WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

OPAG ON
DATA PROCESSING AND FORECASTING SYSTEMS

MEETING OF THE

EXPERT TEAM ON EXTENDED AND LONG-RANGE FORECASTING

BEIJING, 7-10 APRIL 2008

FINAL REPORT

EXECUTIVE SUMMARY

The meeting of the Expert Team on Extended and Long-Range Forecasting of the CBS OPAG on DPFS was held at the kind invitation of China Meteorological Administration in Beijing Climate Centre (BCC) from 7 to 10 April 2008. Eleven experts representing ten Global Producing Centres (GPCs) of Long-Range Forecast and one regional centre participated in the meeting.

The exchange of products and data between GPCs, NMCs and potential RCCs was reviewed. In the spirit of Resolution 40, the Team had previously proposed that GPCs' products defined in the Appendix II.6 of the Manual on the GDPFS shall be considered as essential and given free to NMCs and RCCs. After discussion, the Team agreed to that statement and also stressed that other data or products could be provided by GPCs at request of RCCs, NMCs or Lead Centre(s), to further assist them to perform their tasks. Provision could be made if the producing GPC has a compatible data policy, and provided that the RCCs, NMCs and Lead Centre(s) adhere to the conditions, if any, attached by the GPCs to the data or products. The Team recommended also that GPCs should provide more information on their web site for indicating clearly timing of production, formats available, possible access to Grid Point Value (GPV) fields (e.g. for down-scaling). GPCs which provide data and products to NMHSs and RCCs, could be helped in their developments by receiving "feed back" from RCCs and NMHSs after use of the LRF information. The Team defined some broad guidelines for feed back that would be useful to GPCs.

After the presentation from the Moscow representative the Team agreed that the Hydrometcentre of Russia adheres to the criteria for a Global Producing Centre of Long-range forecasts listed in the Manual on the GDPFS and should be officially recognized as a GPC. The Expert from Pretoria reported on the current developments and plans of Pretoria and the Team encouraged Pretoria to work towards equivalence between the hindcast and real time components of its forecast system. It also suggested that Pretoria report on the status of its achievements to the Team in September 2008 and seek advice at that time for possible recognition by CBS. The Team was also informed of the developments of CPTEC-INPE Brazil with a view to seeking GPC recognition. The Team encouraged CPTEC-INPE to pursue official recognition and it recommended that the WMO Secretariat notified CPTEC-INPE to present a status of its achievement to the Team in September 2008 and seek advice at that time for possible recognition by CBS. GPC representatives from Beijing, Exeter, Melbourne, Montreal, Washington, and ECMWF presented briefly their latest development to the Team.

The Team reviewed the data needs for global LRF, in particular for ocean initial conditions, including salinity, and land surface, including soil moisture. The Team recommended that the updated list of data needs agreed at the meeting be passed to the chairman of the ET on Evolution of the Global Observing System.

The Team confirmed that there is a significant need for LC-LRFMMEs to collect LRF data from GPCs, to display GPC forecasts in standard formats, and to act as a focus for further research and development of MME techniques and products. These activities will provide a much needed conduit of GPC information to RCCs and NMCs. The Team congratulated KMA/NCEP for very substantial progress in developing capability for an LC-LRFMME, and thanked the 6 GPCs currently providing forecast data to KMA/NCEP. The Team reviewed and adjusted the LC-LRFMME functions. Noting the KMA achievements, the Team recommended that KMA/NCEP be designated a Lead Centre for LRFMME with responsibilities that include maintenance of a web portal of GPC and MME products. The revised functions for Lead Centres of LRFMME were recommended for submission to CBS to be included in the Manual on the GDPFS.

The CCl Implementation Coordination Team (ICT) which met in October 2007 established a technical expert group, with CCl and CBS representation, that met in January 2008 to address Regional Climate Centres (RCCs) issues, and to further develop the amendments required for the Manual on the GDPFS to support formal WMO designation of RCCs or RCC-Networks. The resultant set of amendments, reviewed and slightly revised by the ET/ELRF Team, was recommended and intended for eventual CBS endorsement.

Representatives of Beijing Climate Centre, Tokyo Climate Centre and Moscow presented their achievements and the Team recommended that these Centres seek recognition as RCCs at the next CBS. The Team noted that the National Climate Centre (NCC), India was performing a great number of climate applications for the Region, and that it was also planning in the future to run operationally a dynamical global seasonal forecast model. In view of these achievements, the Team encouraged NCC India to work towards recognition as an RCC and later towards achieving GPC status.

The Team considered the specific needs related to ERF for product exchange or services. The meeting acknowledged the high interest and potential importance of ERF in aiding RCCs and NMCs to provide services to a wide range of users, notably in the agricultural sector. It was agreed that this time scale holds the most promising potential for prediction of delayed or advanced rainy season onset. The team also noted the importance of ERF for prediction on the Madden-Julian Oscillation (MJO), which is an important mode of variability in the tropics. In this regard the Team expressed support for the CAS/WCRP WGNE initiative for Operational Modelling Centres to compare forecasts of the MJO (5 GPCs are already participating) and centres with ERF capability not currently participating were encouraged to do so. After reviewing the status of ERF activities in their respective centres, the Experts agreed that, as development of ERF capability is relatively new at some centres, it would be timely to recommend some standard for infrastructure for ERF. Exchange of ERF forecast and hindcast data would involve frequent transfers of large data volumes, in contrast to LRF exchanges for which a 'fixed' set of hindcast data need only be transferred once. The Team recommended that a workshop on infrastructure and verification of ERF would help to begin the process of convergence between Centres. At the current time the Team agreed there was no need for an extension of the SVSLRF scores to cater for ERF, as the specified scores are sufficient. However, it is recommended that the ETELRF and the associated Lead Centre for verification continue to monitor developments, particularly in regards to the CBS Coordination Group on verification.

There was consensus within the participants that no change is required at the moment to the SVSLRF. However, the ET recommended that a process of continuous review of the SVSLRF be undertaken by the LC-SVSLRF and relevant ET members, and that this should include evaluation of possible additional scores. The ET recommended that the SVSLRF should be applied 'as is' to the outputs of MME in an identical way as for the individual models. The ET considered the status of the Lead Centre for SVSLRF (LC-SVSLRF) and a comprehensive update was provided by the co-hosts Melbourne and Montreal on the status of the Lead Centre, including reference to the current participation of GPCs. The ET noted the considerable contribution made by the LC-SVSLRF to the efficient exchange of verification information. The team considered the coordination between the LC-SVSLRF and the Lead Centre for LRFMME and suggested that both Lead Centre websites be linked, enabling the display of forecast and verification information in a consistent and similar way. The ET agreed that the cross-validation should be mandatory for both calibrated and re-calibrated forecasts. The ET noted the lack of progress in the official definition of ENSO years, and urged that this activity be accelerated by CCI as a matter of some priority. The ET recommends that the SVS verification need not be stratified according the ENSO years until we have a clear official definition available. The ET 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. The ET needs to provide detailed guidelines for conducting related tests.

TABLE OF CONTENTS

PAGE

REPORT OF MEETING OF CBS EXPERT TEAM ON EXTENDED AND LONG-RANGE FORECASTING

Beijing Climate Centre (BCC) 7- 10 April 2008

1. OPENING OF THE MEETING

1.1 The meeting of the Expert Team on Extended and Long-Range Forecasting of the CBS OPAG on DPFS was held at the kind invitation of China Meteorological Administration in Beijing Climate Centre (BCC) from 7 to 10 April 2008.

1.2 The representative of the Secretariat was invited to open the meeting and expressed the gratitude and appreciation of WMO to China Meteorological Administration (CMA) and to the Permanent Representative of China with WMO, Dr Zheng Guoguang, for accepting to host the meeting of this Expert Team. He thanked CMA for its contribution to the development of meteorology and for hosting so many WMO events. He also thanked all the staff of CMA who have helped with the planning and preparation for this event, especially Dr Xiao Ziniu, Deputy Director General of Beijing Climate Centre, Dr Yan Yuping, Mr Sun Yuan and Ms Li Mingmei. He recalled that the Fifteenth WMO Congress in 2007 agreed that some GPCs could serve as collectors of Global LRF data to build Multi Model Ensembles (MME), and requested standards for MME products be developed. Congress requested also that the global LRF products be made available to as many Regional Climate Centres (RCCs) and National Meteorological Centres (NMCs) as possible for purpose of enabling them to perform their tasks. Congress further requested that CBS and the Commission for Climatology collaborate to develop the minimum set of functions and services required of RCCs, in order to support their official designation and inclusion in the Manual on the Global Data Processing and Forecasting System (GDPFS). Congress noted that ongoing coordination would be required to ensure that operational products from the GPCs meet the requirements for seasonal forecasting services provided by RCCs and NMHSs, and that RCCs would need assistance from GPCs for training users. The WMO representative stressed that the Team will have to deal with all these issues, including approval of the minimum functions to be recognized as RCC, which have been already well developed, and more or less finalized by CCl and CBS expert meetings. The team will have also to recommend the definition of functions for recognition of Lead Centres for Long-Range Forecast Multi Model Ensemble. The team will have also to consider the Extended Range Forecasts (that is from 10 days to one month) now generated by some centres in terms of potential for exchange of products and verification. The recommendations of the team will be considered by the Implementation Coordination Team on DPFS in October and by CBS during its next session in March 2009.

1.3 Dr Xiao Ziniu, Deputy Director of Beijing Climate Centre (BCC) welcomed the participants (see list in Annex to this paragraph). The Deputy Director stressed that BCC has, during recent years seriously developed and improved its LRF system and could deliver many various seasonal products for climate applications. The government of China had mandated BCC to help China in climate change adaptation. BCC, already recognized as a GPC, had also been recommended to be nominated a Regional Climate Centre by Regional Association II. CMA was in favour of further strengthening the international exchange of products for improving LRF prediction.

1.4 The chairman of the Expert Team on Extended and Long-Range Forecasting, Dr Richard Graham opened the Meeting and welcomed the experts. He noted that since the Workshop in September in Busan for LRFMME a lot of work has been achieved and that GPCs had submitted LRF information and forecast products to the joint centre of KMA (Republic of Korea) and NCEP (USA) for fulfilling the first set of activities of a Lead Centre in that field.

2. ORGANIZATION OF THE MEETING

2.1 Adoption of the agenda

2.1.1 The Meeting adopted the agenda given in Annex to this paragraph.

2.2 Other organizational questions

2.2.1 The Meeting agreed on its working hours and schedule.

3. EXCHANGE OF LONG-RANGE FORECASTS (LRF)

3.1 Exchange of products

3.1.1 The exchange of products and data between GPCs, NMCs and potential RCCs was reviewed. It was recalled that the provision of data and products by GPCs to other NMHSs and RCCs has been clarified at the last Joint Meeting of the Expert Teams on Long-Range Forecasting (of Infrastructure and Verification) at ECMWF in April 2006. At that meeting, in the spirit of Resolution 40, the Team had proposed that GPCs' products defined in the Appendix II.6 of the Manual on GDPFS shall be considered as essential and given free to NMCs and RCCs. After reviewing requests for further clarification, the Team agreed to its original statement, but stressed also that other data or products could be given by GPCs at request of RCCs, NMCs or Lead Centre(s), especially for the purpose of enabling them to perform their tasks. The additional data and products may be provided if the producing GPC has a compatible data policy, and on condition that the RCCs, NMCs and Lead Centre(s) adhere to the conditions, if any, attached by the GPCs.

3.1.2 The Team recommended also that GPCs should provide more information on their web site indicating clearly, for example, the timing of production, formats available, possible access to Grid Point Value (GPV) fields (e.g. for down-scaling).

3.1.3 GPCs which provide forecast data and products to NMHSs and RCCs, could be helped in their developments by receiving "feed back" from RCCs and NMHSs who use the LRF information. The Team defined some broad guidelines for feed back that would be useful to GPCs (see Annex to this paragraph) and recommended the guidelines be included as Attachment II-14 in the Manual on GDPFS. These guidelines will help the RCCs and NMHSs to provide the information expected by GPCs.

3.1.4 The Team also recommended that time was now due for more promotion of GPCs products already available towards all NMHSs, stressing that access is now simplified through the website hosted by the developing KMA/NCEP LC-LRFMME. The Team recommended that WMO secretariat sent a letter explaining the access to LRF GPC products to all NMHSs and other relevant regional institutes. For further promotion of the website, the Team undertook to prepare a short article on the LCs-LRFMME for publication in the WMO bulletin after CBS official designation.

3.1.5 Additional list of products

CBS Ext. 06 noted that data or products in addition to those required from GPCs in the minimum list, could also be provided by GPCs on request to satisfy the needs of RCCs or NMCs. The data will be given, if the producing GPC had a compatible data policy, and if the RCCs and NMCs would adhere to conditions, if any, attached by the GPCs to these data and products. This list of some potential additional products had been given in Annex II of the CBS report, where it was noted that some of the additional products required considerable further research and development to be scientifically feasible. The Team reviewed this list and applied some changes in light of present LRF capabilities. The revised list was proposed as a recommendation for an Attachment II-11 in the Manual on GDPFS, as listed in Annex to this paragraph.

3.2 Recognition of new GPCs

The proposals for recognition of new GPCs were examined by the Team.

3.2.1 Recognition of GPC-Moscow

The Team considered the:

- application of the Hydrometcentre of Russia for WMO CBS official recognition as a Global Producing Centre (GPC) for long-range forecasts;
- compliance of activity of the Hydrometcentre of Russia (see Annex to this paragraph) with the requirements for GPCs posted by the Manual on GDPFS (Vol. I, Part II, APPENDIX II-8).

It was noted that:

1. The Hydrometcentre of Russia has a fixed production cycle and time of forecast issuance. It performs 4-month integrations monthly and issues 4-month forecasts with 1-month temporal resolution 2 days prior to 4-month calendar forecast period. Basing on these 4-month forecasts GCP-Moscow issues:
(a) 1-month forecast with 0-month lead time;
(b) 3-month forecast with 0-month lead time;
(c) 3-month forecast with 1-month lead time.

2. The list of products of the Hydrometcentre of Russia meets the requirements posted by Manual on the GDPFS and 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" in both the basic properties and the content of basic forecast output. Calibrated model data and probability information for forecast tercile categories for temperature and precipitation are available via web-site, with terciles being defined on the basis of 25-year (1979 – 2003) hindcasts.

3. The Hydrometcentre of Russia performs long-range forecast verification in accordance with the Standardized Verification System (SVS) for Long-Range Forecasts, with results of verification assessments on the basis of SMIP-2/HFP type hindcasts from 1980–2002 having been provided for WMO LC SVSLRF (Melbourne, Australia).

4. The Hydrometcentre of Russia provides up-to-date information on model description, forecast verifications and technological set-up for seasonal forecasts production through the web-site and papers.

5. The Hydrometcentre of Russia makes its three-month (rolling season) forecasts of temperature and precipitation with one month lead time accessible through the web-site. Forecasts of other variables, temporal coverage and resolution are available on request. Nowadays, the Hydrometcentre of Russia provides various kinds of forecasts for North Eurasia Climate Centre (Moscow, Russia), APEC Climate Center (Busan, Korea), the developing WMO Lead Centre for Long-Range Forecast Multi-Model Ensemble Prediction (Seoul, Korea).

In conclusion, the Team agreed that the Hydrometcentre of Russia adheres to the criteria for a Global Producing Centre of Long-range forecasts listed in the Manual on the GDPFS and should be officially recognized as a GPC.

3.2.2 Recognition of GPC-Pretoria

Dr Willem Landman reported on the current developments and plan of Pretoria to become a GPC (see Annex to this paragraph). The Team encouraged Pretoria to work towards equivalence of the hindcast and the real time components of its forecast system. It also suggested that Pretoria present a report of its achievement to the Team in September 2008 and seek advice at that time for possible recognition by CBS in March 2009, after official request submitted by the Permanent Representative of South Africa to the President of CBS (through the WMO Secretariat).

3.2.3 Recognition of GPC INPE-CPTEC (Brazil)

The Team was also informed of the developments of CPTEC-INPE Brazil with a view to seek GPC recognition (see copy of an email received as listed in Annex to this paragraph). The Team encouraged CPTEC-INPE to pursue official recognition and it recommended that the WMO secretariat notified CPTEC-INPE to present a status of its achievement to the Team in September 2008 and seek advice at that time for possible recognition by CBS in March 2009, after official request submitted by the Permanent Representative of Brazil to the President of CBS (through the WMO Secretariat)

3.3 Status and development of existing GPCs

GPC representatives from Beijing, Exeter, Melbourne, Montreal, Washington, and ECMWF presented briefly their latest development to the Team as listed in Annex to this paragraph.

3.4 Observation needs

The Team reviewed the data needs for global LRF, in particular for ocean initial conditions and surface, including soil moisture and also ocean salinity. The Team reviewed the list prepared by Dr Laura Ferranti and recommended it, as listed in Annex to this paragraph, to be passed to the chairman of the ET on Evolution of the Global Observing System.

4. MULTI-MODEL ENSEMBLE LRF (MME LRF)

4.1 The need for Lead Centres for LRFMME

The Team reviewed the recommendations of the workshop on Lead Centres for LRFMME held in Busan, 18 to 20 September 2007, and confirmed that there is a significant need for LCs-LRFMME to collect LRF data from GPCs, to display GPC forecasts in standard formats, and to act as a focus for further research and development of MME techniques and products. These activities will provide a much needed conduit of GPC information to RCCs and NMCs, and between GPCs. The Team congratulated KMA/NCEP for very substantial progress in developing capability for an LC-LRFMME, and thanked the 6 GPCs currently providing forecast data to KMA/NCEP (as reported in Annex to this paragraph).

