeting of the participating centres is planned for 31 July – 3 August 2006 to establish a Regional Subproject Management Team and to develop the implementation plan for the subproject. The season when severe events in this region are likely to occur is from November through to May; there should be sufficient lead-time for the preparation of the subproject, including the provision of essential preparatory training, in order to start the experimentation phase in November 2006. The ICT noted that preparatory training should be provided to the operational forecasters who will be directly involved with the operational work of the subproject. The Regional Subproject Management Team should address the question of costs, including those associated with the preparatory training.

5.7 Another regional subproject will focus on severe weather associated with Tropical Cyclones, and will be considered following the implementation of the first subproject. The participant from the Bureau of Meteorology of Australia informed the meeting that at the recent XIV-RA V Session (May 2006), there was strong endorsement of the SWFDP, and both the Bureau and the Session were very interested to implement a regional subproject in RA V with the participation of RSMC Darwin and/or RSMC Nadi.

6 Long-range Forecasting

6.1 Long-range forecasting - Infrastructure

Mr Willem Landman (South Africa) presented the activities and future plans for the Expert Team on Long-range Forecasting – Infrastructure.

Facilitation of multi-model ensembles

6.1.1 The use of multi-model ensembles (MME) for long-range forecasting (LRF) is encouraged since:

- MMEs provide the opportunity for improved reliability over that available from single model ensembles alone;
- MMEs provide the opportunity to estimate uncertainties in LRF, and to particularly identify limitations of LRF;
- MMEs provide a means to a “confidence builder” in the area of LRF; and,
- Larger improvements in skill can be achieved from the use of MMEs, rather than increasing the ensemble size for a single model. The required ensemble size depends on the signal to be detected. For example, in the mid-latitudes bigger ensembles are required for detecting small shifts in probability. Skill should really be the key point in deciding the ensemble size. In order to estimate uncertainty, a large ensemble size is desirable. The definition of optimum ensemble size should be decided in the context of the way of ensemble data usage (it is expected to be different for assessment of means, probabilities and extremes).

6.1.2 Global Producing Centres of Long-range Forecasts (GPCs for LRF) that serve as collectors of global LRF data to build MMEs should be identified. The Korean Meteorological Administration, possibly joint with NCEP (USA) made an offer to become such a GPC, performing the following functions:

- Collect global hindcasts and forecasts from participating GPCs and make them available to other GPCs, Regional Climate Centres (RCC) and NMHSs, as registered users (with password protected access);
- Promote the exchange of research and experience on MME, and provide documentation on MME;
- Work at the establishment of standards for MME products;
- Provide a repository of different MME techniques for the generation of MME in support of GPCs and RCCs; and
- Provide display of GPCs forecasts in a common format based on agreed standards, to RCCs, NMCs and GPCs, with password protected access.

6.1.3 The ICT was informed that Regional Climate Centres (RCC) are being explored in some Regional Associations. RCCs could be recognized by CBS at the request of Regional Associations if they meet specific criteria for their designation. These criteria remain to be defined. CBS has agreed to assist CCl to define such criteria for RCC designations for inclusion in the *Manual on the GDPFS*, Vol. I - Global Aspects, should CCl wish to pursue this direction. The meeting noted that a general set of functions that a RCC may perform has been developed by the Inter-Commission Task Team on Regional Climate Centres (2001) and can be used as guidelines for establishing specific criteria; the statement of the general functions are found in the annex to this paragraph.

Recommended amendments to the *Manual on the GDPFS* – Designation of GPCs and Minimum list of LRF products to be made available by GPCs

6.1.4 The designation of RSMCs with activity specialization includes "long-range weather forecasts" (products) as included in the *Manual on the GDPFS*. The ICT recommended that one note be added in the Manual to clarify the definition in relation to Global Producing Centres of Long-range forecasts (Vol. I, Part II, paragraph 1.4.1.2 (b)), which is found in the APPENDIX to this report, in the LRF section (B.1). The ICT also recommended that the criteria for recognizing a GPC and the list of officially recognized GPCs be added to the Manual as a new APPENDIX II-8; the recommended text is found in the APPENDIX to this report, in the LRF section (B.2).

6.1.5 The Minimum List of Products to be made available by GPCs, as included in the APPENDIX II-6 of the *Manual on the GDPFS* was reviewed. The ICT recommended the revised version that includes some necessary clarifications, without any change to the actual list of products, be incorporated as amendments to the *Manual on the GDPFS*. The recommended amendment is found in the APPENDIX to this Report, in the LRF Section (B.3).

6.1.6 The ICT encouraged the GPCs to interact with RCCs and NMCs to determine and confirm their needs.

6.1.7 Products of the GPCs as defined in the APPENDIX II.6 of the *Manual on GDPFS* should be made available to as many NMCs and RCCs as possible, for the purpose of enabling them to perform their tasks. In addition a list of other data or products, found in the annex to this paragraph, could also be provided by GPCs on request by RCCs or NMCs; the RCCs and NMCs would adhere to the conditions, if any, attached by the GPCs to these data and products.

Observation Data Needs

6.1.8 The new list of Observation Data Needs for Producing Global LRF was recommended by the Expert Team and will be conveyed for consideration by the CBS/OPAG on IOS, CCl, and GCOS. The revised list is found in the annex to this paragraph.

6.2 Long-range forecasting – Verification

Mr Normand Gagnon (Canada) presented the activities and future plans for the Expert Team on Long-range forecasting – Verification.

Recommended amendments to the *Manual on the GDPFS* – Standardized Verification System (SVS) for Long-range Forecasts (LRF)

6.2.1 The Standardized Verification System for Long-range Forecasts, as included in the APPENDIX II-8 of the *Manual on the GDPFS,* was reviewed. The ICT recommended the revised version that includes some necessary clarifications and corrections be incorporated as amendments to the *Manual on the GDPFS*. The recommended amendment is found in the APPENDIX to this Report, in the LRF Section (B.4).

Clarification of technical questions

6.2.2 A number of technical issues concerning verification of Long-range forecasts had been brought to the attention of the Expert Team on Long-range Forecasting – Verification. Clarification on these issues are provided as follows:

6.2.2.1 "Clarification on whether or not verification should be carried out on post-processed output"

In the APPENDIX II-8 of the *Manual on the GDPFS* it is not stated explicitly. Most centres are currently posting forecasts derived from a simple calibration and so, for the sake of comparison on the Lead Centre web site, it was decided that scores for forecasts that were calibrated (simple correction of moments 1 and 2) are to be submitted; revisions to the APPENDIX II-8 in the recommended amendments have included this aspect. It was preferred to exclude verification of forecasts that were post-processed using for example Model Output Statistics or Perfect Prog approaches but GPCs are encouraged to display verification on their post-processed forecasts on their own web-sites.

6.2.2.2 "Development of more information on error bars and significance levels to be made available in the documentation, and consideration of the best means of displaying such information"

Significance levels can be derived from either standard significance statistical test or bootstrapping techniques. The ICT agreed on the general principle that if standard significance tests for a given score are available and valid, given the assumptions about the data, it will be preferable to use them. The ET needed further discussion before recommending specific methods to assess significance levels. Therefore the requirement for the submission of significance levels to the Lead Centre Web-site should be postponed. The GPCs are still encouraged to perform significance level testing and display their results. The ET has updated the APPENDIX II-8 of the *Manual of the GDPFS* to reflect this decision. The Lead Centre for SVSLRF will carry development on this subject with help from ET members and report to its next meeting.

6.2.2.3 "Calculation of the area under ROC curves (use of fitted curves or not)"

In the APPENDIX II-8 of the *Manual on the GDPFS*, it is stated explicitly in section 3.3.3 that: "For the core SVSLRF the area under the ROC curve should be calculated using the Trapezium rule", hence no ambiguity.

6.2.2.4 "Responsibility for display of real-time monitoring information"

In the APPENDIX II-8 of the *Manual on the GDPFS* it is stated that it is the responsibility of each GPC to display real-time performance monitoring. The Team was of the opinion that the SVSLRF is really for hindcast verification. The Team felt that there is need to improve the provision of near real-time global observed data set for verification purpose.

6.2.2.5 "Need for more guidance on the prescription of the cross-validation procedure and its appropriateness for individual dynamical models"

The ICT agreed that the cross-validation should be mandatory for both calibrated and re-calibrated forecasts. It is clearly unavoidable for training of empirical models and statistical post-processing as well as multi-model combination schemes if the data set used is not large enough to be divided in 2 parts (training and then validation). There is a need to define a rigorous cross-validation procedure that can be used as part of the standard SVS guidelines.

6.2.2.6 "Specification of ENSO years"

In 2005 an expert team was formed by the Commission for Climatology (CCl) to prepare a catalogue of El Nino and La Nina indices and definitions used around the world. This team was led by Fiona Horsfall. That team has submitted a report at the Beijing meeting in November 2005. This report essentially recommends that another expert team should be formed to do more work on this. This recommendation was accepted and the new team is named "Expert Team on El Nino and La Nina" (CCl/OPAG 3). The team is led by Luc Maitrepierre and is composed of 7 international scientists, and expected to provide a list of El Nino and La Nina years to allow for a stratification of the data according to these criteria. The ET on SVSLRF should follow closely the work of this new ET of CCl. The ICT recommended that the SVS verification should not be stratified according the ENSO years until we have a clear official definition of the phenomenon.

6.3 Future work of the Expert Team on LRF

6.3.1 The following aspects were discussed by the ET at their last meeting (Reading, April 2006) following guidelines provided by the last ICT meeting (Geneva, November 2004):

- Development of scores to measure skill in the ensemble spread;
- Assessment of multi-model ensembles;
- Standardising methods for defining terciles, etc.;
- Verification of extremes (such as the outlying quintiles);
- Standardising of hindcast period;
- Standardising verification data sets;
- Ongoing coordination and support of Lead Centre role;
- Clarification of issues arising from the broader use of SVSLRF….

The results of the work of the ET as well as clarification on its future work on these aspects are found in the annex to this paragraph.

6.3.2 The ICT recommended the following aspects for the future work on the verification of LRF:

- Definition of a rigorous cross-validation procedure;
- Follow the work of the CCl expert team on El Nino definition to provide stratification of score in function of ENSO state;
- Further work to be done on scores to measure skill in the ensemble spread;
- Ongoing support to Lead Centre activities, including;
  - Maintenance of the web site (posting of new submitted scores, update data sets, etc.) [BOM\CMC];
  - Defining a recommended procedure to calculate terciles [BOM];
  - Development work on scores significance levels (calculation and graphical display)[CMC];
- Further work to be done on verification of extreme forecasts;
- New scores for new forecast types (PDF, cyclone trajectory forecast, etc).

7 Emergency Response Activities

7.1 Nuclear Emergency Response Activities

Mr René Servranckx (Canada) presented the activities and future plans for the Coordination Group on Nuclear Emergency Response Activities.

Improved product distribution / access methods

7.1.1 Faxing remains the official product transmission method and maintaining updated fax numbers and contacts points remains a challenge. Actions will be taken to confirm (testing) and update (via correspondence to Permanent Representatives with WMO) operational contact information.

7.1.2 All RMSCs use web-based technologies to exchange information and products. Some RSMCs have implemented identical (mirrored/congruent) but independent password protected web pages. As an example, RSMCs Washington, Montreal and Melbourne use FTP to exchange their products in order to make them available in a congruent system. The key advantage is that the three Centres' web sites have identical content while being completely independent from one another. Therefore, even when one server is down, congruency allows accessibility to the RSMC products. The system is tested in monthly exercises and has been implemented in a way that minimizes the risk of failure due to Internet disruptions, as well as accounting for varying capabilities of NMHS to access.

7.1.3 The mirrored/congruent web pages should be extended to include all RSMCs. The exchange of data in GRIB, GRIB2 and BUFR codes will be pursued.

Procedures, services and response to nuclear emergencies

7.1.4 The relationship of WMO, its designated Centres with the IAEA is strongly recognized, including by other relevant International Organizations. Exercises and regular testing are key elements to ensure operational readiness.

7.1.5 Operational test of notification between the IAEA's Incident and Emergency Centre (IEC) and WMO's RTH Offenbach has been conducted on a monthly basis. Since 2004, quarterly tests have taken place between IEC and lead RSMCs for WMO RAs and will continue in the foreseeable future. The scope of the tests included the requesting of RSMC products by the IAEA, testing the link between RTH Offenbach and the RSMCs and testing the delivery of products. A test of the full arrangements, including the transmission of messages on the GTS, participation of NMHSs and IAEA Contact Points is to be done every other year.

WMO's participation in ConvEx-3 (2005)

7.1.6 WMO participated during the ConvEx-3 (2005) international exercise that was carried out on 11-12 May 2005. WMO's performance during the exercise in relation to the standing Regional and Global Arrangements was assessed as relevant, excellent and functioning. Information collected from a WMO post-exercise survey indicated that the NMHSs that participated (mainly from RA VI – the region of the accident scenario) were satisfied with the specialized services and products of the RSMCs (Exeter and Toulouse). Actions have been undertaken to remediate the few minor problems that were identified as a result of the exercise. No procedural changes are recommended in the Arrangements.

7.1.7 The ConvEx-3 international exercises are conducted every 3 to 5 years, with the next one being planned for 2008. IAEA considers this frequency is inadequate exercising for certain aspects of operational procedures and proposes an additional major exercise to be conducted between the ConvEx-3 years.

Technical documentation

7.1.8 In addition to maintaining the operational readiness of the RSMC / RTH Centres, it is important that users be aware of the services and arrangements. The WMO Technical Note No. 778 entitled: "Documentation on RSMC support for Environmental Emergency Response (targeted for meteorologists at NMHSs)" is the technical reference to the ERA programme. It contains background, definitions, regulatory materials for the operational standards, procedures and forms, important scientific notes, and annexes that describe each of the RSMCs. Updates and additions are incorporated into the document as they become available. It is important for this document to continue to serve as the definitive information reference on the ERA for all Members.

Review of requirements for RSMC products / services

7.1.9 The IAEA Board of Governors adopted the International Action Plan for Strengthening the International Preparedness and Response System for Nuclear and Radiological Emergencies (2004-2009). Under the direction of the National Competent Authorities (NCA), a working and expert group structure has been established to implement the Action Plan in close cooperation with IAEA. Under this NCA framework an Expert Group on Atmospheric Dispersion Products was established and tasked to define updated standard meteorological products and enhanced arrangements for providing the products.

7.1.10 The current concept of operation between the WMO and IAEA Secretariat and the agreed products under the Regional and Global Arrangements remain in place until

IAEA decides and conveys to WMO the new requirements and when their implementation are to be completed.

7.1.11 The current agreement between the WMO and the IAEA is founded on the principle that a link between the NCAs concerning the Conventions and their respective NMHSs was developed to help with the interpretation of the atmospheric dispersion products. This is valid for the majority of States. There is a clear need to improve and promote contacts, coordination and liaison between NMHSs that receive RSMC products, and their respective counterpart NCAs for nuclear emergencies.