4.2 Functions of Lead Centres for LRFMME

The proposed functions of Lead Centres for LRFMME, refined at the Busan workshop, were reviewed in light of the evolving policy on LRF data distribution of some GPCs. It was noted that some GPCs not currently participating in provision of forecast anomalies to KMA/NCEP (though fully compliant with the forecast requirements of Appendix II-6 of the Manual on GDPFS) intend to participate in the near future. With the participation of these GPCs in the data provision, the core plan (see Annex to paragraph 4.4) for the development of Lead Centre capability will be completed. It was noted that some GPCs are not currently able to participate in the additional provision of both forecast and hindcast data to Lead Centres. This has some impact on the detail, but not on the essence, of the functions of Lead Centres proposed at Busan. It was also acknowledged that expert centres for MME already exist (e.g the EUROSIP project) with specific services to their Members. Accordingly, revised proposals for Lead Centre functions were generated and are reproduced in Annex to paragraph 4.4.

4.3 Status reports on development of KMA/NCEP Lead Centre capability

Dr Won-Tae Yun (KMA) and Dr Arun Kumar (NCEP) presented reports on progress and plans for development of LC-LRFMME capability. The Team congratulated KMA/NCEP on very considerable progress made. Milestones set at the Busan workshop had been accomplished and, to summarise, achievements include:

- development of a repository of information on the system configurations of the 10 GPCs
- refinement and agreement on the format of the initial data exchange
- ingestion of forecast data from the 6 GPC so far participating in the initial data provision, and generation of GPC forecast maps, in common format, for the seasons (December-February 2007/8 and March-May 2008.
- Hindcasts and forecasts had also been ingested and processed from a subset of GPCs.
- GPC data was supplied to Dr Simon Mason of IRI for use in developing seasonal forecasts for malaria control in southern Africa (from those GPCs providing consent).

Future plans for display of GPC forecasts and multi-model forecasts were also presented. Details of progress are listed in Annex to paragraph 4.1.

4.4 Recommendations to CBS

Considering the review of LC-LRFMME functions noted in 4.2 and the KMA achievements noted in 4.3, the Team recommended that KMA/NCEP be designated a Lead Centre for LRFMME with responsibilities that include maintenance of a web portal of GPC and MME products. The revised functions for Lead Centres of LRFMME for submission to CBS and inclusion in the Manual on the GDPFS are listed in Annex to this paragraph.

5. REGIONAL CLIMATE CENTRES (RCCs)

5.1 The representative of the Climate Department in WMO, Ms Leslie Malone presented to the Team the background and progress in implementation of Regional Climate Centres (RCCs).

5.1.1 History:

WMO has formally sought to define and establish RCCs since the thirteenth World Meteorological Congress (Cg-XIII, May 1999). An Inter-Commission Task Team on Regional Climate Centres (ICTT-RCC) was set up and met several times. These sessions noted that RCC responsibilities should not duplicate or replace those of NMHSs; that establishment of RCCs should follow the steps set up for designation of Regional Specialized Meteorological Centres (RSMCs); and that the procedures for designation of RCCs needed to be defined. It was also recognized that the requirements of NMHSs for RCC functions may vary from Region to Region, and that RCC functions for a Region may be undertaken within a single centre, or may be distributed amongst various centres, or nodes, in a Regional Climate Centre Network.

Subsequent to the 2003 meeting on organization and implementation of RCCs, most regions have considered implementation of RCC(s) or an RCC network. At the fifteenth World Meteorological Congress in May 2007 (Cg-XV), RA II indicated that the Beijing Climate Centre (BCC) and Tokyo Climate Centre (TCC) would be recommended as components of the RA II network of RCCs, each of these centres being a multi-functional centre fulfilling a wide range of tasks in all 5 areas of RCC potential functions. In late 2007, the Russian Federation established a North-Eurasian Climate Centre (NEACC). In August 2007, the RA VI Working Group on Climate-related matters sought applications from Members for establishment of a 4-node RA VI RCC Network, to cover areas of activity specialization for Long-range Forecasting; Climate Monitoring; Climate Data; and Climate Applications. RA V, at its fourteenth session (Adelaide, Australia, May 2006) noted its intentions to continue to fulfil its requirements for regional climate activity in a distributed system with 4 nodes (Melbourne, Australia; Auckland, New Zealand; Singapore (ASEAN); and Hawaii, USA). In 2004, RA IV developed and considered a virtual RCC model that would strengthen the capacities of institutions already serving the Region, with services including training, data services, coordination of climate services, etc. No official request for establishment of an RA IV RCC has yet been made to WMO. The Working Groups on Climate-related Matters of RAs I and III have discussed RCC implementation, but have not yet issued surveys to gauge regional interest in needs for, or offers to host, RCC functions.

5.1.2 Proposal for RCCs recognition

The Commission for Climatology Implementation Coordination Team (CCI ICT) which met 9-11 October 2007 in Geneva, Switzerland, with representation from the six regional Working Groups on climate-related matters and of the WMO World Weather Watch and the CBS, agreed on definitions of RCCs and RCC-Networks, and also agreed that the terms RCC and RCC-network would be exclusively used for centres designated by WMO under the Manual on the Global Data Processing and Forecasting System (GDPFS) (Volume 1, global aspects). Roles and responsibilities of RCCs and RCC-Networks were identified in two categories: mandatory functions that would be common to all designated RCCs or RCC-Networks, and highly desirable functions. It was decided that RCCs and RCC-Networks will be considered, in the Manual on the GDPFS, as a type of Regional Specialized Meteorological Centre (RSMC), and will be 'centres in a cooperative effort', a concept already defined in the Manual on the GDPFS. These decisions underpin the concept that RCCs and RCC-Networks will be centres of excellence, with uniformity of service around the globe in their mandatory functions. The CCI ICT established a technical expert group, with CCI and CBS representation, to address and resolve remaining issues, and to develop the amendments required for the Manual on the GDPFS to support formal WMO designation of RCCs or RCC-Networks, and established a workplan for this activity.

As agreed by CCI and CBS at the meeting of the CCI ICT in October 2007, the WMO Division on DPFS worked with the Secretariat Divisions responsible to the CCI and with experts from CBS and the CCI to finalize the CCI submission to CBS, for amendments to the Manual on the GDPFS (Vol. 1, global aspects) for designation of RCCs. It was recognized that, prior to submission by CCI to CBS, there should be implicit agreement between CCI and CBS experts on the content of the amendment. The final version will be submitted for consideration of CBS at its next session, and if approved, CBS will submit the amendment to EC-LXI (2009) for its approval for implementation. A CCI-CBS Intercommission Technical Meeting on Designation of Regional Climate Centres (RCCs) held in Geneva, on 21-22 January 2008, reviewed and revised the draft amendments to the Manual on GDPFS. These had been based on the principle of least interference to the Manual, and on the decisions of the CCI ICT in October 2007. The final set of amendments, as agreed by all participants of the CCI-CBS Inter-Commission Technical Meeting on Designation of RCCs, and slightly reviewed (small additions concerning use of LC-LRFMME and LC-SVSLRF) and approved by the ET/ELRF Team is listed in Annex to this paragraph.

5.2 Information on planned activities and services of Centres considering recognition as future RCCs, including relations with GPCs

The Team was informed of the project of three centres to be officially recognized by CCL and CBS as RCCs, following the approval of Regional Associations II and VI.

5.2.1 **Beijing Climate Centre** representative, Dr Peiqun Zhang presented the achievements and current development of the Centre.

Activities as Regional Climate Centres (RCCs)

Beijing Climate Center (BCC) was established in March 2003, based on the National Climate Centre (NCC) of China Meteorological Administration (CMA) which was founded in January 1995, in order to meet the increasing requirements of social-economic activities on natural disaster mitigation related to climate anomalies and extreme climate events from domestic relevant communities to other National Meteorological and Hydrological Services (NMHSs) in Asia as well. Since its establishment, BCC has being engaged in its capacity building on provision of climate-related services and issuance of operational products of monitoring, diagnostics, long range forecast and assessments on regional and global climate to Asian communities through its websites (http://bcc.cma.gov.cn in English and http://ncc.cma.gov.cn in Chinese). BCC also provides operational data services to support climate monitoring, analysis and prediction in the web-based interactive way or on requirements of users. By now, Beijing Climate Center has hosted four sessions of the Forum on Regional Climate Monitoring-Assessment-Prediction for Regional Association (FOCRAII) in Beijing, sponsored by CMA and WMO. There are hundreds of participants from more than twenty countries/territories or regional groupings and representatives of the WMO, CIIFEN (Ecuador) and ICPAC (Kenya). BCC conducts training courses during FOCRAII and hosts International School on Climate System (ISCS) and Climate Change since 2004 to deliver knowledge and techniques of diagnosis, modeling and prediction/projection on climate variability and climate change to experts from NMHSs and young scientists as well.

5.2.2 Mr Takayuki Tokuhiro presented the activity of **Tokyo Climate Center (TCC),** established in April 2002 in the Headquarters of the Japan Meteorological Agency (JMA). TCC has conducted climate-related services with the main purpose of assisting National Meteorological and Hydrological Services (NMHSs) in Asia and Pacific regions in long-range forecasting and climate monitoring.

The followings are TCC's current and planned activities concerning RCC mandatory functions.

1) Operational Activities for LRF:

JMA provides four kinds of long-range forecasts: one-month forecast, three-month forecasts, warm season forecasts and cold season forecasts. One-month forecast is issued every Friday, covering the coming 4 weeks. Three-month forecast is issued once a month, around 25th of every month, covering the coming 3 months. Warm season forecasts and cold season forecasts are issued 5 times a year, February, March and April for warm season, and September and October for cold season.

The numerical prediction models used in the operational ensemble prediction system for the 1-month forecast is the T159L60, forced by persisted SST anomalies, with 50 ensemble members. The long-range-forecast model is TL95 (V0502). The Model for ERF and LRF is a version of the Global Spectral Model used for short- and medium- range forecasting (GSM0507, TL319). Soil moisture, soil temperature and snow depth are predicted by the model, and the initial conditions are provided by the land data assimilation system. TCC has been providing registered National Meteorological and Hydrological Services with LRF Products derived from GPC Tokyo through the TCC website. Registered NMHSs can get these data for one-month, three-month and seasonal forecast which can be used in their operational long-range forecast.

2) Operational Activities for Climate Monitoring:

JMA collects weather reports (CLIMAT) disseminated by NMHSs to produce and provide several kinds of map and information on global climate. For monitoring the climate, normalized temperature anomaly, precipitation ratio and quintile are mainly used. JMA provides maps showing extreme climate events on weekly, monthly, seasonal and annual bases through the TCC website.

JMA also monitors and analyzes climate variability through atmospheric circulation data, surface observation data, ocean data and satellite data. The purpose of monitoring and analyzing climate variability is to identify key processes of observed climate variations, especially extreme events such as heat waves, cold spells, droughts and prolonged heavy rain, because they greatly affect socio-economic activities and agriculture, and sometimes cause severe disasters.

JMA has provided consolidated climate information to the public, decision makers and researchers through publication of the "Monthly Highlights on Climate System". This report contains diagnostic information on current climate conditions with emphasis on climate in Japan, world climate, extratropical circulation, tropical circulation and convection, oceanographic conditions, and snow/ice coverage with the time scales from 5 days to decades. A new publication, Annual Report on Climate System 2007, will be issued in early 2008, covering topics on extreme climate events around the world as well as summary of the climate system in 2007.

JMA carries out the monitoring and prediction of El Niño events operationally, issuing a monthly report covering the current diagnosis and outlook for the coming six months. As to activities on global warming, JMA monitors annual mean surface temperature over the globe as well as Japan to get hold of climate change due to global warming.

3) Operational Data Services, to support operational LRF and climate monitoring

As one of the new services via TCC website, an online web-based interactive climate database called ClimatView was made available, enabling users to view and download data on monthly mean temperatures and monthly total precipitation derived from CLIMAT reports.

Reanalysis data JRA-25 and JCDAS data (1979-present) are available through the JRA-25 official website (http://jra.kishou.go.jp/index_en.html). Furthermore, maps of annual, seasonal and monthly averaged climate fields of various meteorological variables from the JRA-25 products have been archived as the JRA-25 Atlas, which are available at JRA-25 Atlas site (http://ds.data.jma.go.jp/gmd/jra/atlas/eng/atlas-tope.htm).

4) Training in the use of operational RCC products and services

JMA has conducted annual training courses in meteorology for experts of NMHSs since 1973 as one of a number of courses provided by the Japan International Cooperation Agency (JICA). TCC plans to enhance its services through the provision of user-oriented data and products, and training activities for NMHSs in Asia/Pacific region to meet users' requirements.

As described above, TCC website (http://ds.data.jma.go.jp/tcc/tcc/index.html) provides climate-related data and products as well as quarterly online newsletters (TCC News).

5.2.3 Dr Vladimir Kryzhov presented the plan of **Moscow** to become an RCC for Region II (RA II: North Eurasia regional Climate Centre) and an RCC for Region VI

Introduction

North Eurasia regional Climate Centre (NEACC) was established by the Intergovernmental Council for Hydrometeorology of the Commonwealth of Independent States (CIS - Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, the Russian Federation, Tajikistan, Turkmenistan, Uzbekistan and Ukraine) at its 18th Session held in Dushanbe, Tajikistan, 4-5 April 2007, with the aim to provide regional climate related services to CIS countries. The 19th Session of CIS Intergovernmental Council for Hydrometeorology held in Obninsk, Russian Federation, 16-17 October 2007, adopted the Status of North Eurasia regional Climate Centre. At the current stage NEACC is a virtual multi-institutional centre comprising several institutions from Roshydromet:

1. Hydrometeorological Research Centre of the Russian Federation (HMC RF),
2. Institute of Global Climate and Ecology of Roshydromet and Russian Academy of Sciences (IGCE),
3. Research Institute for Hydrometeorological Information – World Data Centre (RIHMI-WDC),
4. Main Geophysical Observatory of Roshydromet (MGO),
5. All Russia Research Institute for Agricultural Meteorology - Centre for Drought Monitoring of CIS Intergovernmental Council for Hydrometeorology,
6. Main Computer Centre of Roshydromet
7. Main Radiometeorological Centre of Roshydromet.

This structure is open for all other interested NMHSs of the neighbouring countries to participate in the virtual centre.

The NEACC activity is focused on the provision of climate information products and services for the area of North Eurasia, with coverage comprising Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan, Turkmenistan, Uzbekistan within RA II (Asia) Region and Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Moldova, the Russian Federation, Ukraine within RA VI (Europe) Region.

Summary of the NEACC current status and future plans

The NEACC has established and currently develops a website http://neacc.meteoinfo.ru in Russian taking into account that Russian language is convenient for majority of the end-users of the North Eurasia Region; mirror site in English is under construction. Nowadays, the NEACC produces a large number of the products and services assigned to the RCCs. Particularly, seasonal and monthly probabilistic forecasts of temperature and precipitation based on the WMC Moscow (HMC RF) model global outputs are issued operationally and posted on the web-site, with all forecasts being supported by hindcast based verification results. Research on climate variability, predictability and development of multi-model ensemble predictive tools are conducted. In the near future, the NEACC intends to adjust the scope of products and services provided to the requirements of the RCCs. Particularly, to extend the web-site, extend the list of the forecast products provided via the web-site; to implement multi-model ensemble postprocessing predictive tools including those for the forecast of climate extremes; etc. Special attention will be paid to coordination and organization of the training and capacity building activity focused on end-users within NMHSs-members of CIS Intergovernmental Council for Hydrometeorology.

5.2.4 Dr D. S. Pai from India presented the activities, future plans and needs of India National Climate Centre (INCC, Pune).

5.2.4.1 Background

National Climate Centre (NCC), Pune of the India Meteorological Department (IMD) has been functioning since 1995 carrying out many India specific climate related activities like Climate Monitoring and Analysis, Climate Data Management, Climate Research and Climate Prediction (Seasonal Forecasts). NCC is bringing out climate diagnostic bulletins regularly and different climate data products are prepared for the user community. Operational Seasonal forecast for rainfall over the country is another important activity of the NCC. As a part of recent major modernization activities undergoing in IMD, efforts are going on to widen the activities of the centre so that in the near future it can cater the needs of the entire south Asian region. Brief information regarding the present activities, future plans and needs of the center provided here.

5.2.4.2 The present activities of the NCC

(i) Climate monitoring and analysis: prepares and publishes monthly, seasonal and annual climate diagnostic bulletins for Indian region regularly. Detailed special monsoon reports are also being published every year.

(ii) Seasonal forecasts: prepares operational seasonal forecasts for winter (Jan- March) precipitation (issued in January), monsoon season (Jun to Sept) rainfall and northeast monsoon (October-December) rainfall. These forecasts are prepared using empirical models. Recently, the centre has implemented a dynamical prediction system based on an atmospheric GCM and experimental monthly and seasonal forecasts for the monsoon season are prepared using this system.

(iii) Data services and Climate data products: IMD has long time series of various climate data in its archive. Data rescue and data services are mainly provided by National Data Center(NDC) at

Pune. NCC generates, many climate data products for smaller spatial and temporal scales for the user community. These data products include daily gridded (1^o x 1^o) rainfall data over Indian region, district wise normal for various surface parameters, marine climate summaries for Indian Ocean region etc.

(iv) Research and Development: research projects on climate variability and predictability studies for the Indian Region have been carried out. Major emphasis has been given to monsoon which contributes 75-90% of the annual rainfall over most parts of the country. Studies have also been conducted the links of regional climate variability with ENSO and global circulation features and climate change issues over the Indian region. Empirical models for the long range and extended range prediction of the monsoon rainfall have been developed. The center has published number of research reports.

(v) Training and capacity building: the Central Training Institute of IMD at Pune is one of the WMO RMTCs. Regular training courses, refresher courses and specialized training courses for the IMD personnel as well as personnel from various national and international organizations are being conducted here in various branches of meteorology. NCC provides support in terms of resource persons for various training programs of RMTC.

(vi) Web services: IMD, Pune is hosting a web site since last year for the user community (www.imdpune.gov.in). The web site provides various information such as daily weather information, real time satellite pictures, short range forecasts, agricultural advisories, farmers and other user community, details of surface instruments, air pollution monitoring, cyclone tracks over Indian Ocean etc. Seasonal forecasts and climate diagnostic bulletins issues by NCC are also available in this web site.

5.2.4.3 Future Plans

For the time being, efforts will be made to widen India specific climate services. Once entire system is in place and more experience is gathered, efforts will made to extend the services to entire south Asia.

- To run the dynamical model operationally every month to generate monthly and multi-monthly forecasts and provide forecast outlooks for smaller spatial scales. Generation of hind casts for at least last 20 years and preparation of verification statistics of the as per the SVS guidelines.
- To develop area specific seasonal forecast for both rainfall and temperature based on statistical recalibration of GCM outputs.
- To prepare monthly and seasonal outlooks for the south Asian region based on the ensemble model outputs from the center and that from the GPCs. The climate outlook will be made available to the users through the web site.

The center has prepared daily grid point (1x1) rainfall data over Indian region for the period 1951 to 2007. The data are being updated regularly. It is now planned to extend the data backwards up to 1901. The data can be used for recalibration of the model output as well as verifying the skill of the dynamical models. It is also planned to prepare daily grid point surface air temperature anomaly data over the Indian region.

- Train the personal in the use and interpretation of multi-model ensemble forecast.
- Research projects on the regional climate variability and change and their impacts.

5.2.4.4 Needs

- Accesses to a net based interactive software arrangement through which all the GPC products can be downloaded and maps can be prepared as per the requirement (for required spatial domain etc.).
- At present GCM model is run using persistence SST method. The center would like to run the model using forecasted SST also.
- Simulations, Hindcasts and forecasts from GPCs in digital form for developing regional forecasting system based on statistical downscaling.

- Data for computing regional specialized indices (drought, heat, chill)
- Training of personal in the statistical and dynamical downscaling, use and interpretation of muti-model ensemble forecast.
- User interactive, computer training modules for statistical and dynamical downscaling, preparation of climate outlooks, interpretation of MME forecast etc.

5.2.5 Following the presentation of their achievements by Beijing Climate Centre, Tokyo Climate Centre and Moscow, the Team suggested that these Centres seek recognition as RCCs for Region II at the next CBS. The Team noted that National Climate Centre, India was performing a great number of climate applications for the Region, and that it was also planning in the future to run operationally a dynamical global seasonal prediction model. In view of these achievements, the Team encouraged NCC India to work towards recognition as an RCC and later towards GPC status.

Revision of data and products required from GPCs following the needs expressed by RCCs and LCs-LRFMME

5.3 The Team reviewed the list of data and products required by RCCs and LCs-LRFME and considered that some changes were to be performed in Appendix II-8 of the Manual on GDPFS (see Annex to paragraph 4.4) and a new Attachment II-11 (see also Annex to paragraph 3.1.5) and a new Attachment II-13 were proposed. It noted that some products could be obtained by direct bi-lateral agreement between centres.

6. EXTENDED RANGE FORECASTS (ERF)

The Team considered the development of ERF (11-30 days range) activities and the potential for exchange of data, products and verification. CBS has extended the remit of Team to include ERF because of the greater similarity of ERF to LRF rather than to MRF (for example in the issuance of time-averaged forecasts).

6.1 Importance of prediction on 11-30 day (ERF) timescale

The meeting acknowledged the high interest and potential importance of ERF in aiding RCCs and NMCs to provide services to a wide range of users, notably in the agricultural sector. It was agreed that this time scale, rather than the LRF timescale, perhaps holds the most promising potential for prediction of, for example, delayed or advanced rainy season onset. With lead-times of order 10 days reliable ERF forecasts could assist in appropriate preparations for planting or irrigation. The team also noted importance of ERF for prediction of the Madden-Julian Oscillation (MJO), which is an important mode of variability for ERF in the Tropical Areas, and which can be associated with timing of monsoon onset, and dry spell during rainy seasons. In this regard the Team noted invitation from CAS/WCRP WGNE for Operational Modelling Centres to participate in an activity to monitor and compare forecasts of the MJO. The Team expressed support for this activity. Five GPCs are already participating in the experiment and centres with ERF capability not currently participating were encouraged to do so.

6.2 Status of ERF activities

The team reviewed the status of ERF activities at their centres. The activities of ECMWF for ERF were well presented by Dr Laura Ferranti as listed in Annex to this paragraph. A number of centres are engaged in operational prediction on timescales that cover all or part of the ERF timescale. At most, but not all, centres ERF and LRF activities are closely connected, and are generally under the remit of the same research group with related dynamical models used in prediction for the two timescales. For this reason, the team agreed that it was appropriate that ERF and LRF be included in the terms of reference of a single Expert Team. However, it was noted that responsibility for both timescales would potentially restrict the attention given to each. It was agreed that the Team would monitor the practicalities of its expanded remit, and report back to CBS. Brief status reports on ERF activities at each centre are included in the GPCs reports. It was noted that there is currently little uniformity between centres in forecast outputs, with differences in, for example, issuance times and update frequency, sub-division of the 10-30 day period, and in the specific quantities predicted. The team agreed that, as development of ERF capability is relatively new at some centres, it would be timely to define recommended infrastructure for ERF. Some convergence of forecast outputs from operational centres would be required before a meaningful exchange of ERF data could take place. Adapting the LRF data exchange (e.g LC-LRFMME) to ERF would not be simple, because some specific differences exist between ERF and LRF. ERF models are often closely connected to MRF model versions and as such are frequently updated, unlike LRF models for which model versions are usually fixed for several years. For example at ECMWF, ERF hindcasts are generated freshly ahead of each new forecast, to ensure that hindcasts and forecasts are made with the same model version. Exchange of ERF forecast and hindcast data would therefore involve frequent transfers of large data volumes, in contrast to LRF exchanges for which a 'fixed' set of hindcast data need only be transferred once. The Team recommended that a workshop on infrastructure and verification of ERF would help to begin the process of convergence between Centres.

7. VERIFICATION SYSTEMS FOR ERF AND LRF

7.1 Need for specific scores for ERF

The ET considered the specific scores for ERF and their relationships to LRF. At the current time there is no need for an extension of the SVSLRF scores to cater for ERF, as the specified scores are sufficient. However, it is recommended that the ET-ELRF and the associated Lead Centre for verification continue to monitor developments, particularly in regards to the CBS Coordination Group on verification.

There are substantial differences in the operational ERF systems across the GPCs meaning that the SVSLRF methodology cannot be applied simply to ERFs. In particular, many centres do not have an extensive set of hindcast data. In this regard, for some Centres, ERF verification has some similarities with the medium range verification problem.

7.2 Need for improvement to the SVSLRF, especially in developing areas such as MME

The workshop considered issues of verification related to GPCs activities, as well as implications for the work of the LC-LRFMME

In this regard there is consensus within the participants that no change is required at the moment to the SVSLRF. The SVSLRF should be applied as is to the outputs of MME in an identical way as for the individual models.

Verification of LRF continues to be a matter of some research, and it will be necessary to review new scoring methods as they are proposed. The ET-ELRF and the associated Lead Centre for verification will continue to monitor developments, particularly in regards to the CCL ET and the CBS Coordination Group on verification.

7.3 Provision of ERF and LRF verification scores and related information for use by NMHSs and RCCs

The Lead Centre for SVSLRF provides a robust vehicle for the provision and communication of SVSLRF scores to NMHSs and RCCs, and in this regard NMHSs and RCCs are encouraged to make full use of this information.

It is premature to extend the Lead Centre activities to the area of ERF, owing to the highly divergent system configurations across GPCs and uncertainty about the availability of hindcasts.

7.4 Status of the Lead Centre for SVSLRF

The ET considered the status of the Lead Centre for SVSLRF and the need for any necessary change. A comprehensive update (See Annex to this paragraph) was provided by the co-hosts Melbourne and Montreal on the Lead Centre, including reference to the current participation of GPCs. The ET noted the considerable contribution made by the Lead Centre to the efficient exchange of verification information.

7.4.1 Issues related to the development of the Lead Centre for SVSLRF

The ET considered a number of outstanding issues related to the Lead Centre for SVSLRF. In this regard it is recommended that GPCs pursue the generation of Level-3 verification, but that these not be incorporated into the Lead Centre website for the moment. There remains a need to fully evaluate the value of this additional information. Further, the ET recommends that the GPCs pursue significance testing of their forecasts using computer code, which will be made available to GPCs by the Lead Centre.

7.4.2 Coordination between the Lead Centre for SVSLRF and the Lead Centre for LRFMME

It was suggested that both Lead Centre websites be linked, enabling the display of forecast and verification information in a consistent and similar way. For example, the forecasts from a particular GPC model should be available alongside the corresponding relevant verification information.

Subject to the future evolution of the Lead Centre for LRFMME there is a strong case for closer integration of the two Lead Centre websites with a view to their possible future co-location.

The ET noted that the recommend list of GPCs products to be provided to the Lead Centre for LRFMME includes above/below median forecasts as well as the additional variables of MSLP, T850 and Z500. Currently these are not incorporated into the SVSLRF or displayed on the Lead Centre for SVSLRF website. The two lead Centres and GPCs are requested to take the necessary steps to ensure that verification information is available for every forecast field in a way, which is consistent with the SVSLRF.

7.4.3 Ongoing issues with the SVSLRF

The ET recommends no immediate change to the SVSLRF, but that a process of continuous review be undertaken by the Lead Centre and relevant ET members. Some ongoing issues include the following:
"Need for more guidance on the prescription of the cross-validation procedure and its appropriateness for individual dynamical models"

The ET 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 MME if the data set used is not large enough to be divided in 2 parts (training and then validation).

The leaving one year out method defined in the SVSLRF guidelines should be the minimum method for cross validation. However, this may not be sufficient in cases where data contains significant autocorrelation. In such cases more than a single year should be omitted. The CCI ET on verification has undertaken to provide additional support in this regard.

"Specification of ENSO years"

The ET noted the lack of progress in the official definition of ENSO years, and urged that this activity be accelerated by CCI as a matter of some priority. The ET recommends that the SVS verification need not be stratified according the ENSO years until we have a clear official definition available.

“New Scores”

There are some ongoing concerns with the complexity of scoring techniques in LRF and ERF which means that the associated scores may not be readily understandable by non-experts. The ET notes these concerns, but does not recommend a change to the SVSLRF as non-experts are not the target audience. However the ET recommends ongoing evaluation of possible additional scores. The Team expressed gratitude to Dr Simon Mason for his input on this subject (see Annex to this paragraph).

“Development of scores to measure skill in the ensemble spread”

The ET 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. The ET needs to provide detailed guidelines for conducting related tests. Little progress has been made on this issue which remains a matter of some research.

“Calculation of tercile boundaries”

The ET recommends that Terciles be calculated using the counting method following the WMO Guide for Climatological Practice (see section 5.2.4.1.2 p. 59 of the second edition). This document is available at:
http://www.wmo.int/pages/prog/wcp/ccl/guide/guide_climat_practices.html

8. CLOSURE OF THE MEETING

Before closing the meeting the team thankfully acknowledged the significant contributions made by Mr Normand Gagnon (CMC) in many years of service to the team, particularly in regard to the development of the SVSLRF and the LC-SVSLRF. Mr Gagnon is moving to the MRF field. After having led the Team with diplomacy and efficiency the chairman, Dr Richard Graham closed the Meeting at 16.45 on Thursday 10 April 2008.

ANNEX TO PARAGRAPH 1.3

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ANNEX TO PARAGRAPH 2.1.1

PROVISIONAL AGENDA

1. OPENING OF THE MEETING

2. ORGANIZATION OF THE MEETING
   2.1 Adoption of the agenda
   2.2 Other organizational questions

3. EXCHANGE OF LONG RANGE FORECASTS (LRF)
   - Exchange of products
   - Recognition of GPCs
   - Status, development, specific needs of GPCs
   - Observations needs

4. MULTI-MODEL ENSEMBLE LRF (MME LRF)
   - Conclusions and recommendations of the last Workshop on Lead Centre for LRF MME (LC-LRFMME) in Busan in September 2007
   - Reports on the status of development of the LC-LRFMME
   - Defining new standard products and formats, model output, forecast skill
   - Defining terms and conditions for exchange
   - Proposals for inclusion of role of GPCs and Lead-Centre for MME LRF in WMO Manual on GDPFS (recommendations to CBS).

5. REGIONAL CLIMATE CENTRES (RCCs)
   - Information on planned activities and services of Centres considering recognition as future RCCs, including relations with GPCs.
   - Needs of RCCs from GPCs and from NMHSs.
   - Proposals for minimum set of functions and services required of RCCs and updates to the Manual on the GDPFS (Volume I) for official designation of RCCs.

6. EXTENDED RANGE FORECASTS (ERF)
   - Status and specific needs related to ERF for products exchange or services

7. VERIFICATION SYSTEMS FOR ERF AND LRF
   - Need for specific scores for ERF.
   - Need for improvement of the Standard Verification System for LRF especially in developing areas such as multi-model ensembles.
   - Provision of ERF and LRF verification scores and related information for use by NMHSs and RCCs.
   - To monitor and compare numerical model forecasts of the Madden-Julian oscillation (MJO)
   - Status of Lead Centre for SVS LRF
   - Adjustments, if necessary of the tasks of the LC-SVSLRF, in the view of ERF and MME

8. CLOSURE OF THE MEETING

ANNEX TO PARAGRAPH 3.1.3

ATTACHMENT II-14

Suggested guidelines for feed back from RCC/NMHS to GPCs

1. Products used (from the minimum list defined in Chapter 4.2 Appendix II-6)

2. Additional products used

3. Your score on the following aspects of products (out of 10):

    a) accessibility & timely availability;
    b) completeness & quality;
    c) usefulness for your purposes.

4. How is the data processed? (e.g. is any post-processing/downscaling carried out?)

5. Forecast applications that have been developed using the data

6. Research studies that have been conducted using the data

7. Any other comments

ANNEX TO PARAGRAPH 3.1.5

Additional information that may be provided by GPCs

ATTACHMENT II-11

Other Long-Range Forecast data, products or other information, in addition to the minimum list in chapter 4.2 Appendix II-6, which could also be provided by GPCs on request by RCCs or NMCs (the RCCs and NMCs would adhere to conditions, if any, attached by the GPCs to these data and products):

1. Grid point value (GPV) products (these are preferred in GRIB 2 format, especially for downscaling):

- hindcast and forecast data for downscaling algorithms:
- data for RCM boundary and initial conditions:
- predicted global weekly values of SST.

2. Information to assist in building capacity in areas such as:

- interpretation and use of ERF and 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 3.2.1

Compliance between activity of the Hydrometcentre of Russia and the WMO CBS requirements for Global Producing Centres

1. Fixed production cycles and time of issuance

The Hydrometcentre of Russia has a fixed production cycle and time of issuance.
The Hydrometcentre of Russia performs four-month integrations in the last week of each month as a routine procedure. The integrations yield four-month model output two days ahead of the next month. Three types of forecasts with monthly temporal resolution are issued on the basis of four-months model output:

a. One-month forecast with zero lead time;
b. Three-month forecast with zero lead time;
c. Three-month forecast with one month lead time.

Thus, the Hydrometcentre of Russia meets Criterion 1. Hydrometcentre of Russia has a fixed production cycle and time of issuance: the Hydrometcentre of Russia produces and issues extended and long range forecasts monthly two days ahead of the next month on the regular basis.

2. Provide a limited set of products as determined by the APPENDIX II-6 of Manual on the GDPFS with recommended amendment

The list of products of the Hydrometcentre of Russia meets the requirements posted by Manual on the GDPFS (Vol. I, Part II, APPENDIX II-6 “Minimum list of LRF products to be made available by global scale producing centres”).

Forecast Products:

2.1. Basic properties

Temporal resolution: Averages over 1-month and 3-months periods
Spatial resolution: 2.5° x 2.5°
Spatial coverage: Global
Lead time: 0 month (for 1-month and 3-month forecasts), 1 month (for 3-month forecast)
Issue frequency: Monthly
Output types: digital data, forecast charts.
Indications of skill: verification assessments of real-time forecasts and over hindcast period are computed in accordance with recommendations from CBS on the Standardized Verification System (Attachments II-8) matching level 1 and level 2 requirements.
Hindcasts (1979-2003) in digital form are available on request (see Item 5).

2.2. Content of basic forecast output

Calibrated model output from ensemble prediction system (10 ensemble members) and probability information for forecast tercile categories for temperature and precipitation are posted on the web-site, with terciles being defined on the basis of 25 year (1979 – 2003) hindcasts.

Parameters: 2 metre temperature (T2m), sea surface temperature (SST), precipitation, Z500, MSLP, T850.

These fields along with corresponding hindcasts are available in digital form for North Eurasia Climate Centre and are provided to APEC Climate Center (Busan, Korea) and WMO Lead Centre for Long-Range Forecast Multi-Model Ensemble Prediction (Seoul, Korea).