Specialized atmospheric transport modeling backtracking

7.1.12 While the atmospheric transport modeling technology (forward advection, dispersion and deposition) has been recognized as a critical element to support response to environmental emergencies, the evolution and expansion of the same numerical simulation technology to include backtracking has also proven to be a very useful tool for the determination of the possible source of an airborne tracer that has been detected at a monitoring location or through some other method such as remote sensing.

7.1.13 Through the close collaboration with CTBTO, the backtracking capability that has been developed for the Comprehensive Nuclear-Test-Ban Treaty (CTBT) Verification support has matured to a point that the participating WMO Centres in this development are prepared to consider providing atmospheric transport modelling products in backtracking mode, on a case by-case request basis, to all WMO Members. These WMO Centres are primarily the same RSMCs that are already designated for the activity specialization for environmental emergency response, based on their capability to produce atmospheric transport modelling products. This backtracking could have important benefits to NMHSs and relevant international organizations (e.g. IAEA, WHO).

7.1.14 Recognizing the evolution of atmospheric transport modelling technology in recent years, the ICT recommended that the present RSMC designation with Activity Specialization in Environmental Emergency Response be maintained and renamed as "RSMCs with Activity Specialization for Atmospheric Transport Modelling". This activity specialization would then include support to environmental emergency response, backtracking support to the CTBT Verification, and backtracking in support of other environmental incidents to NMHSs and relevant international organizations. The WMO centres that are not designated RSMCs but that would wish to be designated for backtracking would be invited to submit a nomination for their Centre with supporting documentation to demonstrate capabilities.

7.1.15 The ICT agreed that it would be useful for the RSMCs to conduct an experiment on backtracking modelling for an event, to be coordinated by the Chairman of the Nuclear ERA Coordination Group. The experiment will also be helpful as a starting point to explore the concept of operations for the requesting and the provision of atmospheric transport modelling backtracking products and services by NMHSs.

Recommended amendments to the Manual on the GDPFS – Emergency Response Activities

7.1.16 Sections of the Manual on the GDPFS relevant to Emergency Response Activities were reviewed, corrected and revised, in particular to include atmospheric transport modeling backtracking. The ICT recommended the revised version be incorporated as amendments to the Manual on the GDPFS. The recommended amendment is found in the Addendum to this Report, in the ERA Section (C.1 to C.6).

Cooperation with CTBTO

7.1.17 The successful CTBTO-WMO collaboration during the last decade has now reached a stage for the installation of a CTBTO-WMO response system triggered upon Treaty relevant radionuclide detection in the CTBTO radionuclide International Monitoring System. In such a system, WMO Centres would, at the request of the CTBTO Provisional Technical Secretariat, apply atmospheric dispersion models in backward mode (“backtracking”) to calculate ‘’standardized Source Receptor Sensitivity (SRS)’’ information related to Radionuclide Measurements in the CTBTO International Monitoring Network and report back their results within 24 hours.

7.1.18 A series of coordinated numerical experiments with several WMO Centres (RSMCs and other WMO Centres) demonstrated that the system is now mature regarding its design and its potential benefits. The system will in fact be beneficial to the WMO as well as CTBTO. The meeting recommended that the backtracking response system be formally included into the WMO Manual on the GDPFS, as has been reflected in the recommended amendment to the Manual on the GDPFS, found in the APPENDIX to this Report, in the ERA Section (see above paragraph 7.1.16).

Cooperation with ICAO

7.1.19 In the context of air navigation and air traffic control operations, significant benefits have been realized from the specialized atmospheric and transport modelling (e.g. tracking airborne volcanic ash). Actions are ongoing at ICAO to seek a solution to the establishment of a single contact point within air traffic control operations for the IAEA IEC to provide notifications of a nuclear accident or radiological emergency. Coordination with ICAO will continue.

Ensemble forecasting

7.1.20 The Coordination Group has been considering and exploring the potential benefits of applying the ensemble approach to atmospheric transport modeling to develop suitable products to meet the needs of environmental emergency response and other environmental incidents. The RSMCs noted that while no requirement has yet been expressed by IAEA nor NMHSs for emergency response products based on the ensemble method (e.g. the ensemble median prediction, or probabilistic type predictions of atmospheric dispersion), it would nevertheless good for the RSMCs to work towards exchanging among themselves numeric files that would enable the exploration of additional tools to quality assure or enhance the RSMC specialized products, including ensemble techniques.

7.1.21 The meeting suggested that the Chairs of the Coordination Group and Expert Team on ERA consult with the Expert Team on EPS, when appropriate.

7.2 Non-Nuclear Emergency Response Activities

Mr Chris Ryan (Australia) presented the activities and future plans for the Expert Team on Atmospheric Transport Modelling for non-Nuclear Emergency Response Activities.

7.2.1 CBS-XIII (2005) established a new Expert Team on Modelling of Atmospheric Transport for non-Nuclear Emergency Response Activities and its Terms of Reference. This ET complements the Coordination Group on Nuclear ERA and shares many of the experts. The new Expert Team met for the first time in September 2005 at Melbourne.

7.2.2 It has been widely recognized that the tools used to model the dispersion of nuclear contaminants in the atmosphere can also be applied to other airborne hazardous materials, so the ERA programme has been directed to expand its activities into non-nuclear environmental emergencies. CBS-XIII (2005) agreed that priority should be given to expanding the programme to atmospheric transport and dispersion modelling to support response to chemical accidents and smoke from large wild-land fires.

Needs and capabilities

7.2.3 The meeting noted the following in the context of emergency response to chemical accidents, volcanic eruptions, wild-land, bush and forest fires and biological emergencies:

- Many NMHSs want support, training and guidance in all hazard areas;
- Some, even if they already run modelling systems, want guidance and training because of the limitations of their own models or modelling systems;
- The first priority need for assistance is the case of atmospheric dispersion from chemical accidents and the second priority is for smoke from wild-land fires, with the third priority being in biological emergencies;
- The modelling capabilities in the case of chemical accidents are presently quite unequally distributed among the Regions, with the majority concentrated in Europe;
- Although chemical dispersion and transport in water are seen as a similar level of threat as smoke from wild-land fires, the existing modelling capabilities for transport in water are less developed than for the atmospheric pathway, and assistance in the case of an accidental release to water is less requested than releases into the atmosphere.
- Many NMHSs have a national responsibility to provide specialized products and information in support of chemical accident emergency response; some are the RSMCs that have been designated for nuclear ERA products.

7.2.4 Because of the predominantly localized and short-lived nature of chemical incidents the ICT concluded that the strategy should be concentrated on developing the necessary capabilities at the NMHSs. However, in the case of smoke from large fires, a regionalised approach would be appropriate, where designated RSMCs would provide emergency support to NHMSs and at the same time build capacity at the national level. Similarly, for large trans-boundary dust or sand storms RSMC-type operational arrangements might be appropriate.

7.2.5 The ICT agreed with the updated relevant sections of the WMO Technical Note 778 on the ERA programme related to meteorological aspects of chemical incidents, which were originally adopted and included in the General Summary of CBS-Ext.(98) including the following:

- CBS-Ext.(98) Annex V – Definition of requirements concerning chemical incidents
- CBS-Ext.(98) Annex VI – Role of national meteorological services (in Environmental Emergency Response); and
- CBS-Ext.(98) Annex VII – Guidance for development of the interface between national meteorological service and other emergency response agencies in case of chemical incidents.

7.2.6 The ICT-DPFS decided that the corresponding sections of WMO Technical Note 778 be amended to incorporate the revisions, which are found in the annex to this paragraph.

Cooperation with relevant International Organizations

7.2.7 It is clear from the activities of the nuclear component of the ERA programme and the volcanic ash forecast service that strong linkages with relevant international organizations are essential for the successful utilisation of meteorological support services for non-nuclear environmental emergencies.

7.2.8 The United Nations Environment Programme and United Nations Office of the Coordinator for Humanitarian Assistance (UNEP/UN OCHA) Joint Unit serves as the integrated United Nations emergency response mechanism to activate and provide international assistance to countries facing environmental emergency disasters. It is interesting to note that over ten years of response to these emergencies almost 24% of the responses were for chemical incidents. Over 50% of responses were located in the geographical regions of Asia and Africa.

7.2.9 Cooperation with the Joint Unit could potentially be developed in several areas:

- During the emergency phase, updated weather forecasts and, where necessary, atmospheric dispersion modelling, could be provided directly to emergency responders. Within the OCHA framework a password-controlled website, accessible to all emergency managers exists (Virtual On-Site Operations and Coordination Centre), and could be utilised to deliver meteorological support products;
- Interface procedures, including 24/7 emergency contact details could be developed between WMO and the Joint Unit;
- Technical expertise and/or training for atmospheric transport and models related to airborne hazards could be provided by WMO for UN Disaster Assessment and Coordination teams.

7.2.10 The activities of World Health Organization (WHO) of most relevance to the non-nuclear ERA programme fall under its International Programme on Chemical Safety (IPCS). Under the IPCS there are operational components that could be linked to the developing operational framework for non-nuclear ERA, as follows:

- The Global Chemical Incident Alert and Response System utilises a small team to consider information received about chemical events from both formal and informal sources;
- Formal information sources used for alert and surveillance include reports from national authorities, WHO offices, WHO Collaborating Centres, other

UN agencies and members of the communicable disease Global Outbreak Alert and Response Network (GOARN);

- Informal sources include Internet-based resources, particularly the Global Public Health Intelligence Network (GPHIN) and ProMED-Mail;
- IPCS can call upon a network of experts known as ChemiNet;
- WHO established the Strategic Health Operations Centre (SHOC) in November 2004 to provide coordination of the WHO response to communicable disease outbreaks, and chemical, biological or radiological accidents and terrorism.

7.2.11 Possible goals of collaboration between WMO and the IPCS are:

- To improve the understanding of the roles and responsibilities of the public health and meteorological sectors at global, regional and national levels;
- To identify synergies and to strengthen links between these sectors at all levels;
- To expand the public health application of atmospheric distribution models following chemical accidents; and
- To engage in joint capacity building activities.

Future work

7.2.12 The goal of the first meeting of the ET was to develop both a concept of operations for non-nuclear environmental emergency response and a plan of action for enhancing the scope and capabilities of NMHSs beyond nuclear emergencies. The experts concluded that because of the predominately “localized” and short-lived nature of environmental emergencies related to chemical incidents, that the strategy and plan of action should be concentrated on developing the necessary capabilities at the NMHSs.

7.2.13 In the case of smoke from large fires, a regionalized approach would be appropriate, where designated RSMCs would provide emergency support to NHMSs and at the same time build capacity at the national level. There is also potential for a similar concept of operations to be applied to major sand and dust storms, although more investigation into the level of need for Regional/Global arrangements was required.

7.2.14 The ICT agreed with the draft work plan structured around chemical incidents, large fire and sand/dust storm activities, together with a number of cross-cutting actions is found in the annex to this paragraph.

8 Impact of changes of GOS on GDPFS

8.1 The meeting noted that CBS Management Group (MG-VI, April 2006) agreed that the Terms of Reference of the OPAG-DPFS Rapporteur on the Impact of Changes to GOS on NWP actually duplicated to a large extent those established for OPAG-IOS Co-rapporteurs on Scientific Evalutation of OSE and OSSEs. The Management Group therefore decided to merge the activities of the DPFS Rapporteur into those of the IOS Co-Rapporteurs and for the latter to also report to the OPAG on DPFS.

9 Regional aspects

9.1 Reports of the Rapporteurs of the Regional aspects of the DPFS were presented. The following conclusions and issues were raised:

NWP

- A growing number of NMHSs are running NWP models, particularly limited area models (LAM). Coordination among these initiatives such as within geographical subregions, or the establishment of a Working Group within the relevant Regional Association could enhance collaboration and the success of the implementations. RSMCs with geographical specialization could play such a coordination role;
- NMHS continue to require technical support in efforts to implement and maintain NWP systems (LAM);
- There is a need to review and list what NWP forecast products are distributed on the GTS, with a view to ensure that products that are required for international exchange are in fact made available. The meeting felt that this should be part of the WIS initiative in the effective management of contents of the distribution/exchange system;
- Formal feedback mechanisms need to be established with NMHSs (users) to allow NWP producers to quality assure their products;

Training

- Training in DPFS continues to be noted as a requirement in broad subject areas of NWP. Building capacity for numerical weather predictions seen as critical for weather forecasting as well as a method of maintaining meteorological expertise through training and scientific development;
- Training activities related to operational weather forecasting, should be better coordinated, and published. Alternative and complementary training methods should be considered and used to increase the effectiveness of the training;
- Training materials would become more widely beneficial and used if they become available in languages other than in their original language.

10 Future work programme

10.1 Data-processing and forecasting systems and Nowcasting

10.1.1 The Rapporteur on the Application of NWP to Severe Weather Forecasting provided an overview of the subject, supported by iinformation gathered from the recent WWRP international symposium on “Nowcasting and Very Short-Range Forecasting (WSN05)” held in Toulouse (5 – 9 September 2005). Information about this symposium can be found at: http://www.meteo.fr/cic/wsn05/.

10.1.2 In the Manual of the GDPFS “nowcasting” is defined as weather forecasting from the present to up to 2 hours into the future, while the terminology loosely refers typically to the 0- to 6-hour period beyond the present within which techniques are used to improve forecasts (e.g. over persistence). While nowcasting does not exclusively benefit severe weather forecasting, this area represents the driving force for this activity.

10.1.3 Nowcasting relies on observational data and systems, high resolution NWP and such techniques as image processing, data fusion, data analysis, extrapolation, improve high-impact weather forecasting, e.g., convective hazards (heavy rain, hail, lightning, wind gusts, etc.), winter weather events (snowstorm, blizzards, etc.) or other hazardous conditions (fog, extreme fire danger, dust storms, etc…. The complementary mix of the observations and high-resolution NWP to support nowcasting depends on the phenomenon, the lead-time, and actual events.

10.1.4 Nowcasting can be implemented on a wide variety of systems and means, ranging from local treatment on a PC to dedicated centres.

10.1.5 In the context of the Severe Weather Forecasting Demonstration Project (SWFDP), nowcasting products will be included in the list of products exchanged and used in regional subprojects by the Regional and National Centres to help the tracking and nowcasting of severe weather events.

10.2 Evolution of the Working Structure of the OPAG on DPFS

10.2.1 In general terms, the mission or "raison d'être" of the OPAG on DPFS can be summarized as follows: to ensure that the operations of the NWP and related data-processing functions are maintained (GDPFS) and that advances made by research are transferred as quickly and as efficiently as possible in operational meteorology, for the benefit of PWS and other services and applications. This implies that the working structure of the OPAG needs to be flexible enough to adapt to the evolutions of research as well as the changing needs for the weather forecasting function.

10.2.2 The CBS Management Group at its 6th meeting (2006) considered that, while the current working structure is well suited to the short-term goals, some changes would be necessary in view of the overall terms of reference of the DPFS and of the emerging requirements, to facilitate the work of the various teams and groups under DPFS and the coordination with other groups within or outside CBS. Therefore, the meeting recommended a revision to the working structure and terms of reference of the groups of the OPAG, including:

- To establish an expert team on very short-range forecasting, to address issues related to the use of emerging operational models with resolutions in the order of a few kilometres;
- To establish an expert team on Infrastructure for Numerical Weather Prediction, to deal with the development of the exchange of NWP products on the GTS, including the provision of nesting data sets for Limited Area Models (LAM) run at NMHSs
- To merge the existing Teams on LRF infrastructure and LRF verification into one Expert Team on Extended- and Long-Range Forecasting
- To place increased emphasis by the Expert Team on EPS on the use of ensembles (or any other tools) for the production of probabilistic forecasts, and in broader terms for the generation of products in support of decision-making.
- To establish a Coordination Group on forecast verification, to review and update current procedures for computing WMO standard scores, and to respond to new requirements such as the verification of very high-resolution NWP models, or the verification of nowcasting products. As

well, an expert from this group would participate in the appropriate expert group in the Commission for Atmospheric Sciences (CAS) that is concerned with NWP verification. This Group would draw on the output of the relevant Expert Teams dealing with verification e.g., of EPS products or of long-range forecast products, and would address the verification aspects not covered by any Expert Team;

The ICT stressed that strong liaison with the PWS programme would be required in several areas, in particular in the area of EPS and of very short range forecasting because of the wide range of end users who could benefit from their development.

10.2.3 The ICT recommended the following new structure for the OPAG on DPFS including:

- Implementation Coordination Team on Data-Processing and Forecasting System;
- Coordination Group on Forecast Verification;
- Expert Team on Ensemble Prediction Systems;
- Expert Team on Infrastructure for Numerical Weather Prediction;
- Expert Team on Very Short-range Forecasting;
- Expert Team on Extended- and Long-range Forecasting;
- Coordination Group on Nuclear Emergency Response Activities
- Expert Team on Modelling Atmospheric Transport Modelling for Non-nuclear Emergency Response Activities;
- Rapporteur on the Application of NWP to Severe Weather Forecasting

10.2.4 The ICT recommended updated and new Terms of Reference for the OPAG's Expert Teams, Coordination Groups, and Rapporteur. They are found in the annex to this paragraph. The revised OPAG structure and Terms of Reference will be proposed to CBS-Ext.(06) in November 2006.

11 Other business

11.1 The Chairman reminded the ICT that in the month ahead of the CBS-Ext.(06), which will take place in November 2006, he will request from the members summary updates to the activities for the various teams and the rapporteur, as well as presentation materials to be included into a presentation to CBS. ,

12 Closure of meeting

12.1 The meeting closed at 15:30, on 2nd June 2006.

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Annex to paragraph 4.4

Guidelines on using information from EPS in combination with single higher resolution NWP forecasts

(February 2006)

Motivation

Traditionally forecasters have focused their attention on finding the most likely solution for the future weather. This is the first and most important aspect of weather forecasting. As the lead time for forecasts increases, the uncertainty associated with the most likely solution generally also increases. Information about the uncertainty in the forecasts is critical for a large group of users. One way of assessing uncertainty in traditional single (or “control”) forecasts is through collecting verification statistics over a period of time, and using the error statistics as a way of providing a distribution of expected errors in a forecast. This process, however, assumes that errors for a given lead time are stationary. Operational experience shows that this is not a valid assumption. NWP-based ensemble forecast systems were designed, through dynamical methods, to quantify forecast uncertainty as a function of uncertainty in the initial conditions, in the NWP model, and the evolution of the atmosphere under different synoptic situations. The ET-EPS recommends the more widespread use of EPS systems to provide the best estimates of forecast uncertainty.

Properly describing the uncertainty in any forecast requires the use of probability distribution functions (pdf). An EPS can be used to form such a pdf in a consistent manner. Due to resource limitations, EPS systems involve many forecast integrations and therefore often have to be run at a somewhat reduced resolution. Questions arise as to the compatibility of information from a single higher resolution integration versus an ensemble of lower resolution runs. In particular, higher resolution integrations generally show a lower level of systematic error, and may simulate certain aspects or phenomena of the atmosphere with more fidelity (e.g., diurnal cycle, meso-scale features, frontal structures, etc.). Guidance has been sought by WMO members as to the proper use of high-resolution control and lower resolution ensemble information, in particular regarding when information from one or the other system may be more relevant and how they can be best combined/utilized in the forecast process.

Determining the most likely scenario

The initially symmetric cloud of possible solutions that are centered around the control analysis in a set of ensemble forecasts deforms with time into an irregularly shaped cloud. This is due to nonlinear processes that necessarily displace the control from the center of the cloud. The critical level of nonlinearity is reached sooner for smaller scale and/or more unstable phenomena. For example, in case of convective precipitation, linearity may be lost in a matter of hours, while large scale features may retain linearity for several days.

A forecaster can assess how much weight to place on a single high-resolution forecast (or on the ensemble control) from the spread in the ensemble. Small spread in the ensemble provides confidence in the single forecast, while larger spread indicates that it is essential to include information on forecast uncertainty. If the single model forecast is significantly different from the ensemble mean, in relation to the spread, then very little weight should be given to the high-resolution forecast.

As spread increases, it is less appropriate to rely on a single forecast as the most likely scenario (be it the high resolution or the control forecast of the ensemble). All solutions in the ensemble must then be considered when weighing the likelihood of different forecast scenarios. However, until the lead time where an ensemble indicates large forecast uncertainty, a high resolution control forecast can be utilized in the formation of the most likely scenario. Once nonlinearities become dominant, the high resolution control forecast should be considered only to analyze detailed structure of relevant phenomena indicated, but not necessarily resolved well by the lower resolution ensemble members. However, one should keep in mind that the higher resolution control has its own limitations (e.g. biases in two model resolutions may not be drastically different etc). In less predictable situations the most likely scenario can be derived from the ensemble, e.g., the ensemble mean, median or mode.

Assessing forecast uncertainty

So far we have focused on the estimate of the most likely state of the system (first moment). Regarding the important issue of assessing the uncertainty in the most likely forecast (second and higher moments of the pdf), the lower resolution ensemble can be used. As long as the best estimate of the state is based on the ensemble solutions (including the equivalent resolution control that we consider as a member of the ensemble), the same solutions offer a proper way of quantifying forecast uncertainty. For example one can consider the 10, 50, and 90 percentile values in the ensemble distribution at any point and lead time as a simple measure of predictability. If necessary, additional percentile levels can be added, or a detailed pdf can be provided. If the forecaster's best estimate of the state is based more on the high resolution control forecast, the range of ensemble solutions, with a good approximation, can still be considered for establishing a range of possible solutions as far as the scales resolved by the lower resolution ensemble are considered. Consider a thought experiment where an ensemble with the higher resolution model is run (that we cannot afford in real practice due to computer limitations). We expect that uncertainty regarding the larger scales resolved by the higher resolution ensemble would be very similar to that captured by the lower resolution ensemble. What will be missing from the uncertainty estimate derived from the lower resolution ensemble is related to the smaller scale details that are represented only by the higher resolution model.

These guidelines were written as a first attempt to reconcile the concepts of using single high-resolution forecasts and EPS in the weather forecasting process. Many more tools than those described above are available at advanced centres including probabilistic forecasts, assessment of alternative scenarios (clusters, tubes, and other classification techniques). Based on such a rich array of ensemble-based tools, the ET-EPS recommends more widespread use of EPS in weather forecasting.

Developments on post-processing

The aim of post-processing should be to produce a pdf taking account of information from both single high-resolution model run and EPS members. In general it is expected that in short-range forecasts high weight will be attached to the high-resolution forecasts and lower weights to the perturbed members whereas for the longer range forecasts it is expected that similar weights will be applied to all members. Post-processing methods to achieve this are under development.

Annex to paragraph 6.1.3

LIST OF REGIONAL CLIMATE CENTRE FUNCTIONS
From WCASP No. 52, May 2001

The requirements of NMHSs for RCC functions will vary from Region to Region, and may comprise only a subset of the following list. The required activities may be undertaken within a single centre or distributed amongst NMHSs.

Operational Activities:

- Interpretation and assessment of relevant output products from global prediction centres;
- Generation of tailored products to meet NMHS needs including seasonal outlooks etc.;
- Product verification, including the necessary exchange of basic data;
- Product distribution.

Coordination Functions:

- Strengthen collaboration between NMHS on related observing, communication and computing networks including data collection and exchange;
- Development of systems to facilitate harmonisation and assistance in the use of SI Forecast products;
- Assist in coordination with end users, including the organisation of workshops and other forums on users' needs;
- Assist NMHSs in the development of a media and public awareness strategy relating to SI Forecasts;
- To represent the needs of associated NMHSs.

Data Services:

- Rescue of climate data sets;
- Provision of climate data base and archiving services;
- Assist in the development and maintenance of software modules for standard applications;
- Advising on data quality management.

Training and Capacity building:

- Training of NMHS staff in SI Forecasting methods and characteristics to assist NMHSs to strengthen their services;

- Assist in the training of end-users on the application and impact of SI Forecast products;

- Assist in the introduction of appropriate decision models for end-users, especially as related to probability forecasts;

- Assist in technical capacity building on NMHS level.

Research and Development:

- Develop a climate Research and Development agenda and coordinate it with other RCCs in the Region;

- To arrange for studies of climate variability, predictability and impact in the Region;

- To develop consensus practices to handle conflicting information for the Region;

- Develop validation procedures relating to SI Forecast products in coordination with other centres;

- Develop and validate regional models, methods of downscaling and interpretation of global output products;

- Undertake application research, and assist in the specification and development of sector specific products;

- Arrange for studies of the economic value of climate information.

NOTE: The second meeting of the ICTT (May 2002), with an expanded membership, noted that the list of RCC functions developed by the first ICTT (shown above as published in WCASP No. 52) could be expanded to include regional climate monitoring and climate data services including data from satellites and ocean observing systems; and hydrological activities, and that these items would merit the full attention of the relevant implementation groups on the regional level (item 3.1.1, WCASP No. 54, March 2002)

Annex to paragraph 6.1.7

Other LRF Data and Products from GPCs

1. Experimental products desired by users of GPC outputs:

- Averages, accumulations or frequencies over 1-month period to 3-month period.
- Probabilities of exceeding some threshold values (e.g., seasonal rainfall totals above a range of thresholds)
- Risk of extreme climate anomalies that may help in warning of e.g. occurrence of heat and cold waves over a particular region.
- Predicted generalized indices of drought, monsoon etc.
- Dry and wet spells: frequency and duration (with one month lead time)
- Probable date of onset of main rainy seasons (over a region, like South Asia, East Asia, southern Africa, GHA etc).
- The need to have first month (0-lead) averages was expressed.

2. The GPV (grid point value) products are preferred in GRIB 2 format rather than NetCDF, especially for downscaling. The requirements are as follows:

- Forecast data for downscaling algorithms; this is likely to require more than monthly mean data, e.g.:
  - Statistics on daily variability
  - Anomalies for some or all ensemble members
  - Hind cast data
- Data for RCM boundary and initial conditions (including SST data).
- Data for calculating regional specialized indices (drought).
- Analyzed fields of surface and upper air parameters for use in empirical models as predictors.
- Observed and predicted global weekly values of SST.
- Daily satellite precipitation analysis for use in monitoring through the season.

3 Regional climate centres/NMCs may not have expertise in all aspects of Long-range forecasts. They will need assistance in training from GPCs in the following main areas:

- Interpretation and use of GPC LRF products
- Downscaling techniques (both statistical and dynamical)
- Verification techniques (for local verification of RCC generated products and application outputs)
- Development of local user applications from RCC downscaled products
- Use and implementation of regional climate models.

Annex to paragraph 6.1.8

OBSERVATION DATA NEEDS FOR PRODUCING GLOBAL LONG–RANGE FORECASTS (updated April 2006)

This Statement of Guidance (SOG) was developed through a process of consultation to document the observational data requirements to support seasonal-to-interannual (SIA) climate prediction. This version was prepared originally by the ET-ODRRGOS with experts from the NWP community, and was subsequently updated in consultation with a number of experts from the climate community through AOPC and by the CBS ET on Infrastructure for Long-Range Forecasting. It is expected that the statement will be reviewed at appropriate intervals by the OPAG on Data Processing Forecasting Systems to ensure that it remains consistent with the current state of the relevant science and technology

1. Introduction

Coupled atmosphere-ocean models are used to produce seasonal-to-inter-annual forecasts of climate. While empirical and statistical methods are also used to predict climate conditions a season ahead, the present assessment of how well observational requirements are met relates only to the coupled model inputs. It is noted that historical data sets also play an important role in SIA prediction by supporting calibration and verification activities.

Whilst such forecasting is still subject to much research and development, many seasonal forecast products are now widely available. The complexity of the component models ranges from simple models to full general-circulation-model representations of both the ocean and atmosphere. There is also large variation in the approach to the assimilation of initial data, with some of the simpler models assimilating only wind information while the more complex models usually assimilate subsurface temperature information and satellite surface topography and temperature data. Indeed, major challenges remain in the development of assimilation techniques that optimize the use of observations in initializing models.

The time and space scales associated with seasonal-to-interannual variability (large scale, low frequency) suggest the key information for forecasts will derive mostly from the slow parts of the climate system, in particular the ocean, but also the land surface. When considering impacts such as rainfall deficiencies or increased temperatures over land, however, there are very good reasons for considering variables associated with the land surface conditions. In particular, land surface moisture and vegetation should be specified and predicted. The models should also include up-to-date radiative forcing (e.g. greenhouse forcing), which are important for maximizing skill in forecasts of land surface air temperature anomalies relative to recent historical reference-normal periods.

In this list of observation needs, the requirements for SIA forecasts are based on a consensus of the coupled atmosphere-ocean modeling community. It builds on the requirements for Global NWP and represents in addition those variables that are known to be important for initializing models or for testing and validating models. For the most part, aspects that remain purely experimental (i.e. unproven) are not included. There is some attempt to capture the impacts aspects; that is, those variables that are needed for downscaling and/or regional interpretation.

2. Data Requirements

The following terminology has been adhered to as much as possible: marginal (minimum user requirements are being met), acceptable (greater than minimum but less than optimum requirements are being met), and good (near optimum requirements are being met).