The Hydrometcentre of Russia meets Criterion 2. The Hydrometcentre of Russia provides the list of products as determined by the APPENDIX II-6 of Manual on the GDPFS with recommended amendment.

3. Provide verifications as per the WMO Standard Verification System for Long-Range Forecasts (SVSLRF)

GDPFS requirements of the SVS for Long-Range Forecasts are used as a guideline for long-range forecast verification at the Hydrometcentre of Russia. Results of verification assessments on the basis of SMIP-2/HFP type hindcasts from 1980 – 2002 (verification period is limited by observation data) were submitted to WMO LC SVSLRF (Melbourne, Australia).

Thus, the Hydrometcentre of Russia meets Criterion 3. The Hydrometcentre of Russia provides verifications as per the WMO SVS for Long-Range Forecasts (SVSLRF)

4. Provide up-to-date information on methodology used by the GPC

Model description, forecast verifications and technological set-up for seasonal forecasts production are available via English version of the web-site of the Hydrometcentre of Russia http://meteoinfo.ru and publications of specialists of the Hydrometcentre of Russia in the area of long-range forecasting.

Recent publications on seasonal forecasting:

- Kiktev D.B., I.V.Trosnikov, M.A.Tolstykh and R.B.Zaripov, 2006: Verifications of forecasts of seasonal anomalies of meteorological fields for SL-AV model in SMIP-2 experiment, Russian Meteorology and Hydrology, №6
- Trosnikov I.V., Kaznacheeva V.D., Kiktev D.B., Tolstikh M.A., 2005: Assessment of potential predictability of meteorological variables in dynamical seasonal modeling of atmospheric circulation on the basis of semi-Lagrangian model SL-AV, Russian Meteorology and Hydrology, №12
- Kiktev D., 2004: Dynamical seasonal forecasts in Roshydromet – current state. Fourth APCN Working Group and Third Steering Committee meeting.

The Hydrometcentre of Russia meets Criterion 4.

5. Make products accessible through the GPC Web site and/or disseminated through the GTS and/or Internet

The Hydrometcentre of Russia makes its three-month (rolling season) forecasts of temperature and precipitation with one month lead time accessible on the English version of web-site of the Hydrometcentre of Russia - http://meteoinfo.ru. The Hydrometcentre of Russia updates posted forecasts monthly.

The Hydrometcentre of Russia provides the North Eurasia Climate Centre with the whole set of its products. Hydrometcentre of Russia provides the APEC Climate Center (Busan, Korea) and WMO Lead Centre for Long-Range Forecast Multi-Model Ensemble Prediction (Seoul, Korea) with three-months forecasts of T2m, SST, Precipitation, Z500, MSLP, T850 with one month lead time and one month temporal resolution on the monthly basis.

Along with forecasts the corresponding hindcasts for the period 1979-2003 computed in accordance with SMIP-2/HFP protocol are provided to the North Eurasia Climate Centre, APEC Climate Center (Busan, Korea) and WMO Lead Centre for Long-Range Forecast Multi-Model Ensemble Prediction (Seoul, Korea).

Results of SMIP-2 historical seasonal forecasts of the Hydrometcentre of Russia were transmitted for the Livermor National Laboratory (USA) and are available at the address http://iridl.ldeo.columbia.edu/expert/SOURCES/.WCRP/.SMIP-2/.prescribed_SST/.HMC/.

Thus, the Hydrometcentre of Russia meets Criterion 5. Hydrometcentre of Russia makes its products accessible through the Internet and disseminate them among the institution interested in.

Conclusion

The Hydrometcentre of Russia adheres all the criteria for Global Producing Centre of Long-range forecasts listed in Manual on the GDPFS, Vol. I, Part II, APPENDIX II-8 with recommended amendment.

ANNEX TO PARAGRAPH 3.2.2

STATUS OF FUTURE GPC-PRETORIA

The South African Weather Service (SAWS) and one of its partners, the University of Pretoria, are running two atmospheric general circulation models (AGCMs) for the long-range forecasting (LRF) time scale, the ECHAM4.5 and CCAM. Every month 12 ensemble member forecasts are produced by the ECHAM4.5 (6 from using persisted sea-surface temperature (SST) anomalies, and 6 from using forecast SST anomalies) and 8 members by the CCAM (using persisted SST anomalies). The forecasts are combined (equal weights) to produce probabilistic multi-model rainfall forecasts for South Africa on a seasonal time scale. For the purposes of Global Producing Centre recognition, the SAWS has met the requirements for the SVSLRF, but need to expand their AGCM runs to satisfy the requirement with regard to providing at least 15 years of retrospective forecasts. At present only AMIP-type simulations (the AGCMs forced with observed SSTs) are available for a 23-year period. The ECHAM4.5 will be forced with persisted SST anomalies in order to make sure that the SAWS meet all the requirements for GPC recognition by the end of September 2008. One of the plans with the AGCMs is to produce retrospective forecasts through forcing the models with predicted SST anomalies from the fully coupled model forecasts obtained from international centres.

The ECHAM4.5 and CCAM are also being used for making forecasts on the extended-range time scale. The ECHAM4.5 is run every month to produce a 12-member ensemble (the seasonal forecast run) from which the required 20-day period forecasts are extracted. The CCAM is run every week to produce an ensemble of 4 members. These forecasts are subjectively combined every week to produce extended-range (days 11-30) forecasts for South Africa.

ANNEX TO PARAGRAPH 3.2.3

EMAIL RECEIVED FROM CPTEC-INPE, BRAZIL

*Dear Mr Peter Chen
* Chief, Data Processing and Forecasting Systems

This is to inform you that today we made our first submission to the Standardized Verification System for Long Range Forecast, as may be seen in the attachment.

As a first step we submitted the Mean Square Skill Score (MSSS) for the Dec-Jan-Feb for Temperature at 2m and rainfall. The integration was performed for 1979-2001 in a DERF mode with NCEP reanalysis as initial conditions. Up to now 7 members have been obtained but we plan on reaching 10 and resubmitted to the SVS. We will integrate for the other trimesters (JFM, FMA,...) in sequence.

This is a first step to demonstrate our interest in becoming in the near future a Global Producing Centre of Seasonal to Interanual Forecast.

Best regards,

Maria A. F. Silva Dias
Director
www.cptec.inpe.br

ANNEX TO PARAGRAPH 3.3

ACTIVITIES OF GLOBAL PRODUCING CENTRE FOR LONG-RANGE FORECASTS

1. Beijing

The Long Range Forecasting

Since the report presented in Busan September 2007 the BCC has been making progress in improving oceanic condition qualities in BCC's seasonal prediction system based on ocean-atmosphere coupled models by involving more ocean observation in the global data assimilation system (GODAS) of BCC. Beside regular observation of ocean from GTS, more ARGO data downloaded routinely every month from its special website have been launched into BCC's GODAS. And as a result, it has improved the prediction of Nino index, as well as the temperature anomalies of sub-surface. More cases assessments are being undertaken.
BCC is in the process of preparing upgrading of its seasonal prediction system, which commenced on the development of BCC new climate system model (BCC_CSM) since 2005. This system is being developed as an integrated modeling system for LRF through decadal and climate change time predictions. The time of upgrading the new BCC seasonal prediction system is estimated around 2010.

The Extended Range Forecasting

BCC is involved in the Extended Range Forecast (ERF) activities, based on its monthly dynamical extended range forecast model (DERF, AGCM with persisted SST anomalies for the following 40-day period of forecast). Presently, BCC issues its ERF mainly with 10-day and 30-day averaged precipitation and surface temperature every pentad, i.e., 1st, 6th, 11th, 16th, 21st and 26th, with 40 members at most, both in determined way by ensemble means and probabilistic way by 3 terciles. And it is planned that some special products to represent LFO (such as MJO) will be developed by applying BCC's model output at extended range.

2. Australian Bureau of Meteorology

The Long Range Forecasting: An Update

A new coupled model POAMA1.5 became operational in February 2008. This model represents an interim step in the development of a new Australian community model under the Australian Community Climate Earth Systems Simulator (ACCESS) project for applications on weather through climate time scales.

The POAMA1.5 system is an interim version between POAMA1 and POAMA2 (ACCESS). It uses some modules from POAMA1 and new modules developed for POAMA2. The main modules in POAMA1.5 that have evolved from POAMA1 include the ocean model ACOM2 (Australian Community Ocean Model version 2), the atmospheric model BAM3 (the Bureau of Meteorology Research Centre Atmospheric Model version 3) and the OASIS2 (Ocean Atmosphere Sea Ice Soil version 2) coupler. These modules include some re-tuning and improvements. A major new component is a comprehensive Atmosphere-Land Initialization (ALI) scheme.

The POAMA1.5 model has been verified according to the SVSLRF. The new model shows a substantial improvement in both climatology and hindcast skill, particularly for SSTs.

The Extended Range Forecasting

The POAMA1.5 system provides the basis for an experimental intraseasonal (extended range) forecasting system. Some skill is evident for variables such as MSLP and cloudiness. The associated forecasts are not issued operationally, though are available for research purposes.

Further information on the model and full hindcast and forecast datasets are available to GPCs, RCCs and researchers through the websites http://poama.bom.gov.au and http://www.bom.gov.au/climate/ahead .

3. Update on LRF Canadian system

On December 1st 2007, the Canadian Meteorological Centre (CMC) has made a major upgrade to its long-range dynamical forecast system. The operational system is now a ensemble system of 4 models (2 AGCMs from the Canadian Climate Centre for modeling and analysis and 2 NWP models from Recherche en Prévision Numérique, for more details here: http://www.weatheroffice.gc.ca/saisons/howto_seasonal_0-3_e.html) in a 2 tier approach. 10 members for each system are run for a total ensemble of 40 (LAF with a 1 day lag). The SSTs are still predicted using the persistence of the prior 30 day anomaly. CMC is now also issuing a 1 month lead time forecast in addition to the zero lead time forecast. The parameters forecast are anomalies of three month mean of global surface air temperature and precipitation in 3 categories. According to 35 year hindcast verification, both the surface air temperature and precipitation forecasts should be improved by the implementation. Higher correlation and reliability were found for every season but a decrease in the probability sharpness was noted. The global maps of the forecasts produced by this system can be found at:
http://collaboration.cmc.ec.gc.ca/cmc/saison/glb/cmc_seasonal_fcst_global.html
To get the password to access the site, please write to implementation@ec.gc.ca.
The hindcast and the operational outputs in digital GRIB1 format (monthly and seasonal means of individual members) are also available at the above web site.

ERF at CMC

The Meteorological Service of Canada suite of products for the ER is currently:

1) Anomaly of the week 2 mean surface air temperature (days 8-14) as produced by the North American Ensemble Forecast System (NAEFS). This system is composed of the CMC ensemble system (20 members) and the NCEP ensemble system (20 members). The anomalies are calculated with forecasts de-biased (daily) and a climatology coming from the NCEP reanalyses. The forecasts are made twice per day and are available at the following web site
http://www.weatheroffice.gc.ca/ensemble/semaine2_combinee_e.html
No hindcast was made with this system at the moment.

2) Anomaly of monthly (30 days) mean surface air temperature is forecast twice per month (day 1 and 16).
http://www.weatheroffice.gc.ca/saisons/image_e.html?img=mfe1t_s&title=forecasts
The system used to do the forecast is identical to the seasonal one (4 models with 10 members each). A description of the system can be found here:
http://www.weatheroffice.gc.ca/saisons/howto_seasonal_0-3_e.html
Climatology used to calculate the anomalies is derived from a 35 year hindcast (SMIP2/HFP protocol, 1969-2003).

4. Status report UK Met Office Hadley Centre

Operational GPC activities continue using the Met Office Hadley Centre dynamical global seasonal (GloSea3) prediction system to generate real-time operational long-range predictions for up to 6-months ahead. The forecasting system is based on a version of the Hadley Centre climate model, HadCM3, specially adapted for seasonal forecasting purposes and known as 'GloSea' (system details and products are available at www.metoffice.gov.uk/research/seasonal). GloSea is run in a 41-member ensemble on the ECMWF super computer and forms one component of the developing European multi-model (EUROSIP) along with, currently, the ECMWF system3 and the Météo France seasonal forecast models. Initial conditions for the GloSea3 ensemble are generated from a mix of windstress perturbations applied during assimilation and instantaneous SST perturbations. Atmospheric and land-surface initial conditions are taken from the ECMWF operational analysis.

A major upgrade of the GloSea system (to GloSea4) will be implemented in May 2009. GloSea4 will be based on the new Met Office Hadley Centre climate model HadGEM3. Key advantages of the GloSea4 system are: improved atmosphere and ocean dynamics and physical parameterisations; higher horizontal and vertical resolution (N96 (~140km), 60 levels; compared with GloSea3, N48 (~250km), 19 levels); inclusion of both and initial condition perturbations and uncertainties due to model formulation (using both perturbed physical parameter methods and stochastic kinetic energy backscatter).

ERF Activities:

Predictions to 15 days are made using the Met Office Global and Regional Ensemble Prediction System (MOGREPS-15). The predictions are used to support medium-range prediction range. Additionally MOGREPS-15 output is provided to the CAS/WCRP WGNE experiment to monitor and compare forecasts of the MJO. No prediction model is currently run for the latter part of the extended-range period. However, extensive use is made of the ECMWF varEPS system, which is run to 32 days ahead in a 51-member ensemble once each week. More detail on ERF products generated from the varEPS system are provided below.

Forecast products: Met Office post-processing is performed for mean, maximum and minimum temperature, precipitation, wind speed and sunshine amount averaged/accumulated over three forecast periods; days 5-11 ahead, days 12-18 ahead and days 19-32 ahead. Products include global probability forecasts, forecasts for European weather regimes, and detailed forecasts for the 10 UK climate districts. Global probability products are provided in the form of 1) probability maps for tercile and outer-quintile categories, and 2) for specific regions, probability histograms for quintile categories (well-below, below, near, above, and well-above the climate normal for the region and time of year). Population weighted probability products are also generated. For the 10 UK climate districts temperature and rainfall forecasts are generated in terms of quintile categories. Tercile categories are used for sunshine. The UK forecasts are expressed both in terms of the probability of each category and a deterministic forecast based on either the ensemble mean or the most probable quantile.

Products are being developed for health and marine applications (eg. heat stress and significant wave height). Forecast products based on the statistics of daily events are also being developed, e.g. number of days of heatwave duration and number of days of dry spell duration. Verification of ERF is performed using the same set of WMO SVSLRF diagnostics defined for long-range forecasts: mainly Relative Operating Characteristics and reliability, Gerrity Scores are used for deterministic forecasts.

5. U.S. National Weather Service's Climate Prediction Center (CPC)

By Dr. Arun Kumar

Subsequent to the meeting in Busan in September 2007, following changes in the Climate Forecast System (CFS) have been made:

(1) Number of seasonal forecasts has been changed from 2 forecasts per day to 4 forecasts per day. The forecast duration still remains 9 months. Following this paradigm there are 120 seasonal forecasts in a month. The CFS forecasts displayed on the Climate Prediction Centre (CPC) website are based on lagged ensemble from the last 10-days (or 40 different initial conditions)

(2) The Global Ocean Data Assimilation System (GODAS) was modified to run one day behind the real-time. In the previous configuration, the GODAS was 7-day behind the real-time. This change was prompted by the desire to use the CFS for generating the monthly forecasts.

NCEP is in the process of upgrading its seasonal forecast system and the current estimate of the schedule upgrade is beginning of year 2010. This upgrade will involve following components:

1. A coupled climate reanalysis from 1979-present involving same atmospheric and ocean modelling components that will be used for the next update of the seasonal forecast system. This coupled climate reanalysis will provide consistent initial conditions for hindcast and forecasts and will be completed in early 2009 and will be available for community access.
2. A hindcast for from 1981-present and will be completed in 2009.
3. Finally, upgrade to the current seasonal forecast system in 2010.

The CPC is also involved in the Extended Range Forecast (ERF) activities that rely on the dynamical and statistical prediction systems. ERF is an emerging activity among different GPCs and this may be the right time to establish necessary coordination for the emerging (model based) forecast system. This role can be played by the ET-LRF.

6. Update on ECMWF Seasonal Forecast activity

Since the last report presented in Busan September 2007 the ECMWF has been making progress in constructing the verification statistics for the newly implemented seasonal forecast system. Verification statistics based on 25 years of hindcast (1981-2005) have been computed according to the guidelines given by the WMO SVS for LRF. On the ECMWF web site, real time forecasts and various estimates of the forecast skill are displayed. At the time of writing not all the initial dates have been verified. Once the verification is completed the scores for level 1 and level 2 will be submitted to the Lead centre of SVS for LRF.

Some additional tropical storm products (based on ACE Accumulated Cyclone Energy) have been recently developed. Those products will soon be available on the web.

As a consequence of the implementation of a new surface scheme in the NWP system, values of soil moisture created by the analysis became inconsistent with the old surface scheme used by the seasonal forecast model. A low resolution analysis with the old surface scheme is running in order to create consistent soil moisture initial conditions for the seasonal forecast.

The large reductions in Arctic ice cover during the 2007 Northern Hemisphere (NH) summer are not correctly represented in the ECMWF seasonal forecasting system. A set of experiments were carried out to explore the effect of ice anomalies on the atmospheric flow. Results indicate that the anomalous ice cover observed during JJA 2007 has an impact on the Northern Hemisphere atmospheric circulation suggesting a potential benefit from proper sea-ice treatment in the seasonal forecasting system. However, the predictability of sea ice anomalies in coupled models is still poorly understood, and it is likely that accurate initialization of sea-ice properties is needed to predict such anomalies few months in advance.