2.1 Sea surface temperature

Accurate SST determinations, especially in the tropics, are important for SIA forecast models. Ships and moored and drifting buoys provide observations of good temporal frequency and acceptable accuracy, but coverage is marginal or worse over large areas of the Earth. Instruments on polar satellites provide information with global coverage in principle, good horizontal and temporal resolution and acceptable accuracies (once they are bias-corrected using *in situ* data), except in areas that are persistently cloud-covered (which includes significant areas of the tropics). Geostationary imagers with split window measurements are helping to expand the temporal coverage by making measurements hourly and thus creating more opportunities for finding cloud-free areas and characterizing any diurnal variations (known to be up to 4 degrees C in cloud free regions with relatively calm seas). Microwave measurements provide acceptable resolution and accuracy and have the added value of being able to 'see through' clouds. Blended products from the different satellites and *in-situ* data can be expected to be good for SIA forecasts.

There is a requirement for high quality, fast delivery SST (ideally with accuracy < 0.1 deg C on 100 km spatial scale and < 0.25 deg C on 10 km spatial scale, available within 24h (by SST we mean eg bulk temperature at 2m depth).

2.2 Ocean wind stress

Ocean wind stress is a key variable for driving ocean models. It is important to recognise the complementarities between surface wind and surface topography measurements. Current models use winds derived from Numerical Weather Prediction (NWP), from specialist wind analyses or, in some cases, winds inferred from atmospheric models constrained by current SST fields. The tropical moored buoy network has been a key contributor for surface winds over the last decade, particularly for monitoring and verification, providing both good coverage and accuracy in the equatorial Pacific. Fixed and drifting buoys and ships outside the tropical Pacific provide observations of marginal coverage and frequency; accuracy is acceptable.

Satellite surface wind speed and direction measurements are now the dominant source of this information. Currently their data reach SIA models mostly through the assimilated surface wind products of NWP, where their positive impact is acknowledged. Overall, a two-satellite scatterometer system, or its equivalent, would provide good coverage and acceptable frequency, and it would complement the ocean-based systems. At this time, continuity and long-term commitment are a concern. Improved integration of the data streams and operational wind stress products from NWP and other sources will be needed to achieve acceptable or better coverage, frequency and accuracy.

High quality scatterometer winds are the best products available at the moment and need to be maintained operationally. Additional data would always be useful. For example data to allow better estimates of heat-fluxes and P-E (precipitation minus evaporation) could help give a better definition of the mixed layer structure.

2.3 Subsurface temperature

Many, but not all, SIA forecast models assimilate subsurface temperature and salinity data, at least in the upper ocean (down to ~500 m depth). The Tropical Atmosphere Ocean (TAO) / TRITON moored buoy network provides data of good frequency and accuracy, and acceptable spatial resolution, of subsurface temperature for the tropical Pacific, at least for the current modeling capability. The tropical moored network in the Atlantic (PIRATA) is better than marginal but does not yet have the long-term resource commitments and stability to be classified as acceptable. There is no array in the Indian Ocean. The Ships-of-Opportunity Programme (SOOP) provides data of acceptable spatial resolution over some regions of the globe but the temporal resolution is marginal. It is noted that SOOP is evolving to provide enhanced temporal resolution along some specific lines. The Argo Project is providing global coverage of temperature and salinity profiles to ~2000 m, mostly with acceptable-to-good spatial resolution, but only marginal temporal resolution in the tropics. In all cases the accuracy is acceptable for SIA purposes.

Ocean observation system over Equatorial Atlantic is deficient in moorings. Moorings at and near the equator are important. Equatorial moorings in the Indian Ocean are also useful.

2.4 Salinity

Salinity is becoming an important parameter. Some models are starting to make use of such data in the ocean data assimilation. ARGO is a major source of salinity observations. It provides global coverage of temperature and salinity profiles to ~2000 m, mostly with acceptable-to-good spatial resolution, but only marginal temporal resolution in the tropics. Valuable data also comes from the tropical moorings although data coverage is too limited. Surface salinity will be measured by satellite in the forthcoming research mission. There will be a need for continuity of those measurements.

2.5 Ocean topography

Ocean altimetry provides a measure of the sea surface topography relative to some (largely unknown) geoid (or mean sea surface position) that in turn is a reflection of thermodynamic changes over the full-depth ocean column. In principle, the combination of altimetry, tropical mooring and Argo will provide a useful system for initializing the thermodynamic state of SIA models. Long term commitments for satellite altimetry are required. Research satellites are providing a mix of data with acceptable accuracy and resolution and data with good spatial resolution (along the satellite tracks) but marginal accuracy and frequency. The "synoptic" global coverage, particularly beyond the tropical Pacific, is an important requisite. Ocean altimetry data can currently only be used to look at variability in the sea state. There are plans to make use of geodetic data to obtain information about the geoid and the mean state of the oceans. It is expected that geodetic data will become available from satellites; GRACE and CHAMP are flying missions; GOCE will be an important addition.

2.6 Surface heat and freshwater fluxes

There are a few sites in the tropical ocean where the data on surface heat flux are of value for validation and are required at a number of sites in the tropical oceans. NWP products (derived from analysis from short range forecast), in principle, have good resolution but the accuracy is at best marginal. Satellite data provide prospects for several of the components of heat flux, particularly shortwave radiation, but at present none is used on a routine basis for SIA assimilation. Precipitation estimates are important for validation because of the fundamental role of the hydrological cycle in SIA impacts. They also have importance in initialization because of the links to salinity. However, there remain significant uncertainties in estimates of rainfall over the oceans. In addition the fresh water run off information from rivers (large estuaries) will become important in coastal areas and regional parts of the oceans, e.g., the Gulf of Bengal.

2.7 Ocean current data

Models generally do not currently assimilate ocean current data, perhaps in part because data is limited. However, because of the central importance of dynamics and advection, current data are important for testing and validation. For example, experimental fields of surface current for the tropical Pacific and Atlantic are now being produced routinely by blending geostrophic estimates from altimetry with Ekman estimates from remotely-sensed wind observations. Inferred surface currents from drifting buoys are acceptable in terms of accuracy and temporal resolution but marginal in spatial coverage. Satellite altimetry is also being used to infer the distribution of ocean currents. Moored buoys are good in temporal coverage and accuracy, but marginal otherwise.

2.8 In-situ sea level

In-situ sea level measurements provide an additional time-series approach (good temporal resolution and accuracy; marginal spatial coverage), particularly for testing models and validating altimetry.

2.9 Atmospheric data

Since several SIA systems are driven by winds and, in several cases, surface heat flux products from operational analyses, the global (atmospheric) observing system is fundamental for SIA forecasts and their verification.

2.10 Land surface

- Snow cover. Snow cover and depth are important, particularly at short lead times (intraseasonal-to-seasonal). Snow depth observations are marginal.
- Soil moisture and terrestrial properties:
    - Soil moisture are still very marginal although soil moisture initial conditions are a crucial element in the forecast performance in mid-latitudes spring/summer (Beljaars, 1996) and might extend predictability over land in the monthly to seasonal range (Koster et al., 2004a, b). Soil moisture drifts are ubiquitous in NWP models, due to deficiencies in land surface models and/or the forcing precipitation and radiative fluxes (Viterbo, 1996).
    - Due to its extended memory, the relevant quantity to initialise is the soil water in the root layer. There are no existent or planned direct observations of such quantity with global or even regional

coverage. Soil moisture analysis relies on proxy data. Such data covers 3 main groups:

- o Observations related to the surface-atmosphere feedback, or the partitioning of available energy at the surface into sensible and latent heat fluxes (e.g. Screen-level temperature and humidity and early morning evolution of IR radiances in the window channels in geostationary platforms)
- o Observations related to the soil hydrology, such as microwave remote sensing; radiances are sensitive to water in the first top few cm of the soil.
- o Remote sensing observations related to plant phenology, such as leaf area index (LAI), fraction of available photosynthetically active radiation (fAPAR), broadly based in the contrast in reflectances between the visible and NIR. In as much as the phenological evolution of plants depends on available water, there is a soil water related signal in the LAI and/or fAPAR; conversely, assimilation of such quantities will constrain the model evaporation, impacting on the background soil moisture.

- Without careful constraints, the use of one of the 3 classes of observations presented above will alias information into the analysed soil moisture. A strong synergy is expected from combining observations from each of the 3 classes above, because they sample "complementary directions" in the physical space.

2.11 Sea Ice cover and thickness

Sea ice cover is important for high latitudes. It is implicitly included in the leading SST products. Sea ice thickness is important for fluxes and would be useful for initialisation. Too few ice thickness measurements are presently available.

2.12 Other data

There are many other data sets that may play a role in future-generation SIA forecast models. Because these roles are largely unknown, it is premature to discuss the adequacy of observing systems to meet these needs; generally speaking, they are not expected to rank near the above data in terms of priority. These data sets include:

- ▪ Ocean colour. Ocean transparency is already included in several ocean models and is thought to be a factor in SIA models (helping to determine where radiation is absorbed). Ocean colour measurements provide a means to estimate transparency.
- ▪ Clouds. Poor representation of clouds remains a key weakness of most SIA models. Better data are needed to improve parameterisations but these needs are adequately specified under NWP and elsewhere.
- ▪ Aerosols data such as volcanic ash is also required. Continuity of satellite observations of volcanic aerosols is important.
- ▪ Stratospheric ozone concentration data might be of interest in the future for seasonal forecasting.

Annex to paragraph 6.3.1

Results of work of the Expert Team of LRF Verification and clarification on its future work

1. Development of scores to measure skill in the ensemble spread

The ICT recognized that identifying whether there is a correlation between the accuracy of a forecast and the ensemble spread is not an optimal way of identifying whether there is any information in the ensemble distribution. A more successful approach would involve comparing the quality of the forecasts given the observed ensemble spread / distribution with the quality achieved by keeping the ensemble spread/distribution constant. The ET needs to provide detailed guidelines for conducting such tests.

2. Assessment of multi-model ensembles

No new scores are required specifically for assessing the quality of multi-model ensemble forecasts (except for the need for probabilistic scores on continuous scales), but the ET needs to consider making recommendations for minimizing problems associated with the dangers of over-estimating forecast performance given a large number of models ("multiplicity"). Specifically the ET should establish some guidelines for conducting rigorous out-of-sample validation.

3. Standardising methods for defining terciles, etc.

Two approaches for defining quantiles are in common usage: parametric methods based on assumption of a distribution (e.g. tercile boundaries can be estimated at +/- 0.43s.d for data with a Gaussian distribution), and ranking or counting methods (e.g. the lower tercile separates the data ranked in the lowest third of the sample). Parametric methods require choice of the most appropriate distribution and parameter estimation procedures, and incorrect choices can lead to pathological results (e.g. lower quantiles for precipitation may have negative values). The ICT therefore recommended that counting methods should be used in preference to parametric methods.

There are various ways of applying the counting method, the differences lying in the details of interpolation from the two data points surrounding the quantile (the simplest method being an unweighted average of the two surrounding values). The ICT decided that the relative benefits of the different interpolation methods be explored before defining a recommended method for the SVSLRF.

4. Verification of extremes (such as the outlying quintiles)

The ICT recognized the inherent difficulty of verifying forecasts of extreme events because of the small sample sizes involved. The only option is to perform verification and to indicate the uncertainty in the calculation of these scores. The uncertainty in these scores will be unavoidably large. While the existing SVSLRF contains adequate procedures for verification of probabilistic forecasts of extreme events, the ICT recognized the importance of estimating confidence limits for these verification scores and decided that appropriate procedures for calculating these confidence limits need to be developed by the ET and added to the SVSLRF.

The ICT decided that the ET needs to identify appropriate procedures for verification of deterministic forecasts expressed as estimates of the frequency of extreme weather events during the season and should consider the following options and questions:

- Data transformation: can the counts be transformed to have normal distribution, and if so would the current scores for deterministic forecasts in the SVSLRF be appropriate?
- Categorization: should the counts be categorized, and the current scores for categorical forecasts in the SVSLRF be used? If so the ET needs to consider guidelines for the categorization.
- New scores: would a new set of scores be more appropriate, such as percentage error instead of mean bias, and non-parametric measures of association instead of Pearson's correlation?

5. Standardising of hindcast period

The ICT recommended the period of hindcast should be 1981-2002 for submission to the Lead Centre Web-site. The beginning of the period was chosen to be 1981 because it was the first year where good ocean observation data were made available. The end of the period was chosen because it was the ending year of the ERA-40 data set. The specification of the hindcast period will be reconsidered by the ET as suitable observation data sets evolve and become available, noting that in-homogeneity and incompleteness of reference observation data sets impose a constraint on increasing the hindcast periods. The ICT decided that future changes in the details of SVSLRF, such as the definition of the hindcast period, will be communicated through the Lead Centre Web-site to avoid frequent updating of APPENDIX II-8 of the Manual on the GDPFS, and also delays in their implementation.

6. Standardising verification data sets

The precipitation field represents the only parameter for which more than one data set are currently listed in the APPENDIX II-8 of the Manual on the GDPFS. Effectively in the document and on the Web-site both the GPCP and the Xie-Arkin (CMAP) data sets were recommended. A paper by Yin et al. (2004) suggests that the GPCP has fewer flaws than the Xie-Arkin one however the latter may be discontinued in the near future. The ICT recommended the GPCP data set as the official data set for precipitation verification.

7. Ongoing coordination and support of Lead Centre Role

At the meeting of the ET (Reading, 3-7 April 2006) Dr David Jones on behalf of Dr Andrew Watkins gave an update on the Lead Centre activities. WMC Melbourne (Australia) and RSMC Montreal (Canada) collaborated in the Lead Centre for LRF Verification and achieved a successful launch of the Lead Centre Web-site in early 2006. WMO has invited Global Producing Centres for LRFs to submit their verification results for inclusion on this Web-site in a letter sent to relevant Permanent Representatives with WMO on 6 February 2006. A detailed description of this status report of the Lead

Centre is found in the ET meeting document CBS-OPAG/DPFS/ET/LRF/Doc. 7(1), and the Lead Centre Website is located at http://www.bom.gov.au/wmo/lrfvs/.

The Lead Centre has so far processed some verification information from 4 long-range forecast models, originating from 3 separate centres: JMA (2), MSC and Met Office UK. These results are currently displayed on the Web-site. They have also demonstrated to the Lead Centre the practicalities (or otherwise) of some of the procedures in processing and displaying the verification information. Such interactions have resulted in a streamlining of procedures at the Lead Centre. Many other centres have expressed their intention to submit verification information to the SVSLRF Web-site in the near future.

The ICT decided to assign one additional responsibility to the Lead Centre concerning the development of software for graphical display of confidence level information. Once this development work is completed the guidelines included in the APPENDIX II.8 of the Manual on the GDPFS will be updated.

Annex to paragraph 7.2.6

Updated Annexes V, VI, VII to the General Summary of CBS-EXT.(98) and WMO Technical Note 778

Updated Annex V to paragraph 4.3.29 of general summary of CBS-Ext.(98)
Updated at ET-nNERA (Sept. 2005)

DEFINITION OF REQUIREMENTS CONCERNING CHEMICAL INCIDENTS

1. In a broad discussion on meteorological requirements aspects related to chemical incidents it was noted that there was a need to have:

(a) Representative meteorological data reflecting the characteristic atmospheric conditions at and in the vicinity of the incident site;
(b) Data on evolution of atmospheric conditions within the incident area;
(c) Chemical information data base;
(d) Emergency planning and response information including meteorological support aspects;
(e) Expertise at various organizational levels, (e.g. regional to the local level), to provide model output interpretation and/or run very simple models on site to support rapid response;
(f) Dispersion model facilities;
(g) Good communication facilities for rapid receipt of notification and dissemination of results.

2. The above requirements should be considered with a specific focus on:

(a) Data (meteorological observations and incident related);
(b) Tools including models and visualization facilities;
(c) Expertise.

2.1 Data

METEOROLOGICAL:

As input to dispersion models and for understanding and evaluating the dispersion processes involved, data that characterize the atmospheric conditions, especially the local boundary layer and turbulence regime, of the site normally should include:

(a) Wind speed at 10 m;
(b) Wind direction and the directional fluctuations (σ_θ);
(c) Atmospheric stability (e.g. Pasquil category);
(d) Height of atmospheric boundary layer;
(e) Humidity at surface;
(f) Precipitation — occurrence and type;
(g) Surface temperature;

(h) Boundary layer profile (temperature, humidity, wind);
(i) Prevailing climatological conditions and dispersion climatology.

INCIDENT:

Dispersion models can be executed with default parameters (except for location) when little or no information on the incident is available. However, as input to dispersion models, the following parameters characterizing the release of pollutant should be provided whenever possible (actual or estimated):

(a) Location latitude and longitude (units must be specified)
(b) Start date / time / duration of release
(c) Type of incident / name of pollutant
(d) Rate of release or total quantity of pollutant
(e) Effective height / base and top of release.

2.2 There are a number of approaches to obtain the characteristic atmospheric conditions. These may include making arrangements to have deployable mobile weather stations, or to establish standard observing facilities installed and operated at the chemical plant sites and to provide such data routinely from the site. Another approach in countries with dense networks and running mesoscale atmospheric models, is that their outputs could be used as input to dispersion models. Mesoscale model output could also serve to indicate the evolution of atmospheric conditions within the incident area.

2.3 To efficiently run such a model and provide outputs for rapid guidance, there is a need to have an up-to-date integrated system of other related data and information prepared and selectable to include for example, chemical information data base, possible accident scenarios, local surface cover characteristics, and related response planning information. These may include:

(a) Chemical inventories (e.g. types and quantities, geographically referenced to facilities, and transportation corridors);
(b) Type of possible release (fixed facility, mobile tanks, explosive, flammable, etc);
(c) Physical characteristics (mapped) of the incident site and nearby or local areas (e.g. out to 50 km);
(d) Action levels (e.g. Immediate Danger to Life and Health (IDLH) or Lethal Dose (LD50)) that are established in emergency response plans and linked to activating specific emergency response activities. These may be defined quite differently from jurisdiction to jurisdiction.

2.4 The available information on chemical information data base and national emergency planning include the US Environmental Protection Agency (EPA) Computer-Aided Management of Emergency Operations CAMEO: a computer-based planning and response system designed to help emergency planners and responders at regional and local level for, and safely handle, chemical hazards does address these issues. CAMEO operates in two computer environments, IBM compatibles and Apple Macintosh. It contains chemical specific response information, a planning module for assisting the risk posed by extremely hazardous chemicals, an atmospheric dispersion model to assist in evaluating release scenarios, and a series of related data bases for storing and retrieving information required for planning and response (the latter to serve as place holders for local information). CAMEO information may be displayed on maps to assess the relative risk presented by various chemical release scenarios and determine response actions to chemical emergencies.

2.5 Tools

Major tools include atmospheric boundary layer and dispersion models for domains less or equal to 50km. These should assimilate all available local data for diagnostic and prediction purposes. Various factors may come into play in the choice of a suitable model to be run:

(a) Nature and scale of incident (chemical species, emission conditions, surrounding terrain e.g. open field, urban setting, etc);

(b) Treatment of different dispersion regimes, e.g. heavy gas, passive tracer, or buoyant plume (explosion, fires);

(c) Nature of source (chemical release scenario), depending on whether it is a facility or transport incident, or different source term modelling (e.g. jets, pools, flashing liquid) to provide input for specific dispersion model;

(d) Input data requirements (some models will require extensive data sets); timeliness in receiving input data and turn-around time of running models will constrain the possible support to response, perhaps limiting response options to only major incidents;

2.6 Several NMHSs operate EER procedures and models in support of chemical incidents. These models may be:

(a) Empirical ones informed by basic meteorological conditions such as wind velocity, vertical stability, existence of precipitation etc.;

(b) Gaussian models of passive dispersion are easy to run on PCs, require little input data (wind and vertical stability) but are of limited applications;

(c) Integral models of heavy gas dispersion may also be run quickly and efficiently on PCs, and are applicable to a range of chemical releases;

(d) Complex, time dependent, three-dimensional, non-homogeneous models are difficult and expensive to operate in real-time. However, they may be used for scenario simulation of the pollution around a potentially hazardous site, taking into account the small-scale features of the topography. The focus of this application is examining worst cast scenarios for prospective of inputs. It is necessary to run the models on a selected sample of worst case characteristic meteorological condition for each site with due consideration for worst case impacts. Such a catalogue of dangerous areas corresponding to the worse case meteorological situation could be useful in order to determine areas of vulnerability depending on worst case meteorological conditions;

(e) Model intercomparison and validation against observational data (e.g. from field trials) contributes to the understanding of the applicability of the various models.

2.7 Assimilation and application of the output information will require:

(a) Visualization facilities for estimating hazardous zones from model output (e.g. scalable map size, zoom, pan, sections, animation, overlays, etc.);

(b) Geographical information system facilities for detailed interpretation of local meteorological effects on the movement and dispersion of chemicals and aiding in communicating output results using geographical references;

(c) Coupling with established action levels for hazards related decision making.

2.8 Expertise

The meteorological expertise required include expert knowledge and information related to the dispersion models and dispersion processes with a view to advising facility operators on meteorological data measurement systems and on implementation and operation of local dispersion models. This also includes:

(a) Selecting and operating suitable models;

(b) Assessing quality and suitability of model results in the context of specific incidents.

Updated Annex VI to paragraph 4.3.30 of general summary of CBS-Ext.(98)
Updated at ET-nNERA (Sept. 2005)

ROLE OF NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES (NMHSs)

1. Role of NMHSs

(a) Using and providing all available meteorological data, from the NMHS network and other agencies' facilities;

(b) Implementing and operating tools including meteorological NWP models, local dispersion models, related visualisation and geographic information systems and possibly source term models;

(c) Review which models are being run at industries or at emergency response agencies so as to ensure proper use of models; however, not necessarily the role of NMHSs.

(d) Provide meteorological expertise and advice to national, regional and local emergency response teams;

(e) Cooperate with the national emergency response/disaster management agencies and play an active support role by participation in emergency contingency planning and simulation exercises.

2. Possible gaps in the provision of services

2.1 While it is recognized that the identified roles of the NMHSs are broad in relation to requirements in supporting emergency response for chemical incidents, and that individual NMHSs may prioritize certain roles as more critical to implement than others, it should be noted that due to present day operational realities, NMHSs are generally not in a position today to provide specialized support to response in:

(a) Very short time scale incidents;

(b) The near field (i.e. near the source);

(c) Complex source and obstacles to flow (e.g. buildings wake);

(d) Spills where chemicals are released into a body of water.

2.2 The operational capabilities and communications for provision of NMHS services at national, regional and local offices to meet emergency response operations may in some cases not be assured during emergency situations.

2.3 Issues needing to be addressed include minimum standards for dispersion models with a view to harmonization of inputs (in relation to measurement data) and outputs (in relation to parameters used in defining hazards). A methodology is needed for calculating uncertainties in the model estimates, or the sensitivities of outputs to varying input parameters.

Updated Annex VII to paragraph 4.3.32 of general summary of CBS-Ext(98)
Updated at ET-nNERA (Sept. 2005)

GUIDANCE FOR DEVELOPMENT OF THE INTERFACE BETWEEN AN NMHS AND OTHER EMERGENCY RESPONSE AGENCIES IN CASE OF CHEMICAL INCIDENTS

National level

1. The NMHS should take account of existing procedures and make arrangements with agencies responsible for environmental contingency plans to assure participation of the NMHS in national, provincial and local contingency planning.

2. Specific action should be taken by the NMHS to obtain a registry of chemical sites and holdings. In addition, NMHS could assist in developing climatologies of prevailing meteorological conditions at major chemical sites and other high risk zones. The NMHS should arrange to acquire in-situ (plant site) meteorological data routinely and in real-time including remote sensing data. *Note: This is not necessarily the role of NMHSs. However it is important that having the chemicals information database co-located (or rapid access available) with the dispersion model optimizes the calculation of concentrations of the hazardous material in an emergency response situation. The chemicals information that is usually required includes the density of the substance and the threshold concentrations associated with emergency action levels (for public protection).*

3. NMHS should build a knowledge base on what are the response arrangements at various levels of authorities in relation to different incidents including particularly roles and responsibilities and communication arrangements.

4. NMHS should make arrangements to participate in tests and exercises related to response to chemical incidents.

5. NMHS should seek information on and review dispersion models used by other national agencies and industries.

6. NMHS should make arrangements with emergency response authorities to obtain the incident parameters characterizing the release of pollutant.

Regional (Subregional)

7. Interfaces may be required among NMHSs (likely within a limited geographical region); appropriate action by NMHS may include:

(a) Developing bi-national shared stake arrangements with neighbouring NMHSs and procedures for response to agreed areas of common concern, in case of trans-national boundary incidents;

(b) Developing back-up arrangements and procedures for response between NMHSs and/or NMHS (or NMCs) and RSMCs (EER) in accordance with mutually agreed conditions.

For neighbouring States, regional and subregional operational response interfaces could be developed and implemented by the NMHSs. Specific documentation on how NMHS and RSMC deal with chemical accidents should be included as part of relevant contingency plans. Coordination of emergency response, for planning and response to incidents should include:

(a) Identification of contact points (programme and operational);

(b) Arrangements (e.g. data and information exchange, communications, security of information, exercise);

(c) Criteria for activation and deactivation of regional or subregional interface;

(d) Harmonizing of the authoritative information on meteorological aspects of the incident as well as the exchange of information on models and data.

Annex to paragraph 7.2.14

PROPOSED WORK PLAN FOR THE NON-NUCLEAR ERA PROGRAM (Draft)

General

Area of Requirement	Component Action	Priority / Timing / Milestone	Responsibility
Observational data (chemical sniffers, etc)	Explore availability of real-time and post-incident measurement data. Define the use of such data from local and national monitoring in real time operations and post event validation and incorporate as a statement of guidance in operational framework document.	End of 2006	Chair, Viatcheslav Shershakov
Role of International Organizations (including linkage between NMHS with their national civil protection authority)	Develop interface (program coordination, etc including operations) between WMO and WHO, and with UNEP/OCHA Acquire contacts from WHO and UNEP/OCHA and provide to NHMS	2006	Chair, Secretariat
Promote ERA programme to NMHS via Regional Associations	Role for DPFS Rapporteurs in RAs	May 2006 (ICT DPFS)	Secretariat

Dispersion Modelling	Provide an up to date bibliographical list, to be included in chemical accidents framework document	Mid-2006	Roland Draxler
Articles and updates to WMO Tech. Note 778	Review and update to articles and annexes	Future consideration	Chair, Chair ERA

Chemical Release to the Atmosphere[1] [2]

Area of Requirement	Component Action	Priority / Timing / Milestone	Responsibility
Interim Arrangements	SG letter to willing provider states regarding what they are prepared to do to support capacity building – request national technical contact point	2005	Secretariat
	SG letter to all Members to promote PR-to-PR arrangements for capacity building, and basic principles of ERA	2005	Secretariat

[1] There are a number of areas that could be considered (e.g. chemical releases in the water, biological events, etc) and that have been raised by other international organizations (e.g. UNEP OCHA), but this expert team will prioritized work related to chemical releases in the atmosphere.
[2] Events might cover all the horizontal scales. Therefore different arrangements might be required. This expert team will focus on local scale chemical emergency. In the context of this expert team, local scales cover the range up to hundreds of kilometres.

NMHS's to have access to available Mesoscale meteorological models (Aladin, MM5, WRF, GEM LAM, HRM, etc)	WMO secretariat to put relevant point of contact information on web page	February 2006	Chair, Secretariat
Dispersion Model (Air)	Web-based reference (inventory) of modelling tools and services available from provider NMHSs Preparation of a document that describes the stratification from basic minimum tools to sophisticated ATMs	February 2006 February 2006	Chair, Secretariat (with support from ET) Chair, Stewart Wortley to draft

Chemical Release to the Atmosphere (Cont'd)

Area of Requirement	Component Action	Priority / Timing / Milestone	Responsibility
Develop Operational Framework[3]	Preparation of a document describing the proposed operational framework which would contain local response information, including the Melbourne submitted paper, Wortley paper on stratification, and tech 778 doc The following also has to be included in the document: - Training and exercising - Preparedness considerations - How to transit from preparedness to an operational outfit? - Quality assurance guidelines, use of test data should be normal procedure within NMHSs to validate the correctness of their approach; Develop guidelines for procedures, standards for outputs, benchmarking, exercises, etc.	End of 2006	Chair, Stewart Wortley, Chris Ryan, Laurent Perron

[3] There will be the possibility of bi-lateral agreements between NMHSs (PR to PR; e.g. Météo-France is offering to contribute to capacity building) or multi-lateral arrangements. As one example of a multi-lateral, RSMC Obninsk is providing and committing services to the 'NIS' countries. NIS New Independent States formerly known as CIS (organization of former Soviet Union Republic).

Chemical Release to the Atmosphere (Cont'd)

Area of Requirement	Component Actions	Priority / Timing / Milestone	Responsibility
Training (Implementation and Maintenance)	COMET collaboration: - Case studies - Translation of modules[4] - Additional modules Explore web addresses and further discussions with Tim Spangler	Mid-2006	Secretariat
	Identify On-line training Publish Suitable Internet Links	End of 2006	ET provide to Chair by mid-2006
	WMO co-sponsored Training Seminars (planning, who is capable of carrying or participating as experts)	3 over the next 2 or 3 years, starting in 2007, resource permitting	Secretariat, Laurent Perron, Stewart Wortley, Roland Draxler, Michel Jean
	Identify and take advantage of WMO co-sponsored training events of opportunity (few places offered to WMO participants)	Ongoing	Secretariat

[4] The availability of training in languages other than English is rather limited. The group is invited to think about practical solutions to alleviate this problem.