ANNEX TO PARAGRAPH 3.4

DATA NEEDS FOR LONG RANGE FORECAST

(prepared by Dr Laura Ferranti (ECMWF) and endorsed by CBS Expert Team on Extended and Long-Range Forecasting – 10 April 2008)

An accurate description of the ocean, land surface, sea ice and atmospheric conditions is the basic need to create the best initial conditions for long-range forecasts. On timescales beyond one or two months, the ocean state has an important role. Land surface conditions play a role during the first two months of the forecast. Although little is known about the predictability of the sea-ice, it has been shown that changes in the ice coverage have the potential of impacting the atmospheric circulation at monthly and seasonal time scales. In general, the quality of LRF is still much affected by model errors, and there is a real need for suitable data to assess and improve models.

Ocean initial conditions

Sea Surface Temperature (SST)
High quality, fast delivery SST, ideally with accuracy < 0.1 deg C on 100 km spatial scale, available within 24h (by SST we mean e.g. bulk temperature at 2m depth).

Data used to force the ocean model, such as wind stresses.
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, surface radiation and Precipitation-Evaporation could help give a better definition of the mixed layer structure.

High quality, time homogeneous equatorial data: temperature, salinity and velocities.
The equatorial mooring arrays, providing homogeneous and continuous time-series of observations are essential. TAO array is a vital backbone for the subsurface temperature in the Pacific. It could be easily enhanced by providing also salinity measurements. Data at higher vertical resolution, and real-time velocity would also be beneficial. Although the PIRATA array over Equatorial Atlantic is useful, its spatial sampling is still deficient, and the salinity data, measured in real time, is often not received by the assimilation centres. Temperatures from the recently implemented moorings in the Indian Ocean are being used operationally, and further developments of this array will be welcome.

Broad-scale ocean sub-surface Temperature and Salinity data.
In overall terms the Argo array has been demonstrated to have a substantial impact in the knowledge of the ocean and in the skill of seasonal forecasts. It is absolutely essential that the sustainability of the Argo array is maintained for the foreseeable future. The Ships-of-Opportunity Programme (SOOP) provides data of acceptable spatial resolution, over some region 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.

Real time delivery of satellite derived sea level data.
The spatial coverage provided by the Altimeter data has been proved to be valuable. Again, it is important to guarantee the continuity of the altimeter missions without interruptions.

A good knowledge of the earth's geoid provides essential information for estimating the mean dynamic topography, which has been proven to have a large impact in the ocean state when combined with the altimeter information, although further developments of assimilation methods are needed. There are plans to make use of geodetic data to obtain information about geoid and the mean state of the oceans. It is expected that geodetic data will become available from satellite; GRACE and CHAMP are flying missions; GOCE will be an important addition.

Sea-ice data (concentration and thickness) will be helpful. For instance, the significant reductions in Arctic ice cover during the 2007 Northern Hemisphere (NH) summer are not correctly represented in the ECMWF seasonal forecasting system. Experimental results indicate that this anomalous ice cover has an impact on the NH atmospheric circulation suggesting a potential benefit from proper sea-ice treatment in the seasonal forecasting system. However, the predictability of sea ice anomalies in coupled models is still poorly understood, and it is likely that accurate initialization of sea-ice properties is needed to predict such anomalies few months in advance.

Satellite derived surface salinity data might prove useful, since it will help to reduce the large uncertainty in the upper ocean salinity field, currently very large due to the precarious knowledge of the fresh water fluxes. Surface salinity information will certainly help to constrain the fresh water balance.

Land surface

Soil moisture
Soil moisture initial conditions are a crucial element in the forecast performance in mid-latitudes spring/summer and might extend predictability over land in the monthly to seasonal range. Soil moisture drifts are ubiquitous in NWP models, due to deficiencies in land surface models and/or the forcing precipitation and radiative fluxes. 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:

- 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)

- 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.

- 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.

It is clear that without stringent caveats and 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.

Snow cover, depth and mass.
Both for real time analyses and consistent analyses of the past.

Atmospheric initial conditions

Thanks to Medium-Range Numerical Weather Prediction systems an accurate description of the real-time atmospheric initial conditions is already largely available. However, LRF has some needs additional to those for medium range forecast:

Time variation in the composition of the atmosphere needs to be known and accounted for: greenhouse gases, tropospheric aerosols, volcanic aerosols, and stratospheric ozone. Near real-time data is needed, and in many cases both horizontal variations and the vertical profile are required.

For verification and calibration of model output

i) Global data that can be used to validate the LRF. This is particularly important for rainfall, where high quality, high density and readily available data would be of great value both for assessing model quality, and, more importantly, empirical downscaling global model output for local use.

ii) Long records of station data will be very useful for calibration and downscaling purposes, and will greatly help the application and usefulness of the seasonal forecasts products.

iii) Atmospheric reanalysis should be continued in the real time. Although the existing atmospheric reanalysis have proved an invaluable contribution to LRF, they usually cover only a fixed period, and in order to complete the validation data set, the reanalysis record is often complemented with operational data. This has the potential of introducing undesired inhomogeneities in the validation data sets.

iv) Reanalysis should be repeated as the models and data assimilation methods improve, thus guaranteeing that the quality of the data sets is continuously improved.

ANNEX TO PARAGRAPH 4.1

LEAD CENTRE FOR MULTI-MODEL ENSEMBLE LONG-RANGE FORECAST (LC - MME LRF)

1. Progress report on the status of development of the LC - LRFMME

Following the phased approach for the advancement of the activities of the LC-LRFMME, which were discussed by GPCs at the last workshop on LC-LRFMME in Busan in September 2007, LC-LRFMME has accomplished following steps.

(a) **Implementation of Phase 0**: Forecast system configurations of nine GPCs and Moscow have been collected and displayed at the LC-LRFMME website. LC-LRFMME, therefore, has accomplished the stated goal for Phase 0 and will maintain the repository of forecast system configurations of various GPCs. To keep this repository up-to-date, it is requested that GPCs submit any future changes in their hindcast-forecast configuration.

(b) **Implementation of Phase 1**: Following discussions via e-mails on the data exchange protocols subsequent to the LC-MRFMME workshop in Busan, September 20007, a tentative agreement on data exchange was put in place (see section 4.3 below). Agreement on data exchange issues was followed by a sub-set of GPCs submitting their predicted anomalies for selected variables since last December to the Lead Centre. The Lead Centre generated forecast plots and displayed them in a common format on a website. So far, 2007/08 DJF and 2008 MAM forecast anomalies can be viewed through the website. I t is expected that such data submissions will likely to continue in future. To summarize, LC-LRFMME is ready for the Phase 1, and after a formal consensus on data exchange protocols, terms and conditions for the exchange of data are in place, Phase 1 will be accomplished.

(c) **Implementation of Phase 2:** Some of GPCs have already provided hindcasts and real-time forecasts (raw data) since last December. Anomalies for the GPC forecasts are computed in a common format and LC-LRFMME is ready to take actions for Phase 2. However, since Phase 1 is not fully accomplished, the website did not open the menu for displaying forecast anomalies using hindcasts and real-time forecasts. The LC-LRFMME has established simple composition of MME, weighted combination of MME, linear MME, nonlinear MME (Neural Network, Genetic Algorithm) schemes. To be ready for Phase 2, LC-LRFMME will work on displaying the MME forecasts.

2. Various Milestones

(a) On December 11th, Dr Simon Mason from IRI asked LC-LRFMME for production of a seasonal climate forecast for the malaria control community in southern Africa. On December 14, LC-LRFMME asked for consent from GPCs for providing their data to the IRI. On December 19, LC-LRFMME provided the seasonal climate forecast data to the IRI from the GPCs who sent us their consent for data sharing.

(b) On February 4th, LC-LRFMME has sent an email on updated version for the Phase 1 plan. The main changes are:

(1) A better defined structure for the forecast anomaly files (section 4.3);
(2) A request for submitting ensemble mean anomaly and individual runs as separate files.

LC-LRFMME also requested GPCs who are in position to start sending the data. GPCs were encouraged to start doing so as soon as possible (preferably from February 2008).
Since the data exchange system in LC-LRFMME is ready to proceed with the Phase 1 plans, it is strongly recommended that the data exchange policy and formats be formalized and need to be agreed on by every GPCs and Moscow.

3. Defining data formats and file naming conventions

LC-LRFMME has proposed following standardization for data formats, and file naming convention as follows:

(a) Variables to be submitted (Z500, T850, MSLP, Precip, T2m, SST)

(b) Acceptable data formats (grib1; grib2)

(c) The number of bits of grib data in 16-bits

(e) The number of grid points should be **144*73** (starting from 90N and 0E)

(f) There should be one file with monthly ensemble mean anomaly. Individual members should also be provided as separate files in the same format as the ensemble mean. Therefore, if there are "n" members in the forecast, total number of files submitted will be "n+1"

(g) File naming conventions:

Following naming rule is suggested;

{GPC}_{yymmIC}_{yymmF1_yymmF2 }_{ens OR runid}.{file type}
(Ex.. Seoul_200711_200712_200803.grb1)

- **system abbreviation**: name for GPC submitting the data (maximum 8 characters)
- **yymmIC**: year and month when the forecasts are initiated…e.g, 200711to indicate that forecasts are initiated in November
- **yymmF1:** year and month for the first forecast month, e.g., 200712
- **yymmF2:** year and month for the last forecast month, e.g., 200802
- **ens_OR_runid:** use "ens" for the ensemble mean file, and run1, run2, run3,…for individual runs
- **file type**: **grb1** for GRIB-1, **grb2** for GRIB-2
- **The file should contain only 6 necessary parameters in the following order;** 500hPa geopotential height (m), 850hPa temperature (K), mean sea level pressure (hPa), total precipitation rate (kg m^{-2} day^{-1}), surface temperature at 2m(K), sst (sea surface temperature, K). GPCs that have atmosphere alone forecasts (tier-2) should include the same SST field in each file.

(h) Data can be submitted through LC-LRFMME website (preferred) or via KMA ftp server (especially for hindcasts in Phase 2). Access to the ftp server will be only through the registered IP addresses.

ANNEX TO PARAGRAPH 4.4

(updates to the Manual on Global Data Processing and Forecasting System - WMO publication no 485 are listed in red)

In appendix II-6, it is proposed to replace in paragraph 4.2, for the Content of basic forecast ouput, in (a) and (b):

- “2-metre temperature over land” by: “2-metre temperature over the globe”
- “Precipitation” by: “Total precipitation”

It is proposed to add some items to Vol. I, Part II, APPENDIX II-8

1. Centres that are designated as Global Producing Centres for Long-range Forecasts (GPCs) are as follow: Beijing, Exeter, Melbourne, Montreal, Moscow, Seoul, Tokyo, Toulouse, Washington and ECMWF.

2. 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 chapter 4.2 of 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.

3. Additional data or products to the minimum list above could also be provided by GPCs on request by RCCs or NMCs. The RCCs and NMCs would adhere to conditions, if any, attached by the GPCs to these data and products. This additional list of data and products is given in Attachment II-11

4. Given the anticipated improvements in skill of Long-Range Forecasts (LRF) by using a multi-model ensembles (MME) approach, some GPCs can serve as collectors of global LRF data to build MME and to make MME LRF predictions. Such Centres may become Lead Centres for Long-Range Forecast of Multi-Model Ensembles predictions (LCs LRFMME). The list of such Centres and the functions of LC-LRFMME are defined in Attachment II-12. The list of data that GPCs may supply to LCs LRFMME are defined in Attachment II-13.

ATTACHMENT II-12

1. GPC Seoul and GPC Washington are jointly recognized as a Lead Centre for Long-Range Forecast of Multi Model Ensemble (MME) predictions, including responsibility for a web portal of GPC and MME products with global coverage.

2. Functions of Lead Centres for Long-Range Forecast of Multi Model Ensemble (MME) prediction

1) Maintain a repository of documentation for the system configuration of all GPC systems
2) Collect an agreed set of forecast data from GPCs
3) Display GPCs forecasts in standard format
4) Promote research and experience in MME techniques and provide guidance and support on MME techniques to GPCs, RCCs and NMHSs.
5) Based on comparison among different models, provide feedback to GPCs about the models performance
6) Generate an agreed set of Lead Centre (LC) products (see section 3)
7) Provide web pages to satisfy requirements for regional display of Lead Centre products (e.g. for RCOF coordinators)
8) Where possible verify the LC products using the SVSLRF.
9) Redistribute digital forecast data for those GPC's that allow it.
10) Handle requests for the password for the website and data distribution; maintain a database recording the users who have requested access to data/products and the frequency of access
11) Maintain an archive of the real-time GPC and MME forecasts.

3. Core information to be available from Lead Centres for LRFMME

3.1 GPC digital products:

Global fields of forecast anomalies as supplied by GPCs, and listed below (for GPCs that allow redistribution of their digital data):

Monthly mean anomalies for individual ensemble members and ensemble mean for at least each of three months following the month of submission e.g March, April, May if the month of submission is February:

a) Surface (2m) temperature
b) Sea Surface Temperature
c) Total Precipitation rate
d) Mean Sea Level pressure
e) 850hPa temperature
f) 500hPa geopotential height

N.B the content and format for the supply of data to the Lead Centre by GPCs and terms of exchange are defined in Attachment II-13.

GPCs not currently able to participate in this additional exchange of data are encouraged to do so in the future.

3.2 Graphical products:

Plots and maps for each GPC forecast displayed in common format on the LC website, for the variables listed in 3.1 and for selectable regions where appropriate, showing for 3-month means or accumulations:

a) ensemble 'plumes' of Niño indices (1-month means)

b) ensemble mean anomalies
c) Probabilities of above / below median
d) Model consistency plots, i.e maps showing the proportion of models predicting the same sign anomaly.
e) multi-model probabilities of above/below median.

4. Additional information to be available from Lead Centres for LRFMME

As part of research and development Lead Centres may make available products based on forecast and hindcast data from the subset of GPCs that are able to supply them. These products are additional information to help GPCs, RCCs and NMCs to further develop MME techniques and their application.

GPCs not currently able to participate in this additional exchange of data are encouraged to do so in the future.

4.1 GPC digital products:

Global forecast fields and corresponding hindcasts for the fields listed in 3.1, and additional variables to be agreed, for those GPCs that allow redistribution.

4.2 Graphical products

Forecast maps for each GPC displayed in common format on the LC website, for the variables listed in 3.1 and for selectable regions where appropriate, showing for 3-month means or accumulations:

a) tercile category probabilities
b) model consistency plots for most likely tercile category
c) multi-model probabilities for probabilities for tercile categories, using various established and experimental multi-modelling methods.

These additional products will be distinguished from Lead Centre core products listed in 3.

5. Visualisation of graphical products

The recommended temporal resolution, lead-times, variables and update frequencies for images are those prescribed for GPCs in Appendix II-6, chapter 4.2.

a) Forecasts for individual GPCs will be displayed in common graphical format in a way that allows comparison.
b) The geographical regions displayed will be interactively selectable, or at minimum:
    - Globe
    - Northern extratropics
    - Southern extratropics
    - Tropics
    - Nino regions (for SST plumes)

c) The research and development products in section 4 will be distinguished from the Lead Centre products of section 3.
d) Graphical forecast products displayed will be accompanied by disclaimers stating that the forecasts are for guidance and are not official WMO forecasts, and do not necessarily represent the final official forecast for any country or region as produced by the NMS or RCC for that country or region.

6. Access to GPC data and visualization products held by the Lead Centres for LRFMME

a) Access to GPC data and graphical products from LC-LRFMME websites will be by website password.
b) Digital GPC data will be only re-distributed in cases where the GPC data policy allows it. In other cases, requests for GPC output should be referred to the relevant GPC.
c) Recognized GPCs, RCCs, NMHSs, and institutions hosting RCOFs such as ACMAD, ICPAC, are eligible for password protected access to information held and produced by the LC-LRFMME.
d) Potential new users not belonging to the above categories may request access from an LC-LRFMME, who will refer the request to the designated GPCs. Decisions to allow access must be unanimous. The Lead Centre will be informed of new users accepted for access.
e) A list of users provided with password access will maintained by LC-LRFMME and reviewed by the GPCs, to measure the degree of effective use and also to review any changes in status of eligible users. The GPCs and the LCs-LRFMME will report on the review to the CBS Expert Team on Extended and Long-range Forecasting[1], which will act as an advisory body for the LCs-LRFMME.

[1] It is the name of the CBS Expert Team at the time of this insertion in the Manual. In the future it may be change to another entity, but still dealing with coordination of long-range forecast production.

ATTACHMENT II-13

CONTENT AND FORMAT FOR THE SUPPLY OF DATA TO THE LEAD CENTRE FOR LRFMME BY GPCS AND TERMS OF EXCHANGE

Data formats and file naming convention

LC-LRFMME has proposed following standardization for data formats, and file naming convention as follows:

(a) The following variables: Z500, T850, MSLP, Precip., T2m and SST, should be submitted for each of three months following the month of submission (e.g June, July, August if the month of submission is May)

(b) Acceptable data formats: GRIB1; GRIB2

(c) The number of bits of GRIB data is 16-bits

(d) The number of grid points should be **144*73** (starting from 90N and 0E)

(e) There should be one file with monthly ensemble mean anomaly. Individual members should also be provided as separate files in the same format as the ensemble mean. Therefore, if there are “n” members in the forecast, total number of files submitted will be “n+1”

(f) File naming conventions: (see LC-LRFMME website)

Terms for exchange

The terms for exchange of data between GPCs and LC-LRFMME are as follows:

a) GPCs provide their **monthly mean anomaly forecasts** (and full fields, for GPCs participating in this additional exchange; see Attachment II-12, section 4 for “additional exchange”) to the Lead Center on a monthly basis and LC will be responsible for displaying them.
b) GPCs who are able to do so will submit data for monthly means and for individual ensemble members.
c) Forecast anomalies should be provided by GPCs by the 15th of the month. For example, for June-July-August seasonal forecast, data should be provided by 15th May. GPCs should inform the LC-LRFMME if any delay in submitting data is anticipated.

ANNEX TO PARAGRAPH 5.1.2

MODIFICATIONS TO THE MANUAL ON THE GDPFS VOLUME 1 (GLOBAL ASPECTS) (WMO--NO 485) - RELEVANT TO DESIGNATION OF REGIONAL CLIMATE CENTRES

Part I: Page I-1, section 2 (Functions of the GDPFS), Section 2.1 item (e) shall be amended to read:
'Preparation of specialized products such as limited area very-fine mesh short-, medium, extended- and long-range forecasts, regional climate watches, tailored products for marine, aviation, environmental quality monitoring and other purposes;'

Part I: Page I-1, section 2 (Functions of the GDPFS), Section 2.2 item (a) shall be amended to read:
'Preparation of special products for climate-related diagnosis (e.g. 10-day or 30-day means, summaries, frequencies, anomalies and historical reference climatologies) on a global or regional scale;'

In Part I: Page I-2, section 4.1.2 (Regional Specialized Meteorological Centres (RSMCs)), insert a new paragraph 4.1.2.5 after paragraph 4.1.2.4, and rename existing paragraph 4.1.2.5 as 4.1.2.6. The new paragraph shall read as follows:
'4.1.2.5 Centres designated by WMO for the provision of global long-range forecasts are called Global Producing Centres for Long-range forecasts (GPCs). Centres designated by WMO for the provision of regional long-range forecasts and other regional climate services, or groups of centres who collectively provide these forecasts and services in a distributed network, are called Regional Climate Centres (RCCs) or RCC-Networks, respectively (see notes under (e) in paragraph 1.4.1.2 of Part II).'

In Part I, Appendix I-1, section 3 (The RSMCs with activity specialization are the following:), add the following text:

GPC Beijing		}
GPC Exeter		}
GPC Melbourne		}
GPC Montreal		}
GPC Moscow		}
GPC Seoul		} Global Producing Centres of long-range forecasting
		} products
GPC Tokyo		}
GPC Toulouse		}
GPC Washington		}
GPC ECMWF		}
RCC CITYNAME….		} Regional Climate Centres providing regional long-
		} range forecasts and other regional climate services
RCC-Network (region)	'CITYNAME' Node 1	}
	'CITYNAME' Node 2	}
	……………..	}
	'CITYNAME' Node n	}

Part II

Part II, page II-4, section 1.4.1.2 (Regional Specialized Meteorological Centres (RSMCs) with activity specialization), item (b) shall be amended to read as follows:
"'Global extended- and long-range forecasts and related mean analysed values and anomalies;'
'NOTE: Centres…."

and item (e) shall be amended to read as follows:
'Regional LRF products, climate monitoring, climate watches, drought monitoring, climate data services, and tailored climate products.'

following the modified item (e), add the following Note:

'NOTE: Centres producing regional long-range forecasts and other regional climate services or groups of centres who collectively provide these forecasts and services in a distributed network, and are recognized as such by CBS and CCl at request of Regional Associations, are called Regional Climate Centres (RCCs) or RCC-Networks, respectively. Definitions of RCCs and RCC-Networks, the list of official recognized RCCs and RCC-Networks, and mandatory functions of RCCs and RCC-Networks can be found in APPENDIX II-10. The criteria to be recognized as an RCC or RCC-Network can be found in APPENDIX II-11.'

Part II, add new APPENDIX II-10 as follows:

DESIGNATION AND MANDATORY FUNCTIONS OF REGIONAL CLIMATE CENTRES (RCCs) AND RCC-NETWORKS

1. A multifunctional centre that fulfils all the required functions of an RCC for the entire region, or for a sub-region to be defined by the Regional Association may be designated by WMO as a 'WMO Regional Climate Centre' (WMO RCC). A group of centres performing climate-related activities that collectively fulfil all the required functions of an RCC may be designated by WMO as a 'WMO Regional Climate Centre Network' (WMO RCC-Network). Each centre in a designated WMO RCC-Network will be referred to as a 'Node'. A Node will perform, for the region or sub-region defined by the Regional Association, one or several of the mandatory RCC activities (e.g. long-range forecasting (LRF), climate monitoring, climate data services, training). Only centres or groups of centres designated by WMO will carry the title 'WMO RCC' or 'WMO RCC-Network' respectively. Recipients of RCC products and services will be NMHSs, other RCCs and international institutions recognized by the Regional Association and will be referred to as 'RCC Users'. WMO RCCs and RCC-Networks shall follow Guidance published by the Commission for Climatology on technical, climate-related matters.

2. Designated Regional Climate Centres and RCC-Networks are as follows: ………………..

3. In order for a centre or a group of centres in a cooperative effort to be officially recognized as a WMO RCC (Regional Climate Centre), or a WMO RCC-Network, it shall perform the following minimum* set of functions, criteria and products for which are defined in Appendix II-11:

Notes: *- Additional requirements for RCC functions may vary in detail from Region to Region**.** A list of 'highly recommended', but not mandatory, functions is given in Attachment II-10.
- An RCC is not necessarily an NMHS, but a non-NMHS candidate for RCC designation must be nominated by the Permanent Representative of the concerned country.

- **Operational Activities for LRF*:**
  - Interpret and assess relevant LRF products from Global Producing Centres (GPCs) (some of which can be obtained through the Lead Centres for LRFMME - see Attachment II-12), make use of Lead Centre for Standard Verification System on LRF (see Attachment II-8), distribute relevant information to RCC Users; and provide feedback to GPCs
  - Generate regional and sub-regional tailored products, relevant to RCC User needs, including seasonal outlooks etc.;
  - Perform verification of RCC quantitative LRF products, including the exchange of basic forecasts and hindcast data;

- Generate 'consensus' statement on regional or sub-regional forecasts (see Appendix II-11 for details).
- Provide on-line access to RCC products/services to RCC Users;
- Assess use of RCC products and services through feedback from RCC Users.

  Note: * Both dynamical and statistical, within the range of 1 month to 2 year timescale, based on regional needs.

- **Operational Activities for Climate Monitoring:**
  - Perform climate diagnostics including analysis of climate variability and extremes, at regional and sub-regional scales;
  - Establish an historical reference climatology for the region and/or sub-regions;
  - Implement a regional Climate Watch.

- **Operational Data Services, to support operational LRF and climate monitoring:**
  - Develop regional climate datasets, gridded where applicable;
  - Provide climate database and archiving services, at the request of NMHSs;

- **Training in the use of operational RCC products and services**
  - Provide information on methodologies and product specifications for mandatory RCC products, and provide guidance on their use
  - Coordinate training for RCC Users in interpretation and use of mandatory RCC products.

In Part II, add new **ATTACHMENT II-10** as follows:

ADDITIONAL 'HIGHLY RECOMMENDED' FUNCTIONS OF DESIGNATED WMO RCCs OR WMO RCC-NETWORKS:

- **Climate Prediction and Climate Projection (beyond 2 years timeframe)**
  - Assist RCC Users in the access and use of WCRP-CMIP climate model simulations
  - Perform downscaling of climate change scenarios
  - Provide information to RCC Users for use in development of climate adaptation strategies
  - Generate, along with warnings of caution on accuracy, seasonal forecasts for specific parameters where relevant, such as:
    - onset, intensity and cessation of rainy season;
    - tropical cyclone frequency and intensity
  - Perform verification on consensus statements for forecasts;
  - Perform assessment of other GPC products such as SSTs, winds, etc.

- **Non-operational data services:**
  - Keep abreast of activities and documentation related to WMO WIS, and work towards WIS compliance and DCPC designation;
  - Assist NMHSs in the rescue of climate data from outmoded storage media;
  - Assist NMHSs to develop and maintain historical climate datasets;
  - Assist RCC Users in the development and maintenance of software modules for standard applications;
  - Advise RCC Users on data quality management;
  - Conduct data homogenization, and advise RCC Users on homogeneity assessment and development and use of homogeneous data sets;
  - Develop and manage databases, and generate indices, of climate extremes;
  - Perform Quality Assurance/Quality Control on national datasets, on request of an NMHS;
  - Provide expertise on interpolation techniques;
  - Facilitate data/metadata exchange amongst NMHSs, including on-line access, through an agreed regional mechanism;
  - Perform Quality Assurance/Quality Control on regional datasets.

- **Coordination Functions:**
  - Strengthen collaboration between NMHSs on related observing, communication and computing networks including data collection and exchange;
  - Develop systems to facilitate harmonisation and assistance in the use of LRF products and other climate services;
  - Assist NMHSs in user liaison, including the organisation of climate and of multidisciplinary workshops and other forums on user needs;
  - Assist NMHSs in the development of a media and public awareness strategy on climate services.

- **Training and Capacity building:**
  - Assist NMHSs in the training of users on the application and on implications of LRF products on users;
  - Assist in the introduction of appropriate decision models for end-users, especially as related to probability forecasts;
  - Promote technical capacity building on NMHS level (e.g. acquisition of hardware, software, etc.), as required for implementation of climate services.
  - Assist in professional capacity building (training) of climate experts for generating user-targeted products.

- **Research and Development:**

- Develop a climate Research and Development agenda and coordinate it with other relevant RCCs;
- Promote studies of regional climate variability and change, predictability and impact in the Region;
- Develop consensus practices to handle divergent climate information for the Region;
- Develop and validate regional models, methods of downscaling and interpretation of global output products;
- Promote the use of proxy climate data in long-term analyses of climate variability and change;
- Promote application research, and assist in the specification and development of sector specific products;
- Promote studies of the economic value of climate information.

In Part II, add new **APPENDIX II-11** as follows**:**

DETAILED CRITERIA FOR RCC MANDATORY FUNCTIONS

Functions	Activities	Criteria
Operational Activities for LRF **(**both dynamical and statistical, within the range of 1 month to 2 year timescale, based on regional needs)	Interpret and assess relevant LRF products from Global Producing Centres (GPCs), distribute relevant information to RCC Users; and provide feedback to GPCs (see Attachment II-14)	***Product:*** assessment of the reliability and outcomes of GPCs or LCs-LRFMME products including the reasoning (make use of LC SVSLRF), for the region of interest, in the form of texts, tables, figures, etc. ***Element:*** 2-m mean temperature, total precipitation ***Update frequency:*** monthly or at least quarterly
	Generate regional and sub-regional tailored products, relevant to RCC User needs, including seasonal outlooks etc.	***Product:*** probabilities for tercile (or appropriate quantile) categories for the region or sub-region ***Element:*** 2-m mean temperature, total precipitation ***Output type:*** *rendered images (maps, charts), text, tables, digital data* ***Forecast period*****:** one month up to 6 months ***Update frequency:*** 10 days to one month
	Generate consensus* statement on regional or sub-regional forecasts. **NB: A collaborative process involves discussion with experts in the region (e.g. through Regional Climate Outlook Forums (RCOFs), teleconferencing, etc.).* *Consensus is both the agreed process, and its joint conclusion, and can be that there is limited skill in the prediction for a region or sub-region*	***Product:*** *consensus statement on regional or sub-regional forecast***.** ***Element:*** *2-m mean temperature, total precipitation* ***Output type:*** *report* ***Forecast period*****:** *a climatologically significant period (from one month to one year)* ***Update frequency:*** *at least once per year (to be defined by the region)*
	Perform verification of RCC quantitative LRF products, including the exchange of basic forecasts and hindcast data.	***Products:*** verification datasets (e.g. SVS LRF scores, Brier Skill Score; ROC; Hit Rate Skill Score) ***Element:*** 2-m mean temperature, total precipitation
	Provide on-line access to RCC products/services to RCC Users.	***Product:*** an on-line data/information portal

	Assess use of RCC products and services through feedback from RCC Users.	***Product:*** analysis of feedback (which is made available using a template) ***Update frequency:*** annually, as part of a regular reporting of RCCs to WMO RAs
Operational Activities for Climate Monitoring	Perform climate diagnostics including analysis of climate variability and extremes, at regional and sub-regional scales	***Products:*** climate diagnostics bulletin including tables, maps and related products ***Element:*** Mean, Max and Min temperatures, Total precipitation; other elements (esp. GCOS essential climate variables) to be determined by the region, ***Update frequency:*** monthly
	Establish an historical reference climatology for the region and/or sub-regions	***Product:*** database of climatological means for various reference periods (e.g. 1931-60; 1951-80; 1961-90; 1971-2000; etc) ***Spatial resolution:*** *by station* ***Temporal resolution:*** *monthly at a minimum* ***Elements:*** Mean, Max and Min temperatures, Total precipitation; other elements (esp. GCOS essential climate variables) to be determined by the region, ***Update frequency:*** at least 30 years, preferably 10 years
	Implement a Regional Climate Watch	***Products:*** climate advisories and information for RCC Users ***Update:*** whenever required, based on the forecast of significant regional climate anomalies.
Operational Data Services, to support operational LRF and climate monitoring	Develop quality controlled regional climate datasets, gridded where applicable	***Products:*** regional, quality controlled climate datasets, gridded where applicable, following CCl guidance on QA/QC procedures ***Elements:*** Mean, Max and Min Temperature, and Precipitation, at a minimum ***Temporal resolution:*** *daily* ***Update:*** monthly
	Provide climate database and archiving services, at the request of NMHSs	***Products:*** national databases with metadata, accessible to the NMHS in question (backup service, development site, etc). ***Elements:*** as determined by the NMHS ***Update:*** at the request of the NMHS
Training in the use of operational RCC products and	Provide information on methodologies and product specifications for mandatory RCC products, and provide guidance on their use	***Products:*** *Manuals, guidance documents and information notes.* ***Update frequency:*** when methods/products are revised or introduced or discontinued

services	Coordinate training for RCC Users in interpretation and use of mandatory RCC products	***Products:*** survey and analysis of regional training needs, and proposals for training activities.

NOTE: an RCC is expected to perform certain functions (e.g. for homogeneity testing; database management; metadata management, statistical evaluation of climate data, etc.) using procedures proposed in the WMO Guide to Climatological Practices and in other official Commission for Climatology Guidance documents.

ANNEX TO PARAGRAPH 6.2

REPORT ON THE STATUS OF THE EXTENDED RANGE FORECASTS AT ECMWF AND ITS PRODUCTS

(by Dr Laura Ferranti))

The Extended Range forecasts are forecasts that span from 10 to 30 days.
The extended range forecast bridges the gap between the medium range and the long range (from 30 days to 2 years). It has a mixed and demanding nature since it is short enough that the atmosphere retains some memory of its initial state and long enough that ocean variability has an impact on the atmospheric circulation.

At ECMWF an ensemble of ERF is produced once a week (every Thursday) and some of the products are based on calendar weeks (Monday to Sunday) (a brief description of the ECMWF ERF can be found at the end of this document). Products from ERF are mainly used to predict atmospheric fluctuations on the intra-seasonal time scale. For the ERF it is difficult to suggest an ideal temporal resolution, anything from 5 to 10 days averages could be justified. The temporal resolution depends also on the length of the ERF forecast.

ERF presented as an extension of the medium range?

Similarly to the LRF products the ERF ones are generally expressed in terms of ensemble mean anomalies and probabilities stratified in different categories. The list of products recommended for the LRF (appendix II-6 of the CBS manual) could be considered as a valid starting point for a possible list of recommended ERF products. In addition products related with the intra-seasonal fluctuations of monsoon rainfall, large scale organized convection anomalies (MJO) and large scale weather regimes (blocking, NAO..) could be suggested.

VarEPS/monthly forecasting system at ECMWF

The monthly forecasting system has been built as a combination of the medium-range ensemble prediction system (EPS) (Buizza et al. 2001) and the seasonal forecasting system (Anderson et al. 2003a,b). It contains features of both systems and, in particular, is based on coupled ocean-atmosphere integrations, as is the seasonal forecasting system.

The monthly forecasts are based on an ensemble of 51 coupled ocean-atmosphere integrations (one control and 50 perturbed forecasts). The length of the coupled integration is 32 days, and it is issued every week (on Thursday). The atmospheric component is the same as the integrated forecasting system (IFS) with the same cycle as the operational medium-range deterministic forecast. The oceanic component is the same as for seasonal forecasting system 3. It consists of the Hamburg Ocean Primitive Equation (HOPE) model developed at the Max Planck Institute. The ocean model has lower resolution in the extratropics but a higher meridional resolution in the equatorial region in order to resolve ocean baroclinic waves and processes, which are tightly trapped at the equator. The ocean model has 29 levels in the vertical. The atmosphere and ocean communicate with each other through a coupling interface called OASIS (Ocean,Atmosphere, Sea-Ice, Soil), which was developed at the Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique (CERFACS). The atmospheric fluxes of momentum, heat and fresh water are passed to the ocean every hour and, in exchange, the ocean sea surface temperature (SST) is passed to the atmosphere. The frequency of coupling is higher than in seasonal forecasting (every 24 hours), since high-frequency coupling may have some impact on the development of some synoptic-scale systems, such as tropical cyclones.