Smoke from large fires (wild-land, oil, chemical)[5]

Area of Requirement	**Component Actions**	**Priority / Timing / Milestone**	**Responsibility**
Observational data, monitoring, database [6]	Explore the role of the Global Fire Monitoring Centre (Freiburg), and other international organizations, GMES (Global Monitoring of Environmental Security), etc, and feedback to ET. e.g. is this real-time, etc Identify relevant remote sensing data sets for real-time operations	2005 2005	ET, Ingo Jacobsen, candidate centres Secretariat to ask WMO satellite office, Ingo Jacobsen to ask GFMC
Interim operational arrangements[7]	There is agreement that we have a capability. Develop standards for source term (including satellite measurement techniques), species to consider (e.g. PM2,5), standard products, requests for services; members to share what they are doing/experience in terms of relevant activities; Parallel ‘CTBTO-like’ system to support countries with no capacity Organize a meeting of providers and users, including International Organizations	2006 To plan a Canadian meeting for 2006, will report back to the Chair by Nov-2005	ET, Stewart Wortley (whip) Michel Jean, Secretariat

[5] The group felt that large fire in this context correspond to events that can be detected through space based platform.
[6] Eventually, fire propagation model will become available. In this case, local meteorological monitoring will become extremely important.
[7] There is a need to understand if this capability is required among NMHSs. Need to check against the WMO survey results.

Smoke from large fires (wild-land, oil, chemical) (Cont'd)

Area of Requirement	Component Actions	Priority / Timing / Milestone	Responsibility
Smoke and pollutants transport and dispersion modeling, Ensemble approach	Evaluate tools or standards to facilitate display of different ensemble members: - we note that SVG is a very interesting and promising avenue for the development of standard output. - JRC/Ispra Ensemble project Explore a hosting site for web-site for real-time ensemble display. Virtual OSOOC (OCHA), member country (?). Members to come back with offers. Develop a prototype "poor man's ensemble" modeling system for smoke dispersion	mid-2006 mid-2006 2007	Michel Jean Laurent Perron Chair, Secretariat Chair
Specialized Centres	Call for RSMC designations (new or expanded role)	End of 2006 (or next ET)	Secretariat
	Develop Criteria, standards, procedures, products, contacts	End of 2006 (or next ET)	ET, candidate centres

Sand and Dust Storms[8]

Area of Requirement	**Component Action**	**Priority / Timing / Milestone**	**Responsibility**
Operational arrangements	Determine whether there is a need for Regional/Global arrangements, including international organizations Develop a web-based information page on the subject	End of 2006 End of 2006	Chair, Secretariat ET, Secretariat
Modeling	There is agreement that we have a capability. Members to share what they are doing/experience in terms of relevant activities	 2006	 ET, Stewart Wortley (as part of action under smoke from large fires)
Specialized Centres	Future consideration		

[8] CSIRO dust storm modeling - Chair of the ET to explore the matter with CSIRO experts; Check with WHO, ICAO (including implications of transport of biological vectors with dust), is this an issue, and report back. Members of the ET required to provide information to ET Chair. Need clarity as to why we would do this. Who are the interested international organizations (ICAO, etc)?

Annex to paragraph 10.2.4

Recommended Working Structure of the OPAG on DPFS and Terms of Reference of its Expert Teams, Coordination Groups, Rapporteur

1. Implementation Coordination Team on Data-Processing and Forecasting System

(a) Identify new emerging requirements (input required from RAs and other bodies);

(b) Determine how GDPFS Centres can best contribute to fulfill emerging requirements;

(c) Participate in THORPEX planning groups as appropriate to advise on conditions and requirements for practical implementations in operational systems;

(d) Identify needs for training through workshops and other means of delivery;

(e) Coordinate the implementation of decisions by CBS related to GDPFS;

(f) Review of Expert Teams and Rapporteurs and make recommendations to CBS concerning future work.

2. Coordination Group on Forecast Verification

(a) In consultation with the relevant Expert Teams, review procedures for verification of the performance of forecasting systems to ensure that they are adequate and meet CBS needs;

(b) Ensure that verification systems are appropriate to emerging forecast types such as probabilistic forecasts, very high resolution NWP products, and nowcasting products;

(c) Review Lead Centre activities and provide guidance as appropriate;

(d) Liaise with WWRP/WGNE as required;

(e) Provide guidance on how to implement verification systems.

3. Expert Team on Ensemble Prediction Systems

(a) Provide advice on EPS in relation to probabilistic forecasts in the context of short- and medium-range EPS products, focusing on applications concerned with all aspects of the EPS systems which forecast the weather on a daily basis;

(b) Review progress on EPS and its application to severe weather forecasting including progress on multi-centre ensembles and on regional model based EPS, and prepare ways to make best operational usage of these developments;

(c) Review the list of fields and products that should be distributed taking into account their potential skill and the requirement of all relevant WMO Programmes;

(d) Propose standards for EPS products (eg EPS-grams, presentation of cyclone tracks and strike probabilities, calculation of probability, calibration methodologies, etc.) to ensure compatibility of EPS products supplied to WMO Members by different centres;

(e) Develop education and training material for forecasters including rationale of concepts and strategies of EPS, and on the nature, interpretation and application of EPS products, with a view to contributing to the Guide on the GDPFS;

(f) In consultation with the Coordination Group on verification, review verification system for EPS products and provide Forecast guidance on the interpretation of verification

(g) Support the further development of the Lead Centre on Verification of EPS by reporting on verification measures and determining the best way of presenting skill of ensemble forecasting systems. Provide relevant software to NMHSs through the Lead Centre Website;

(h) Propose an update to the Manual on the GDPFS (WMO-No. 485) concerning

1. the list of output products available for international exchange and dissemination,
2. post-processing and applications of the EPS and how to integrate them into the forecast system,
3. the verification system for EPS;

(i) Develop and test procedures for the exchange of EPS data, including the needs of large centres to exchange their ensembles;

(j) Participate in THORPEX Working Groups

1. to ensure that the new GIFS (Global Interactive Forecast System) is suitable for operational implementation and application,
2. to review progress on the use of EPS for targeting of observations.

4. Expert Team on Infrastructure for Numerical Weather Prediction (NWP)

(a) In consultation with the relevant Expert Teams and in coordination with the Regional Rapporteurs on GDPFS, review the minimum list of NWP products to be exchanged on the GTS (WIS);

(b) Provide requirements for the dissemination of the products to help OPAG/ISS in determining appropriate means of dissemination to assess telecommunication implications;

(c) Propose standards and guidelines for the provision of initial and boundary conditions to NMCs for limited area models for operational NWP, training, or capacity building purposes

5. Expert Team on Very Short-Range Forecasting

(a) Provide guidance on the use of NWP models and of nowcasting systems for the 0 to 12 hours' description of weather parameters, including probabilistic description, in light of the experience and progress in research;

(b) In consultation with the Coordination Group on Forecast verification,

1. identify suitable techniques for the verification of very high resolution NWP;
2. provide guidelines for the development of operational verification of 0 to 12 hours forecast products;

(c) Propose an update to the Manual on the GDPFS (WMO-No. 485) as required

6. Expert Team on Extended- and Long-range Forecasting

(a) On the basis of stated requirements for LRF products and their improvements, review input from the Global Producing Centres (GPCs), Regional Climate Centres (RCCs) and NMHSs and develop proposal concerning the establishment and implementation of appropriate operational infrastructure for the production, access dissemination and exchange of LRF including multi-model ensembles.

(b) Develop procedures for the exchange of LRF forecasts between GPCs, including defining products (multi-model ensemble, model output, forecast skill, etc.) and defining terms and conditions for exchange;

(c) Develop new interpretation guidance to facilitate correct use of extended- and long-range anomaly forecasts, with a view to contributing to the Guide on the GDPFS;

(d) Report on production, access, dissemination and exchange and provide recommendations for future consideration and adoption by CAS, CCl, CBS and other appropriate bodies;

(e) Coordinate the provision of extended- and long-range forecast verification scores and related information from GPCs for use by NMHSs and RCCs;

(f) Encourage and monitor feedback from NMHSs and RCCs to GPCs on the usefulness of verification information provided under the scheme;

(g) Contribute to the further development of the role of the Lead Centre on Verification and of the Web site including the development and provision of relevant software and data sets;

(h) In consultation with the Coordination Group on Forecast Verification, recommend updates to operational practices to be followed in computation of verification statistics and the information useful to attach to extended and long-range forecast products in the light of the experience and progress in research on verification activities;

(i) In consultation with CAS (CLIVAR/Working Group on Seasonal to Interannual Prediction) and CCl, propose recommendations for improvements of the SVSLRF including for developing areas such as multi-model ensembles.

7. Coordination Group on Nuclear Emergency Response Activities

(a) Test and improve the collective ability of all RSMCs, the IAEA, the RTH Offenbach and NMHSs in the ERA to fulfill the operational requirements specified in global and regional arrangements, according to adopted standards and procedures;

(b) Implement and explore further improved distribution/access methods for specialized products to NMHSs, and the IAEA in collaboration with the IAEA and other relevant organizations;

(c) Collate the individual capabilities of RSMCs to produce enhanced products in support of nuclear emergencies;

(d) Examine the operational availability of radiological monitoring data;

(e) Develop concepts of operational arrangements for atmospheric transport Modelling backtracking products;

(f) Pursue the implementation of operational arrangements with CTBTO.

8. Expert Team on Modelling of Atmospheric Transport for Non-nuclear ERA

(a) Identify the needs of the NMHSs for atmospheric transport modelling;

(b) Examine the atmospheric transport modelling capabilities of RSMCs and other centres for support to non-nuclear emergencies, for example in volcanic eruptions, dust storms, wild-land fires, chemical and biological incidents and other hazards;

(c) Identify the potential role of international organizations (e.g. WHO, UNEP, UN-OCHA, others);

(d) Review the status and develop an action plan.

9. Rapporteur on the Application of NWP to Severe Weather Forecasting

(a) Review the application of NWP to severe and high impact weather forecasting at all ranges;

(b) Report on new developments and advances in severe and high impact weather forecasting;

(c) Provide advice on the proposed demonstration project(s).

Reference

Final reports to meetings since CBS-XIII

All these reports can be found at : Reports of meetings

2005

RA III / IV Training Workshop on Use of EPS Products
Brasilia, Brazil, 24-29 January 2005

RA II / V Training Workshop on Use of EPS Products
Shanghai, China, 18-23 April 2005

RA I Workshop for countries ready to implement operational NWP
Casablanca, Morocco, 12-17 September 2005

CBS/ET on Modeling of Atmospheric Transport for non-Nuclear Emergency Response Activities
Melbourne, Australia, 19-23 September 2005

Workshop for Global Long-range Forecast Producing Centres
Jeju Island, Republic of Korea, 10-14 October 2005

Coordination Team on Migration to Table-Driven Code Forms, First session
Geneva, Switzerland, 1-4 November 2005

RA I Workshop on Operational Use of GDPFS Products for French Speaking countries
Dakar, Senegal, 21-25 November 2005

WMO Workshop on Multi-Hazard, Early Warning Centres' Concept of Operations for the Indian Ocean Tsunami Warning System
Singapore, 21-23 November 2005

Expert Team on Data Representation and Codes
Muscat, Oman, 5-8 December 2005

RA II/VI Training Seminar on Table-Drive Code Forms
Muscat, Oman, 10-14 December 2005

Steering Group for the Severe Weather Forecasting Demonstration Project
Geneva, Switzerland, 14-16 December 2005

2006

Expert Team on Ensemble Prediction Systems
Exeter, UK, 6-10 February 2006

Expert Team On Long-Range Forecasting (Infrastructure and Verification)
ECMWF; Reading, UK, 3-7 April 2006

CBS Coordination Group for Nuclear Emergency Response Activities
Vienna, Austria, 2-6 May 2006

Expert Team on Data Representation and Codes and Coordination Team on Migration to Table Driven Code Forms
ICAO, Montreal, Canada, 8-12 May 2006

CBS Implementation Coordination Team on Data Processing and Forecasting System
Toulouse, France, 29 May – 2 June 2006

Planned meetings :

Severe Weather Forecasting Demonstration Project – Subproject RAI
Pretoria, Sth Africa, 29 July – 3 August 2006

RA II/RA VI Regional Training Seminar on GDPFS Products and Improvement of PWS for Early Warnings and Emergency Response
Langen, Germany, 18-22 September 2006

Fifth session of Regional Association I Working Group on Planning and Implementation of the WWW
Nairobi, Kenya, 25-29 September 2006

Annex I - Agenda

WORLD METEOROLOGICAL ORGANIZATION CBS/ICT-DPFS/Doc. 2.1(1)

COMMISSION FOR BASIC SYSTEMS
OPAG DPFS

(4.IV.2006)

IMPLEMENTATION COORDINATION TEAM ON DATA-PROCESSING AND FORECASTING SYSTEM

Original: ENGLISH

TOULOUSE, FRANCE, 29 MAY- 2 JUNE 2006

AGENDA

1. **Opening of the Meeting**
2. **Organization of the Meeting**
   - 2.1 Adoption of the Agenda
   - 2.2 Working arrangements
3. **Forecasting Standards and Recommended Practices**
4. **Ensemble Prediction Systems Products and Applications**
5. **Severe Weather Forecasting**
6. **Long-range Forecasting**
7. **Emergency Response Activities**
8. **Impact of changes of GOS on GDPFS**
9. **Regional perspectives**
10. **Future work programme**
11. **Other business**
12. **Closure of meeting**

Annex II - List of Participants

WORLD METEOROLOGICAL ORGANIZATION

CBS/ICT-DPFS/INF. 2

COMMISSION FOR BASIC SYSTEMS
OPAG DPFS

(4.IV.2006)

IMPLEMENTATION COORDINATION TEAM ON DATA-PROCESSING AND FORECASTING SYSTEM

Original: ENGLISH

TOULOUSE, FRANCE, 29 MAY- 2 JUNE 2006

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APPENDIX to the Final Report of the Meeting of the CBS ICT of the OPAG on DPFS including all Recommended amendments to the WMO Manual on the GDPFS (WMO-No. 485), Toulouse, 29 May 2006.

This APPENDIX provides all recommended amendments to the *WMO Manual on the GDPFS* (WMO-No. 485), that have been recommended by the OPAG on DPFS' Teams and further presented by the OPAG's ICT for further recommendation to CBS-Ext.(06).