Oceanic initial conditions originate from the oceanic data assimilation system used to produce the initial conditions for the ECMWF seasonal forecasting system. However, the oceanic data assimilation system lags about 12 days behind real time. In order to “predict” the ocean initial conditions, the ocean model is integrated from the last analysis, forced by the analyzed wind stress, heat fluxes and precipitation-minus evaporation from the operational analysis. During this “ocean forecast”, the sea surface temperature is relaxed towards persisted SST, with a damping rate of 100 Wm-2K-1. This method allows us to produce monthly forecasts in “real-time” without having to wait for the ocean analysis to be ready.

The first operational real-time monthly forecast was realized on Thursday, 7 October 2004. Before March 2008, the monthly forecasting system was a separate system, after that the real-time VarEPS/monthly forecasting system has replaced the monthly system. This new system consists of 51-member ensemble of 32-day integrations. The first 10 days are performed with a TL399L62 resolution forced by persisted SSt anomalies. After day 10, the model is coupled to the ocean model and has a resolution of TL255L62. The extension of VarEPS to 32 days is performed every Thursday.

After 10 days of coupled integrations, the model drift begins to be significant. The effect of the drift on the model calculations can be estimated from integrations of the model in previous years (the back-statistics). The drift is removed from the model solution during the post-processing. In the present system, the model climatology (back-statistics) is deduced from a five-member ensemble of 32-day coupled integrations, starting on the same day and month as the real-time forecast for each of the past 18 years.

Monthly forecasting products are displayed on the ECMWF web pages. They include anomaly, probability and tercile maps based on comparing the 51-member ensemble distribution of the real-time forecast with the distribution of the model climatology. The forecasts of 2m temperature, precipitation and mean-sea-level pressure are averaged over seven days. The seven-day periods correspond to days 5 -11, days 12-18, days 19-25 and days 26-32. These periods have been chosen so that they correspond to Sunday to Monday calendar weeks. For the purpose of evaluating the skill of extended-range forecasts, this definition has the advantage that the second weekly period is beyond day 10 and corresponds almost to the first week after the 10 days time-range. The length of the monthly forecasting system is 32 days, so that it contains four of these weekly periods. Figure 1 displays a typical example of a probability map produced by the ECMWF monthly forecasting system. The example displayed in Figure 1 is the probability that the weekly-mean 2m temperature anomalies (relative to the model climatology from the past 12 years) predicted by the monthly forecast starting on 24 January 2008 are below the lower third of the model distribution. Typically, the percentage of areas that are coloured decreases week by week, indicating that the model drifts towards its climatology. In general the model displays strong potential predictability over a large portion of the extra-tropics for the period 12-18 days. However, there is generally a sharp decrease of potential predictability in the last two weeks of the forecasts. The range of products from the VarEPS/monthly forecasting system includes probability of occurrence of weather regimes and predictions of the MJO time evolution.

Verification of the monthly forecast

On the web site the verification statistics is regularly updated. The analysis used to verify the monthly forecasting system is the ECWMF operational analysis or ERA-40 reanalysis when available. For precipitation, the operational or the ERA-40 forecasts of precipitation between 12 and 36 hours are used as verification data.
After 10 days, the spread of the ensemble forecast starts to be large, and the forecasts are essentially probabilistic. The probabilistic scores of the monthly forecasting system are evaluated through the scores obtained with weekly averaged surface temperature, 2m temperature, precipitation and mean-sea-level pressure. Basic methods for verifying probabilistic forecasts have been in use for several years at ECMWF for medium-range EPS products and the methodology has being naturally extended to monthly forecasts. The Relative Operating Characteristics (ROC) curve shows, for a range of different probability thresholds, hit-rates versus false-alarm-rates of forecasts of a particular event in different regions. Figure 2 displays an example of ROC diagrams obtained with four different periods: days 5-11, days 12-18, days 19-25

and days 26-32. In Figure 2(a) the event scored is the probability that the 2m temperature is in the upper tercile over each grid point of the northern extra-tropics. Only grid points over land are considered. For the monthly forecast, the upper tercile has been computed relative to the model climatology. In that respect, the systematic bias of the model has been taken into account. Figure 2 shows how the probabilistic scores the ROC score is of order of 0.8, and drops to 0.7 in the next week. It drops again to about 0.6 in the following week. The ROC scores for days 19-25 and days 26-32 are close. The statistics collected up to now suggest that for days 12-18 the model has some moderate skill, and performs better than climatology.
For the two following weeks, the model displays some low skill, but the performance seems generally slightly better than climatology. The point map of ROC scores for the probability that the 2m temperature anomalies are in the upper tercile (Figure 3) are used to give an indication of the spatial distribution of the skill. Figure 3, for example shows that over the vast majority of land points, the ROC score exceeds 0.5 suggesting that the model performs better than climatology. Figure 3b shows the point map of ROC for days 19-32. The skill is generally much lower than the one obtained over days 12-18.

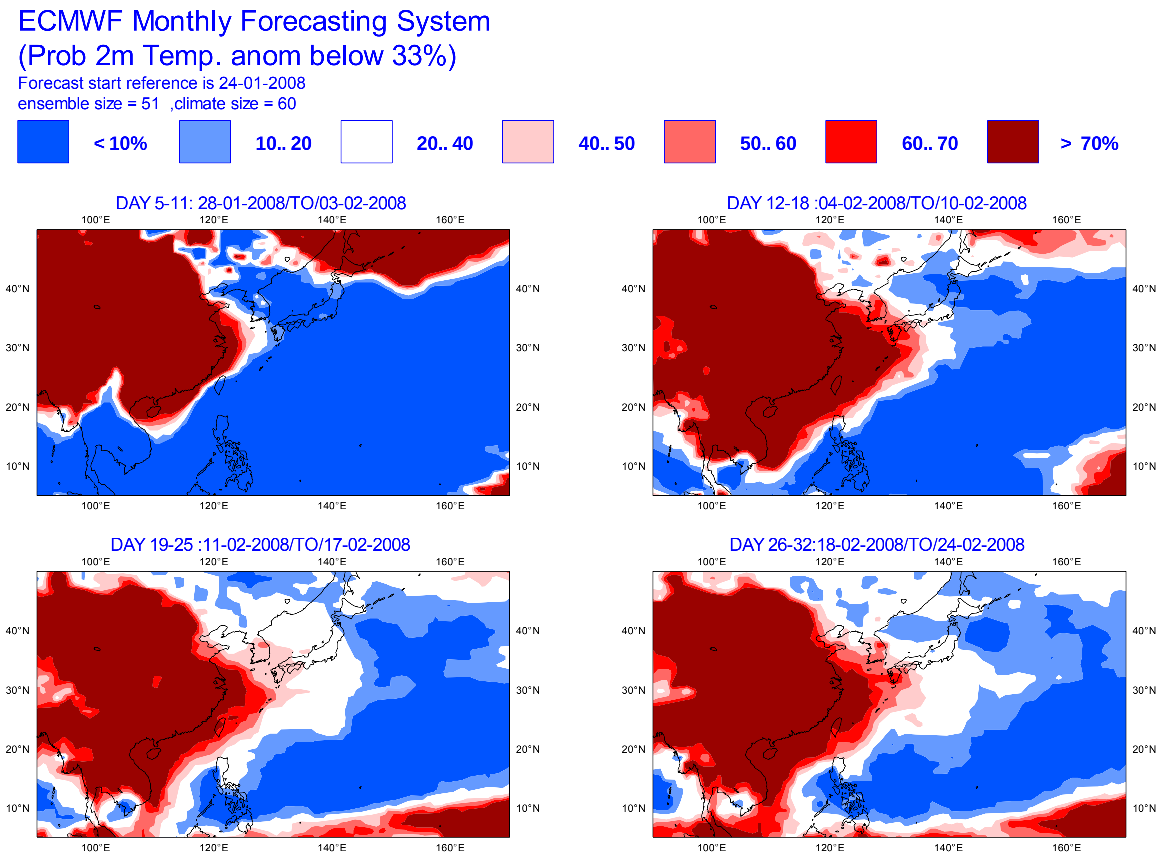


Fig.1 Probability of 2m temperature anomalies predicted by the monthly forecast being below normal (lower tercile of model climate). Each panel represents one seven-day period.

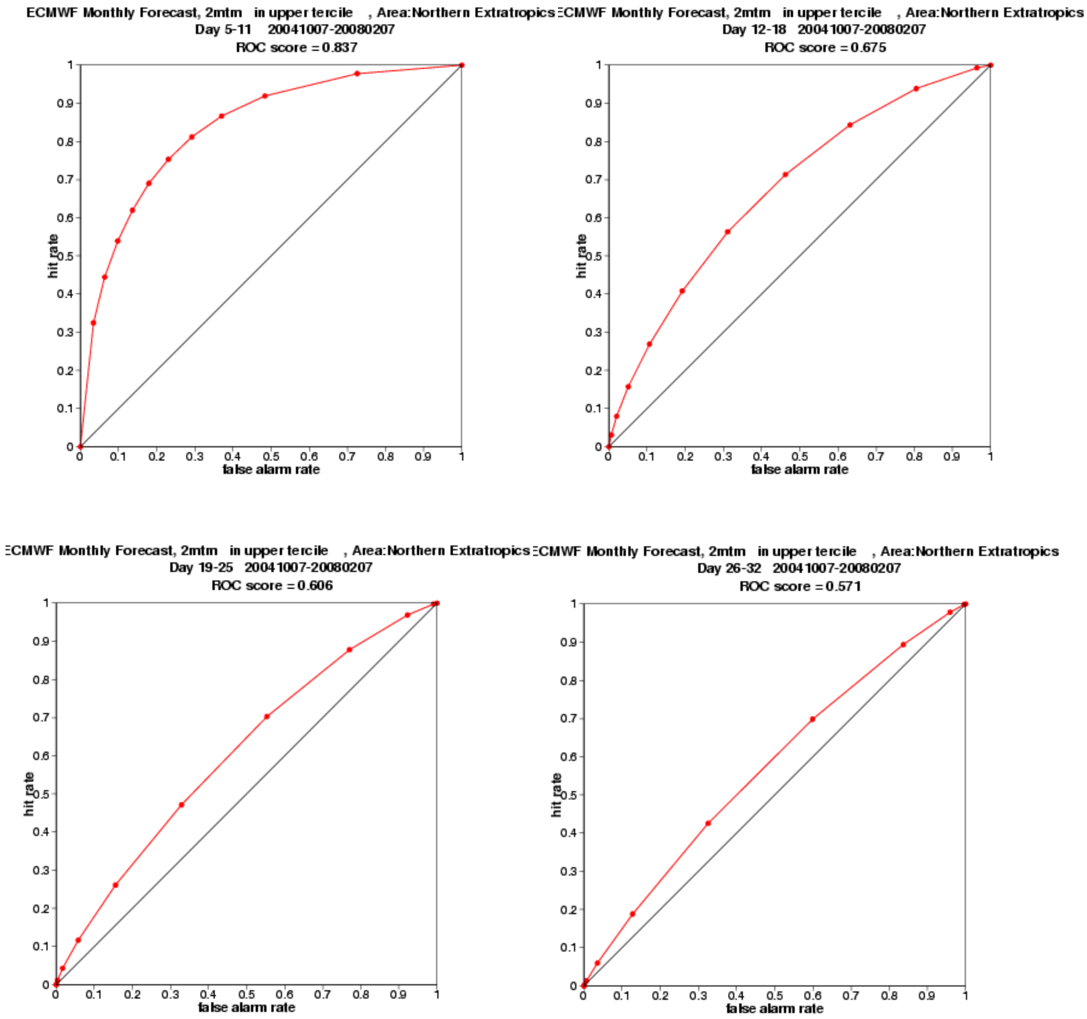
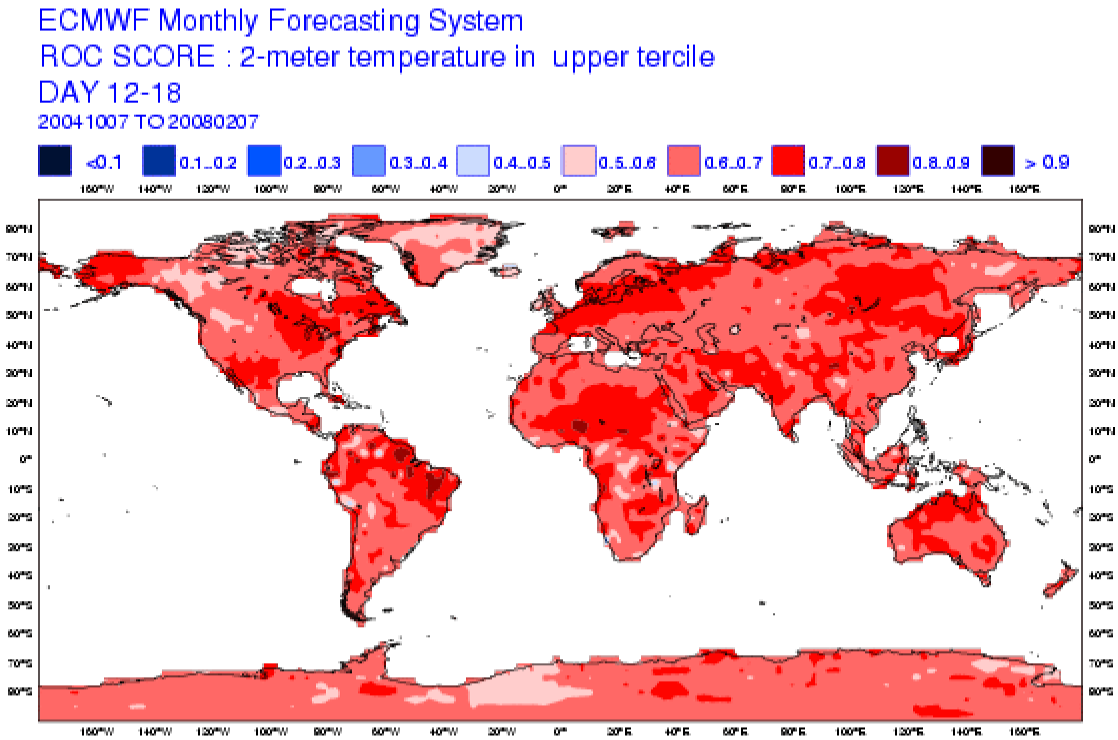


Figure 2 ROC diagrams of the probability that the weekly mean
2m temperature is in the upper tercile. The diagrams have been calculated over all the grid points over the northern extra-tropics (north of 30°N).



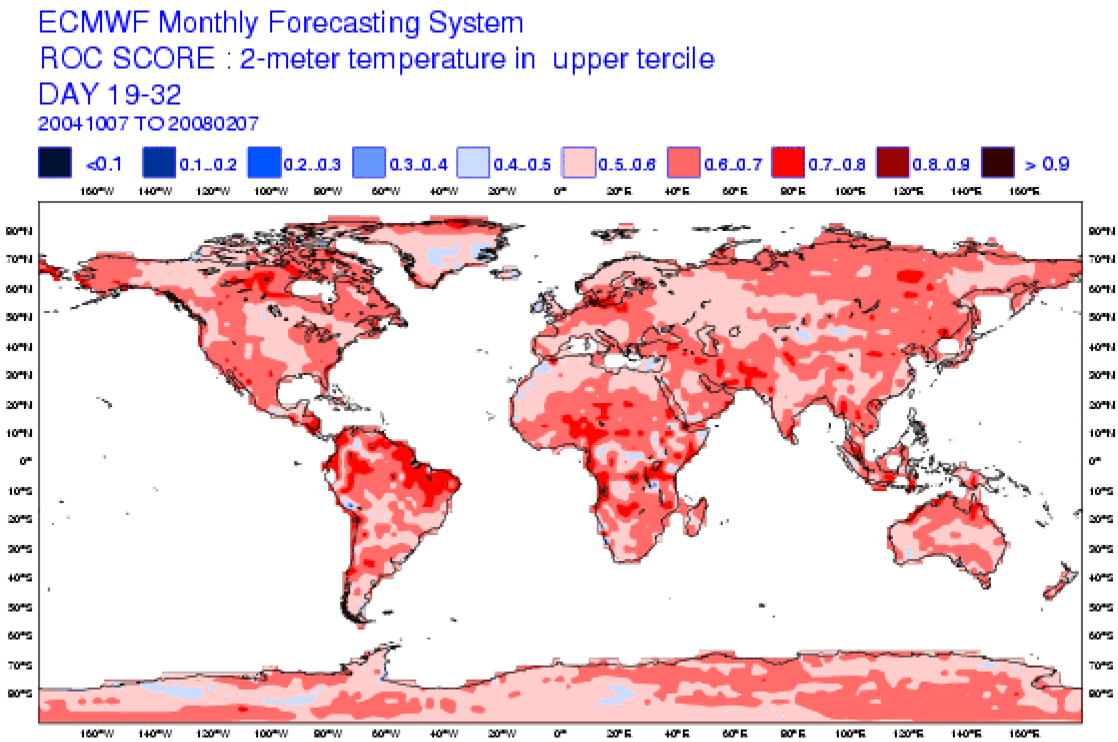


Figure 3 Map of ROC scores of the probability that the 2m temperature is in the upper tercile (defined from the model climatology) for days 12-18 and 19-32. The red corresponds to ROC scores higher than 0.5 (better than climatology) and the blue corresponds to ROC scores lower than 0.5 (worse than climatology).