A. <u>Ensemble Prediction Systems</u>

A.1 Recommended amendment (new) to Vol. I, Part II, APPENDIX II-6

4.1 Ensemble prediction system products
4.1.1 Products for short range and medium range

New paragraph as follows:

(c) Other graphical products
Location-specific time series of Temperature, Precipitation, Wind speed, depicting the most likely solution and an estimation of uncertainty ("EPSgrams"). The definition, method of calculation, and the locations should be documented.

A.2 Recommended amendment (revised) to Vol. I, Part II, Attachment II.7 (Table F)

Revised entire section III – Standard Verification Measures of EPS, as follows:

III – STANDARD VERIFICATION MEASURES OF EPS

EXCHANGE OF SCORES
Monthly exchanges:

Ensemble mean
For verification of ensemble mean, the specifications in this table of the attachment for variables, levels, areas and verifications should be used.

Spread
Standard deviation of the ensemble averaged over the same regions and variables as used for the ensemble mean.

Probabilities
Probabilistic scores are exchanged in the form of reliability tables. Details of the format of the reliability tables are provided on the website of the Lead Centre for verification of EPS.

List of parameters
PMSL anomaly ± 1, ± 1.5, ± 2 standard deviation with respect to a centre-specified climatology. Verified for areas defined for verification against analysis.

Z500 with thresholds as for PMSL. Verified for areas defined for verification against analysis.

850 hPa wind speed with thresholds of 10, 15, 25 m s^{-1}. Verified for areas defined for verification against analysis.

850 hPa u and v wind components with thresholds of 10^{th}, 25^{th}, 75^{th} and 90^{th} percentile points with respect to a centre-specified climatology. Verified for areas defined for verification against analysis.

250 hPa u and v wind components with thresholds of 10^{th}, 25^{th}, 75^{th} and 90^{th} percentile points with respect to a centre-specified climatology. Verified for areas defined for verification against analysis.

T850 anomalies with thresholds ± 1, ± 1.5, ± 2 standard deviation with respect to a centre-specified climatology. Verified for areas defined for verification against analysis.

Precipitation with thresholds 1, 5, 10, and 25 mm/24 hours every 24 hours verified over areas defined for deterministic
forecast verification against observations.
Observations for EPS verification should be based on the GCOS list of surface network (GSN).

NOTE: Where thresholds are defined with respect to climatology, the daily climate should be estimated.

Scores
Brier Skill Score (with respect to climatology) (see definition below*)
Relative Operating Characteristic (ROC)
Relative economic value (C/L) diagrams
Reliability diagrams with frequency distribution

NOTE: Annual and seasonal averages of the Brier Skill Score at 24, 72, 120, 168 and 240 hours for Z500 and T850 should be included in the yearly Technical Progress Report on the Global Data-processing and Forecasting System.

B. <u>Long-Range Forecasts</u>

B.1 Recommended amendment (new) to Vo. I, Part II, paragraph 1.4.1.2 (b)
Add following note :

1) Centres producing global long-range forecasts, and recognized as such by CBS, are called Global Producing Centres for Long-range forecasts (GPCs). They are not necessarily among the WMC, RSMC or NMC GDPFS centres. The criteria to be recognized as a GPCs and the list of official recognized GPCs can found in APPENDIX II-8.

B.2 Recommended amendment (new) to Vol. I, Part II, APPENDIX II-8

In order to be officially recognized as a GPC (Global Producing Centre of Long-range forecasts), a centre must as a minimum adhere to the following criteria:

- Fixed production cycles and time of issuance;
- Provide a limited set of products as determined by the APPENDIX II-6 of this Manual;
- Provide verifications as per the WMO SVSLRF;
- Provide up-to-date information on methodology used by the GPC;
- Make products accessible through the GPC Web site and/or disseminated through the GTS and/or Internet.

Centres that are designated as Global Producing Centres for Long-range Forecasts are listed below :

B.3 Recommend amendment (revised) to Vol. I, Part II, APPENDIX II-6

"Minimum list of LRF products to be made available by global scale producing centres"

1. Forecast Products

Note: it is recognized that some centres may provide more information than the list including for example daily data or hind cast data.

Basic properties

Temporal resolution.
~~**Monthly averages/accumulations for a season**~~**.**

Averages, accumulations or frequencies over 1-month or longer periods (seasons)

Spatial resolution.
2.5° x 2.5° (note: selected to match resolution of current verification data)

Spatial coverage. **Global**
(separate areas of interest to users, down to sub-regions of a continent or ocean basin, may be provided on special request from Members)

Lead time. ~~**0-4 months for seasonal forecasts.**~~ **Any leadtimes between 0, and 4 months (**definition of lead time: for example, a three-monthly forecast issued on 31 December has a lead time of 0 months for a January-to-March forecast, and a lead time of 1 month for February-to-April forecast, etc.)

Issue frequency. **Monthly or at least quarterly**

Output types. Either rendered images (eg forecast maps and diagrams) or digital data.~~Gridded numerical values, area-averaged values and indices, and/or images~~. GRIB-2 format should be used for products posted on FTP-sites or disseminated through the GTS.

Indications of skill including hind cast **should be provided**, in accordance with recommendations from CBS on the Standardised Verification System (Attachments II-8). The minimum required is level 1 and level 2 verification. The verification of Nino3.4 index will only apply to those centres producing such indices. However GPCs are encouraged to provide level 3 verification. Verification results over the hindcast period are mandatory.

Content of basic forecast output: (some products are intended as directly meeting NMS requirements with regard to information needed for end-user applications [direct or further processed]; others are to assist the contributing global centres in product comparison and in the development of multimodel ensembles. These products are regarded as feasible from current systems).

A. **Calibrated outputs from ensemble prediction system showing the mean and spread of the distribution for:**
   - **2 metre temperature over land**
   - **sea surface temperature**
   - **precipitation**
   - **Z500, MSLP, T850**

Notes:

1. These fields are to be expressed as departures from normal model climate.
2. SST used as boundary conditions for (two-tiered) AGCM predictions should be made available.

B. **Calibrated probability information for forecast categories.**

- **2 metre temperature over land**
- **SST (Atmospheric coupled models only)**
- **Precipitation**

Notes:

o B is the minimum requirement. A should be provided, at least, by request.
o **Tercile categories should be provided**, consistent with present capabilities. Information for larger numbers of categories (e.g. deciles) is foreseen, however, as capabilities increase and to match better the anticipated end-user requirements. These targets are implied also for forecasts from statistical/empirical models.
o **Information on how category boundaries are defined should be included.made available.**
o "Calibrated" implies correction based on systematic errors in model climatology, using at least 15 years of retrospective forecasts.

B.4 Recommended amendment (revised) to Vol. I, Part II, Attachment II-8

"Standardized Verification System (SVS) for Long-range Forecasts (LRF)"

In Executive Summary:

Add:

1.5 Exchange of verification information

The SVSLRF verification results are made available through a web site maintained by the Lead Centre. The functions of the Lead Centre for SVSLRF include creating and maintaining coordinated Web sites for the LRF verification information so that potential users would benefit from a consistent presentation of the results. The address of the web site is http://www.bom.gov.au/wmo/lrfvs/.

In : 3. Parameters

The key list of parameters in the Core SVS is provided below. Any verification for these key parameters should be assessed using the Core SVS techniques wherever possible. Many long-range forecasts are produced which do not include parameters in the key list (for example, there are numerous empirical systems that predict seasonal rainfall over part of/or over an entire, country). The Core SVS diagnostics should be used to assess these forecasts also, but full details of the predictions will need to be provided.

Add:

Forecast can be made using different levels of post-processing typically no-post-processing (raw or uncalibrated), simple correction of systematic errors (calibrated, i.e.

calibration of mean and of variance) and more complex correction using hindcast skill (recalibrated, e.g. Model Output Statistics or perfect prog approaches). Most centres are currently issuing forecasts resulting from a simple calibration and so for sake of comparison on the Lead Centre web site scores for forecasts that were raw or calibrated (as specified in respective skill score section) are to be submitted. At the moment the team prefer to exclude forecast that were recalibrated, but GPCs are encouraged to apply the SVSLRF methodology and to display the results on their recalibrated forecasts on their web site.

3.1 Level 1: Diagrams and scores to be produced for regions

Diagrams (e.g. ROC and reliability curves) are to be supplied in digital format as specified on the Lead Centre website.

IN MAIN TEXT:

In 3. SVS for Long-Range Forecasts, Add at the beginning:

Forecast can be made using different levels of post-processing typically no-post-processing (raw or uncalibrated), simple correction of systematic errors (calibrated, i.e. calibration of mean and of variance) and more complex correction using hindcast skill (recalibrated, e.g. Model Output Statistics or perfect prog approaches). Most centres are currently issuing forecasts resulting from a simple calibration and so for sake of comparison on the Lead Centre web site scores for forecasts that were raw or calibrated (as specified in respective skill score section) are to be submitted. At the moment the team prefer to exclude forecast that were recalibrated, but GPCs are encouraged to apply the SVSLRF methodology and to display the results on their recalibrated forecasts on their web site.

Amend 3.1.4 as:

The following gives a summary of parameters, validation regions and diagnostics that form the core SVS. The required periods, lead-times and stratification against the state of ENSO are given in section 3.2.

The number of realisations of LRF is far smaller than in the case of short term numerical weather prediction forecasts. Consequently it is essential as part of the core SVS, to calculate and report error bars and level of significance (see section 3.3.5).

In order to ease implementation, participating LRF producers may stage the introduction of the core SVS by prioritizing implementation of verification at levels 1 and 2.

Other parameters and indices to be verified as well as other verification scores can be added to the core SVS in future versions.

In 3.3.1 amend the following table as:

⇒	MSSS, provided as a single bulk number, is mandatory for level 1 verification in the core SVS. MSSS together with its three term decomposition are also mandatory for level 2 verification in the core SVS. For the exchange of scores via the Lead Centre web site the MSSS and its decomposition term should be calculated using the raw forecasts and preferably not the calibrated ones.

In 3.3.5 Level of significance

MSSS

Amend table as:

⇒ Level of significance will be mandatory in the core SVS once guidelines for calculation have been established for the complete suite of scores. A phased in introduction of level of significance in the SVS may be used (see section 3.1.4).

In 3.4 Hind casts amend first paragraph as:

In contrast to short- and medium-range dynamical Numerical Weather Prediction (NWP) forecasts, LRF are produced relatively few times a year (for example, one forecast for each season or one forecast for the following 90-day period, issued every month). Therefore the verification sampling for LRF may be limited, possibly to the point where the validity and significance of the verification results may be questionable. Providing verification for a few seasons or even over a few years only may be misleading and may not give a fair assessment of the skill of any LRF system. LRF systems should be verified over as long a period as possible in hind cast mode. Although there are limitations on the availability of verification data sets and in spite of the fact that validating numerical forecast systems in hind cast mode requires large computer resources, the hind cast period should be as long as possible. The recommended period for the exchange of scores is advertised on the Lead Centre web site (http://www.bom.gov.au/wmo/lrfvs/).
Add in last array:

⇒ Verification results over the hindcast period are mandatory for the exchange of LRF verification scores. Producing centres have to send new hindcast verification results as soon as their forecast system is changed.

In 4. VERIFICATION DATA SETS amend as:

The same data should be used to generate both climatology and verification data sets, although the forecast issuing Centres/Institutes own analyses or reanalyses and subsequent operational analyses may be used when other data are not available.

Many LRF are produced that are applicable to limited or local areas. It may not be possible to use the data in either the recommended climatology or verification data sets for validation or verification purposes in these cases. Appropriate data sets should then be used with full details provided.

Verification should be done using the recommended data sets as listed on the Lead Centre web site (http://www.bom.gov.au/wmo/lrfvs/).

Amend as:

6.1.1 Create, develop and maintain web-site (the "SVSLRF web site") to provide access to the LRF verification information. The address of the web site is http://www.bom.gov.au/wmo/lrfvs/. The web-site will:

(i) Provide access to standardized software for calculating scoring information (ROC curves, areas, contingency table scores, hit rates, …).

(ii) provide consistent graphical displays of the verification results from participating centres through processing of digital versions of the results;

(iii) contain relevant documentation and links to the web sites of global-scale producing centres;

(iv) provide some means for the collection of feedback from NMHSs and RCCs on the usefulness of the verification information;

(v) Contain information and, preferably, provide access to available verification data sets;

6.1.2 The centre will also:

(i) Produce monthly verification data sets in common format on 2.5° x 2.5° grid where appropriate;

(ii) liaise with other groups involved in verification (e.g. WGSIP, CCI, etc.) on the effectiveness of the current standardised verification system (SVS) and identify areas for future development and improvement;

(iii) provide periodic reports to CBS and other relevant Commissions assessing the effectiveness of the SVS**.**

(iv) facilitate the availability of information to assess the skill of long-range forecasts but not to provide a direct inter-comparison between the GPCs' models.

6.1.3 Detailed tasks of the "lead centre":

C. Emergency Response Activities

C.1 Recommended amendment (revised) to Vol. I, Part II, APPENDIX II-7:

o "Users Interpretation Guide for Atmospheric Transport Model Products provided by RSMCs".

(Introductory section, second paragraph)
"The International Atomic Energy Agency (IAEA) requests support from WMO RSMCs for atmospheric transport modelling products by using the form agreed between WMO and IAEA. The IAEA then sends the completed form immediately, by fax and by e-mail (preferred), to the RSMCs as per the regional and global arrangements and ensures receipt of the form by phone. The Lead-RSMCs shall confirm receipt of the IAEA request by fax or e-mail (preferred) to IAEA. This will initiate a joint response from the RSMCs in their region of responsibility. The IAEA sends an information copy of its Request Form by fax or by e-mail (preferred) to RTH Offenbach." When the Lead-RSMC's products become available, the Lead-RSMCs shall send an announcement to the IAEA that their respective products are available and the products' location (RSMC's dedicated web-site), by fax or by e-mail (preferred)."

o “ENVIRONMENTAL EMERGENCY RESPONSE REQUEST FOR WMO RSMC SUPPORT BY IAEA”

Environmental Emergency Response

Request for WMO RSMC Support by IAEA

The IAEA sends the completed form by fax to all RSMCs and RTH Offenbach.
At the same time the IAEA calls the ‘Lead’ RSMCs (selected on the form) to ensure receipt of this form.

Date/Time of Request: yyyy-MM-dd/HH:mm(UTC)

STATUS: ☐ **EMERGENCY** ☐ **EXERCISE**

REQUESTED RSMCS : (indicate the lead RSMCs by a checkmark below)

☐ EXETER ☐ TOULOUSE ☐ MELBOURNE ☐ MONTREAL ☐ WASHINGTON

☐ BEIJING ☐ TOKYO ☐ OBNINSK ☒ RTH Offenbach

SENDERS NAME :**INTERNATIONAL ATOMIC ENERGY AGENCY**

COMMUNICATION DETAILS:	Tel .: +43 1 2600 22023	use to confirm receipt of request
	Fax: +43 1 26007 29309	use to confirm receipt of request
	Email: eru3@iaea.org	use to confirm receipt of request

NAME OF RELEASE SITE AND COUNTRY (facility and place)

GEOGRAPHICAL LOCATION OF RELEASE: . decimal degrees ☐ N ☐ S
. decimal degrees ☐ E ☐ W
(MUST BE COMPLETED)

DECLARED EMERGENCY CLASS:

☐ NONE ☐ other, specify:

ACTION REQUIRED :

- ☐ NONE
- ☐ GO ON STANDBY (request for products or for assistance on weather conditions is to be expected)
- ☐ GENERATE STANDARD PRODUCTS AND SEND TO IAEA ONLY
- ☐ GENERATE STANDARD PRODUCTS FOR THE IAEA AND REGIONAL DISTRIBUTION
- ☐ OTHER ACTION :

(essential accident information for model simulation - if not available, model will execute with standard default values)

RELEASE CHARACTERISTICS:

START OF RELEASE: Date/Time: - - / : (UTC)

DURATION: (hours) or END OF RELEASE: Date/Time: - - / : (UTC)

RADIONUCLIDE SPECIES:

TOTAL RELEASE QUANTITY: (Becquerel)

OR POLLUTANT RELEASE RATE: (Becquerel/hour)

EFFECTIVE HEIGHT OF RELEASE: ☐ surface or

☐ stack height: (m), or

☐ aloft:top: (m), base: (m)

(helpful information for improved simulation)

SITE ELEVATION: (m)

LOCAL METEOROLOGICAL CONDITIONS NEAR ACCIDENT:

(wind speed and direction/weather/cloudiness/precipitation, etc.)

OTHER INFORMATION:

(nature of accident, cause, fire explosion, controlled release, foreseeable development, normal activity, projected conditions, etc)

(to be completed by RSMC)

DATE/TIME OF RECEIPT OF REQUEST:.. (UTC)

FOR LEAD RSMC(s) ONLY
DATE/TIME OF RETURN CONFIRMATION OF RECEIPT:.. (UTC)

Note: All times in UTC

C.2 Recommended amendment (revised) to Vol. I, Part I, paragraph 4.1.2

4.1.2.2 Centres with activity specialization

The functions of RSMCs with activity specialization shall include, *inter alia*:

(a) Providing long-, extended- and/or medium-range forecasting products;

(b) Providing advisories for tropical cyclones, severe storms and other dangerous weather phenomena;

(c) Providing tailored specialized products to service users in a particular area;

(d) Providing trajectories and atmospheric transport modelling products, including backtracking, ~~or dispersion of pollutants~~ in case of environmental emergencies or other incidents;

(e) Providing information on prolonged adverse weather conditions, including drought monitoring;

(f) Undertaking activities related to the WCP and other WMO international programmes. This includes providing climate diagnostic, climate analysis and prediction products to assist in climate monitoring.

4.1.2.3 RSMCs shall also carry out verification and intercomparison of products and arrange regional workshops and seminars on centres' products and their use in national weather forecasting. RSMCs with geographical and activity specialization shall be co-located where possible.

4.1.2.4 RSMCs designated by WMO for the provision of atmospheric transport model products shall implement the Regional and Global Arrangements and related procedures as found ~~for environmental emergency response shall implement the regional and global arrangements and related procedures~~ in APPENDIX I-3, and/or backtracking in APPENDIX I-6, respectively.

4.1.2.5 The designated WMCs and RSMCs are given in APPENDIX I-1 and the procedures for broadening the functions of existing RSMCs and for designating new RSMCs are given in APPENDIX I-2. ~~Regional and global arrangements for the provision of transport model products for environmental emergency response are given in APPENDIX I-3.~~

NOTE: Guidelines to review the status of RSMCs with geographical specialization are given in Attachment I.1.

C.3 Recommended amendment (revised) to Vol. I, Part I, APPENDIX I-1

APPENDIX I-1

LOCATION OF WMCs AND RSMCs WITH GEOGRAPHICAL SPECIALIZATION AND RSMCs WITH ACTIVITY SPECIALIZATION

1. The WMCs are located at:

   Melbourne (southern hemisphere only)
   Moscow
   Washington

2. The RSMCs with geographical specialization are located at:

Algiers

Beijing

~~Bracknell~~Exeter

Brasilia

Buenos Aires

Cairo

Dakar

Darwin

Jeddah

Khabarovsk

Melbourne

Miami

Montreal

Moscow

Nairobi

New Delhi

Novosibirsk

Offenbach

Pretoria

Rome

Tashkent

Tokyo

Tunis/Casablanca

Washington

Wellington

Broadened RSMC functions:

Offenbach — Provision of ultraviolet-index forecasts for Region VI (Europe)

3. The RSMCs with activity specialization are the following:

RSMC Nadi – Tropical Cyclone Centre

RSMC New Delhi – Tropical Cyclone Centre

RSMC Miami – Hurricane Centre

RSMC Tokyo – Typhoon Centre

RSMC La Réunion – Tropical Cyclone Centre

RSMC Honolulu – Hurricane Centre

RSMC European Centre for Medium Range Weather Forecasts (RSMC ECMWF)

Provision of atmospheric transport modelling ~~products~~ (for environmental emergency response and/or backtracking)

RSMC Beijing

RSMC ~~Bracknell~~Exeter

RSMC Melbourne

RSMC Montreal

RSMC Obninsk

RSMC Tokyo

RSMC Toulouse

RSMC Washington

C.4 Recommended amendment (new) to Vol. I, Part I, APPENDIX I-6

APPENDIX I-6

REGIONAL AND GLOBAL ARRANGEMENTS FOR ATMOSPHERIC BACKTRACKING

NOTIFICATION

In the framework of the cooperation agreement between CTBTO and WMO that entered into force on July 11th, 2003, the (Provisional) Technical Secretariat ((P)TS) notifies the RSMCs designated for the provision of atmospheric backtracking products and the WMO Secretariat in case that anomalous Radionuclide measurements occur in the International Monitoring System. The notification will be in the form of an electronic mail message that will specify the coordinates of the requested stations as well as start and stop of the measurements. The measurement scenario will not be revealed.

Global arrangements for all RSMCs to distribute the products to CTBTO

1. All notified RSMCs shall acknowledge the receipt of the request and deliver the requested atmospheric backtracking products in electronic form and in the predefined format to a server specified by CTBTO/PTS as part of the notification;

2. The products shall be delivered as fast as technically possible within defined timelines;

3. Every participating RSMC that is temporarily unable to honour the request should notify CTBTO/PTS and the WMO Secretariat as soon as possible, but in any case within 24 hours. The contact officer from side of the PTS is specified on the electronic mail message;

4. Requests for support from the PTS are considered confidential and must not be disclosed.

REGIONAL ARRANGEMENTS FOR ONE OR MORE RSMCS TO DISTRIBUTE PRODUCTS TO AN NMHS

If support is required for response to an incident requiring backtracking using atmospheric transport models, then the Permanent Representative with WMO, or the person authorised of the requesting country may direct its request for support to the operational contact point of the designated RSMC(s) for its Regional Association.

1. The RSMC shall consider each request with regard to its capabilities and the suitability of its products to address the requirements and will then respond accordingly.

2. The RSMC shall inform the WMO Secretariat of the request and the agreed actions, and may inform all other designated RSMC's of the request.

3. The RSMC products will be provided to the NMS Operational Contact Point designated by the Permanent Representative.

C.5 Recommended amendment to Vol. I, Part II, paragraphs. 1.4.1.2 (revised), 5.3.10 (revised) , 5.3.11 (new)

1.4.1.2 Regional Specialized Meteorological Centres (RSMCs) with activity specialization

Regional Specialized Meteorological Centre (RSMC) with activity specialization shall be designated, subject to the formal commitment by a Member or group of cooperating Members, to fulfil the required functions of the centre and meet the requirements for the provision of WWW products and services initiated and endorsed by the relevant WMO constituent body or bodies concerned. The centre should be capable of preparing independently or with the support of WMCs, and where appropriate, other GDPFS centres and disseminating to Members concerned:

(a) Global medium-range forecasts and related analyses;

(b) Extended- and long-range weather forecasts and related mean analysed values and anomalies;

(c) Tropical cyclone warnings and advisories, storm position, intensity and track forecasts for their areas;

(d) Three-dimensional atmospheric transport modelling products including ~~environmental emergency response transport model~~ trajectories, integrated pollutant concentration, and total deposition for environmental emergency response; atmospheric backtracking modelling products;

(e) Drought monitoring products such as drought indices.

5.3.10 Standards in the provision of international services by Regional Specialized Meteorological Centres (RSMC~~s~~) for atmospheric transport modelling, in radiological environmental emergency response

5.3.10.1 The designated RSMCs with activity specialization in this field shall implement agreed standard procedures and products.

NOTE: Standards in the provision of international services by RSMCs for atmospheric transport modelling, for radiological ~~evnvironmental~~environmental emergency response are given in APPENDIX II-7.

5.3.11 Standards in the provision of international services by Regional Specialized Meteorological Centres (RSMC) for atmospheric transport modelling in backtracking

5.3.11.1 The designated RSMCs with activity specialization in this field shall implement agreed standard procedures and products.

NOTE: Standards in the provision of international services by RSMCs for CTBT Verification support are given in APPENDIX II-9.

C.6 Recommended amendment (new) to Vol. I, Part II, APPENDIX II-9

"Products Provided by RSMCs with Activity Specialization in Atmospheric Transport Modelling (Backtracking for CTBT Verification Support)"

APPENDIX II-9

PRODUCTS PROVIDED BY RSMCS WITH ACTIVITY SPECIALISATION IN ATMOSPHERIC TRANSPORT MODELLING (BACKTRACKING FOR CTBT VERIFICATION SUPPORT)

The CTBTO (Provisional) Technical Secretariat requests support from WMO Regional Specialized Meteorological Centres (RSMC) for atmospheric transport modelling (backtracking) products by using an electronic mail message with subject line "====== PTS REQUEST FOR SUPPORT ======" to all RSMCs. This will initiate a response from all the RSMCs.

The designated RSMCs shall

a) Mail back the response form to the responsible officer at the PTS within 3 hours

b) Conduct standardized backtracking computations according to the specifications listed below for all measurements included in the notification message

c) Upload the results on a secured ftp server, as defined in the notification message, within 24 hours of reception and according to the format as defined below

The specifications for the backtracking are as follows:

- Simulate a release of 1.3 10^{15} Bq of a tracer integrated backward in time (no deposition, no decay) at a constant rate at the point of the station location from surface to 30 m from measurement stop to measurement start.
- Calculate the respective (backward) tracer concentrations [in Bq/m^3] at a global 1x1 degree grid, output frequency 3 hours, time average of output 3 hours, from surface to 30 m.
- Simulate backwards in time to the requested ending date/time (usually 6-14 days from sample collection stop)

The PTS shall

a) Restrict requests to cases of anomalous radionuclide measurements or system tests

b) Contact the RSMCs in case no confirmation of a request was received within 3 hours

c) Conduct regular announced and/or unannounced system tests

d) Share the results of tests with the other RSMCs at a web site

The (P)TS will not request any graphical or products other than specified above. Customized end-user products will be produced by the (P)TS for submission to the National Authorities, along with RSMC model output. Measurements and end-user products will not be shared by the (P)TS with the RSMCs or the WMO secretariat for reasons of confidentiality.

NOTIFICATION MAIL MESSAGE SENT OUT BY THE PTS TO WMO RSMCs

====== PTS REQUEST FOR SUPPORT =====
Date issued: YYYYMMDD hhmm
Responsible officer: NAME

Point of contact:
NAME
Tel. …………………
Fax. ………………….
name@****.***

Secure Web site (location/user/password)

Download of information:
****://**************
username
Password

Data upload:
****://**************
Username
Password

For authentication purposes, this mail message is also available
on the web site:
****://**************************************.txt
==
Source-receptor matrix results are requested for
005
stations
 #   LON   LAT   ID   Measurement Start/stop time (YYYYMMDD hh)
001 -70.90 -53.10 CLP18 20050328 15 20050329 15
002 -70.90 -53.10 CLP18 20050329 15 20050330 15
003 -71.25 -41.10 ARP03 20050329 12 20050330 12
004 -58.47 -34.54 ARP01 20050329 18 20050330 18
005 -70.90 -53.10 CLP18 20050330 15 20050331 15
==
Please calculate backward to
YYYYMMDD hh
==
Please upload data within
24
hours

==RESPONSE FORM==
=== WMO Centre response form   ===
=== Please send back this form   ===
=== to the sender of the request as ===
=== soon as possible   ===
==

(x) We will send our contributions within the time limit (default)
( ) We will send our contributions kkk hours later then the time limit
( ) We got your request but are not able to perfom computations

==

====== PTS REQUEST FOR SUPPORT =====

FORMAT OF THE MODEL RESULTS AS DELIVERED BY THE RSMCs

Line 1: Header Line (Station longitude, latitude, start of measurement interval (YYYYMMDD hh), end of measurement interval (YYYYMMDD hh), release strength (Bq), number of hours backward, output every "k" hours, time average of output, Station Name)

Line 2-k: data lines (latitude, longitude, time step number, value)

```
17.57  59.23 20030106 09 20030107 09 0.13E+16   144  3  3 1.00 1.00 "SEP63"
 58.00    15.00   1  0.1209120E-01
 59.00    15.00   1  0.6446140E-01
 60.00    15.00   1  0.3212887E-02
 58.00    16.00   1  0.2649441E+01
 59.00    16.00   1  0.9029172E+01
 60.00    16.00   1  0.7616042E-01
 58.00    17.00   1  0.1073919E+02
 59.00    17.00   1  0.3082339E+02
 60.00    17.00   1  0.1408468E-01
 58.00    18.00   1  0.2643455E+00
 59.00    18.00   1  0.7357535E+00
 58.00    14.00   2  0.7759376E-02
 59.00    14.00   2  0.6508716E-01
 60.00    14.00   2  0.2403110E-01
 61.00    14.00   2  0.6662516E-03
 62.00    14.00   2  0.2838572E-04
 58.00    15.00   2  0.1015775E+01
 59.00    15.00   2  0.5030275E+01
 60.00    15.00   2  0.8239139E+00
 61.00    15.00   2  0.6797127E-02
 62.00    15.00   2  0.6521360E-04
 58.00    16.00   2  0.8181147E+01
 59.00    16.00   2  0.2503959E+02
 60.00    16.00   2  0.5937406E+00
 61.00    16.00   2  0.1784474E-02
 58.00    17.00   2  0.1403705E+02
 59.00    17.00   2  0.3715418E+02
 60.00    17.00   2  0.1306086E-01
 58.00    18.00   2  0.2718492E+00
 59.00    18.00   2  0.7555131E+00
……
```