Further Reading:

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ANNEX TO PARAGRAPH 7.4

Status of the Lead Centre for the Long Range Forecast Verification System
Website: http://www.bom.gov.au/wmo/lrfvs

April 2008

Submitted by Lead Centre co-hosts:
WMC Melbourne/Australian Bureau of Meteorology
RSMC Montreal/Meteorological Service of Canada

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With assistance from Dr Andrew Watkins and Dr Lynette Bettio

1. Introduction and background

The Standardized Verification System (SVS) for Long-Range Forecasts (LRF) defined in the WMO Manual on the Global Data-Processing System (GDPS), Volume I (SVSLRF) outlined requirements for Global Producing Centres (GPCs) to verify their forecasts. The document also outlines how a Lead Centre for the Long Range Forecast Verification System may assist GPCs in the verification process.

At a subsequent meeting of the Lead Centre in Montreal Canada, 1-5 December 2003, agreement was made on a division of duties between WMC Melbourne and RSMC Montreal for the development of the Lead Centre activities. In this endeavour the WMC Melbourne and RSMC Canada have worked in close co-operation.

The Lead Centre has been fully function for about 2 years and is now running robustly. Both Level 1 and Level 2 products are widely available, though no progress has been made on Level 3 products to date.

2. Lead Centre role

The role of the Lead Centre, and the division of responsibilities, are outlined in the table below.

Role	Responsibility
To develop and maintain the SVSLRF web site.	WMC Melbourne and RSMC Montreal
To host the SVSRLF web site.	WMC Melbourne
To develop the structure of the SVSLRF web site (HTML code, etc.).	WMC Melbourne
To provide access to verification datasets on the SVSLRF web site.	RSMC Montreal
To update the verification datasets on the SVSLRF web site on a yearly basis provided that new data is made available.	RSMC Montreal
To develop and provide specifications defining the format of the data to be sent to the Lead Centre for graphics preparation. To develop infrastructure to generate all graphics posted on the SVSLRF web site.	WMC Melbourne
To make available on the web site the digital verification information as specified at levels 1, 2 and 3 in Attachment II.9 of the Manual on GDPS. This implies that a structured database will be developed to store digital verification results.	WMC Melbourne

To ensure that clear and concise documentation explaining the verification scores, graphics and data is available and maintained up-to-date on the SVSLRF web site.	RSMC Montreal and WMC Melbourne
To consult with the GPCs to make sure that the verification data is correctly displayed before making available their verification results on the SVSLRF web site.	WMC Melbourne and RSMC Montreal
To ensure that the verification results placed on the SVSLRF web site comes from officially recognized global producing centres with operational guidance commitments.	WMC Melbourne and RSMC Montreal
To provide and maintain software to calculate the verification scores (ROC curves, ROC score, MSSS, contingency table scores, hit rates…)..	RSMC Montreal
To ensure that appropriate hypertext links to participating GPCs are available on the SVSLRF web site.	WMC Melbourne and RSMC Montreal
To publicise the SVSLRF web site to other organizations involved in verification (such as WGSIP, COLA etc.) and establish contacts in order to receive feedback and facilitate discussion for further development and improvement.	WMC Melbourne and RSMC Montreal
Once the SVSLRF web site is operational, to provide progress reports every two years to CBS, prior to its meetings.	WMC Melbourne and RSMC Montreal

3. Progress of the Lead Centre

The Lead Centre is pleased to report that the web site, the software and the datasets are all running robustly with no problems.

3.1 As of March 27 2008, a total of 9 GPCs plus the IRI have submitted verification results to the Lead Centre.
The following GPCs had submitted all the required scores of the levels 1 and 2 of the exchange (although no organisation has submitted results for all variables, for all seasons for all lead times):

- BCC, JMA, Météo-France, NCEP and MSC;
- UKMO had submitted almost everything (except maps of MSSS and its decomposition terms);
- BOM had submitted everything at all lead times but ROC area maps and the diagrams (ROC or reliability diagram) because an ensemble run in hindcast mode has only recently been completed;
- KMA had submitted just the maps associated with the MSSS and its decomposition maps;
- ECMWF had submitted to the SVSLRF web site just the aggregated scores (level 1). The rest of the scores are on their web site;
- IRI (not yet a GPC) had submitted everything but the level 2 maps (ROC area, MSSS, etc.);
- In addition, Russia has recently submitted level 1 results, which have been graphed and are sitting under Test. These results are ready to be moved to sit under their name upon approval of their organisation and the Expert Team; and
- Brazil has submitted MSSS and decomposition maps for precipitation and T2m for DJF but due to a formatting problem these have not been graphed.

The GPCs that have not submitted all the required levels 1 and 2 data are invited to do so as soon as possible. The Lead Centre of SVSLRF will appreciate to receive new relevant data from the official GPCs.

3.2 At the last meeting in Reading (April 2006) an additional action was assigned by the ET to the Lead Centre concerning the development of software and graphical display of confidence level information. The Lead Centre Montreal has made little progress on this task. Simon Mason member of the ET has provided software to calculate confidence interval using bootstrapping technique and more testing is needed before using it in the exchange. Once this development work will be done the guidelines included in the appendix II.8 will be updated. The Lead Centre Melbourne has been developing additional graphing programs to display this data once available. At this stage this is envisaged as cross-hatching or stippling of statistically significant areas, though this is something that will be adapted and/or refined with instruction from the ET.

Datasets on a standard 2.5° x 2.5° grid, in GRIB1 format, are provided for the precipitation data of GPCP (NASA) Huffman et. Al., (1997), the surface air temperature data of Jones et. Al., (1999) (CRU) and Simmons and Gibson (2000) (ERA40) and sea surface temperature data from Reynolds et. al., (2002) and Smith and Reynolds (2003).

The Reynolds et al., (2002), Huffman et al. (1997) and Jones et. al., (1999) are listed as the preferred datasets. Brief descriptions, and links to the original source data and source institution, are provided on the Lead Centre web site.

Software provided by the Lead Centre includes subroutines for calculating Relative Operating Characteristics ROC scores, Reliability Diagrams and Mean Square Skill Scores (MSSS). The Lead Centre web site also offers detailed descriptions of each of these scores to further their understanding.

The Lead Centre web site also offers a users guide, which aims to make the requirements of the SVS-LRF as clear as possible, as well as attempting to guide the users through the process of verifying their results. This is complimentary to the official Manual, and users are advised to consult the Manual during their assessment.

The Lead Centre also defines standard formats and filenames for the submission of verification data to the Lead Centre. This is done so as the data can be easily and efficiently plotted by the Lead Centre. Considerable time and effort has gone into producing a suite of scripts and programs which can automatically plot up the verification results submitted to the Lead Centre, with minimal human intervention and thus minimal cost. Plots have been produced using the "GRaDS" software from the Centre for Ocean-Land-Atmosphere studies to enable ease of transfer to other institutions if required. Data submitted to the Lead Centre will be placed in a structured format to allow ease of future access.

To view the resulting maps, diagrams (e.g., Reliability curve) and contingency table scores, a viewing page has been developed as part of the Lead Centre web site. The verification maps page, at http://www.bom.gov.au/cgi-bin/climate/wmo.cgi , has been developed to respond to users selections. For example, if one selects "maps" then the remaining options are applicable for maps only; selections relevant to "diagrams", for instance, are not shown.

Feedback to the Lead Centre is always welcomed. The Lead Centre may be contacted via the email address: lrfvs@bom.gov.au

The Lead Centre would like to acknowledge the considerable efforts and assistance of Dr Lynette Bettio (Australia) and Mr. Benoit Archambault (Canada).

4. The Future of the Lead Centre

It is the belief of the WMC Melbourne and RSMC Canada that the Lead Centre continues to provide a valuable role. In addition, the centre is fairly robust and requires rather little ongoing maintenance to support. It is suggested that the current structure continue for the time being, with review recommended in the next 1 to 2 years – particularly in relation to how the Lead Centre interacts and overlaps with possible Lead Centres for MME.

No progress has been made on the provision of Level 3 verification (contingency tables at grid points). It is the view of the Lead Centre that this level of information is essentially overwhelming and provides little value but comes at a high computing cost. It is suggested that the ET reconsider the value and desirability of Level 3 verification products.

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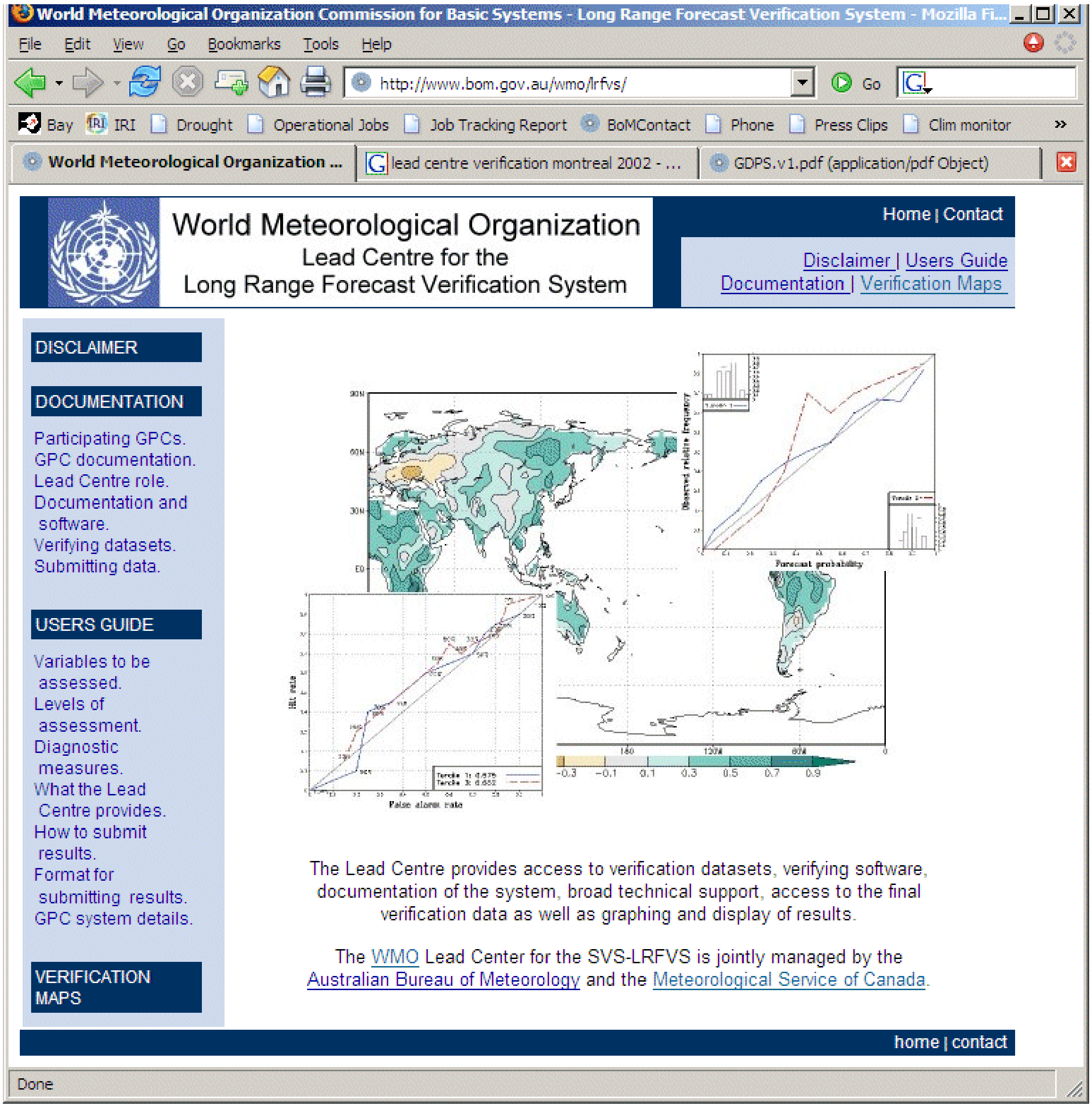

Figure 1: ***The Lead Centre for the Long Range Forecast Verification System: http://www.bom.gov.au/wmo/lrfvs***

ANNEX TO PARAGRAPH 7.4.3

Proposed framework for verification scores

(by Simon Mason, IRI)

Noting some of the conclusions and recommendations of CBS Expert Meetings, CBS Session and Workshops and on LRF, this document presents a proposed framework for defining a comprehensive suite of verification scores. The framework is designed to address the need for a set of scores that can be used to provide an initial indication of whether the model predictions contain any useful information, and is sufficiently flexible to be applicable to virtually all target variables and forecast formats.

DISCUSSION

1. There are numerous reasons for presenting verification information pertaining to ERF and LRF products, and since each verification score addresses different attributes of forecast quality, it is important to consider the precise objective of verification information when recommending specific scores. The current SVSLRF goes a long way towards addressing the needs of model developers whose interest is in identifying strengths and weaknesses of the models, but it is arguably less useful for users who need to address the question of to what extent the model prediction should be believed so as to translate the model output into an official forecast.

2. Typically, the user will have two options for using GPC products in constructing a forecast:

- (a) A map showing the current model prediction, together with graphical SVSLRF products illustrating the quality of the model's hindcasts;
- (b) Access to model hindcasts that are then downscaled using some form of MOS.

In both cases the primary question that the SVSLRF needs to address is: Is there any useful information in the model? Perhaps more specifically, the user will want to know whether any signal in the model can be believed – if the model is predicting unusually dry conditions, can we expect unusually dry conditions to occur. In technical terms, the resolution of the forecasts is the primary characteristic of interest.

3. Given this interest in the resolution of the model predictions, it is important to consider more specifically how this information might be used. In the case of the user who has access only to the graphical products (information "a" as defined above), the user may consider the ensemble mean prediction as well as a probabilistic forecast, but unless they are using only one GPC model, they will invariably not take the reliability of the model at face value; i.e., while the probability indicated for the current forecast will be used as an indication of the strength of the model signal, the user will have their own scheme for defining the probability to assign to their own forecast. The user's probability is largely a "degree of belief", and thus conforms to the "subjective interpretation" of probability. Since the user has to consider issues of downscaling, and the fact that different sources of information may be accessible each time a new forecast is made, this subjective approach is entirely appropriate. The point is that while the reliability of the GPC model is of course important, it is much less important than the resolution of the model: the user is primarily interested in whether the sign of the anomaly can be believed. That is the point of departure, and more sophisticated users may want to have further information about reliability. However, it is helpful to separate measures of reliability and resolution, and the resolution of the model is the first question of interest.

4. In the case of the user who can get access to the model hindcasts and is intending to conduct some form of MOS correction (information 'b" as defined above), again resolution will be the primary attribute of interest. The model is going to be recalibrated anyway, and so the reliability is effectively irrelevant. If the model has no resolution, then it has no useful information that can be exploited to construct anything but a climatological forecast (excepting of course that the spatial correction that may be considered in the MOS identifies a useful signal).

5. Scores that show reliability and resolution will therefore be ambiguous: is a moderately good score a result of good resolution and poor reliability or of poor resolution and good reliability?

6. Another consideration is that target variables of forecasts can be in a wide range of different formats. These formats range from binary outcomes (e.g., will a tropical cyclone hit land during the target period?), polychotomous outcomes (i.e., three or more categories; e.g., will temperature be above-normal? note that the categories are probably ordinal, but are not necessarily so), continuous (e.g., how much rainfall will there be?), circular (i.e., as used to measure wind direction or calendar dates; e.g., when will the rainy season commence?), or even as a probability distribution (e.g., to represent the observation uncertainty in a precipitation measurement). Most of the SVSLRF scores are well-designed for the binary outcomes and the continuous values (as long as the values are Gaussian), but do not address the other possibilities adequately. In addition, totally distinct sets of scores are presented for the different formats, and so there is no means of comparing the quality of an ensemble mean from one model with a probabilistic forecast for three categories from another. (Bear in mind that at the Regional Climate Outlook Forums, for example, the access to GPC products is often highly limited.)

7. As indicated above, the forecasts themselves can take different formats, and these formats do not necessarily match the format of the observation. For example, it is perfectly reasonable to forecast a binary variable using more than two categories, since each of the forecast categories could represent a degree of belief. Probabilistic forecasts of binary outcomes, for example, are not restricted to probabilities of 0% and 100% only. Comparing the quality of forecasts for different formats can be complicated if a consistent set of verification scores is not used.

8. Finally, it is helpful to have a score that has an intuitive scaling. Most scores are affected by the base rate, and so some form of standardization is helpful. Many verification experts seem to prefer skill scores as a means of standardizing scores. On a skill score, forecasts with no skill have a score of 0, a perfect set of forecasts has a score of 1, and bad forecasts have negative scores. Unfortunately, most of these skill scores have some undesirable properties. A primary concern is that many of them are not strictly proper (e.g., the Brier skill score). An additional problem is that in many cases the skill score does not have a lower limit of negative one. In this case one could not then compare a score of -0.5 with one of 0.5 and conclude that the negative of the forecasts with the negative score have the same quality as the forecasts with the positive score. An additional minor consideration is that most non-verification experts expect scores to exceed 50%, not 0%, if the forecasts are good.

9. In summary, what is needed is a set of verification scores that have the following characteristics:

i. Measure forecast resolution;

ii. Can be applied to a wide range of target variables and forecast formats;

iii. Can be used to compare the quality of forecasts of the same target variable yet which may be presented in different formats;

iv. Have an intuitive scaling, and are generally easy to understand.

In both cases the primary question that the SVSLRF needs to address is: Is there any useful information in the model? Perhaps more specifically, the user will want to know whether any signal in the model can be believed – if the model is predicting unusually dry conditions, can we expect unusually dry conditions to occur. In technical terms, the resolution of the forecasts is the primary characteristic of interest.

10. It is proposed that the two-alternative forced choice (2AFC) test be used as a generic test for defining a set of verification scores that address all of the issues above. The 2AFC test addresses the question of whether the forecast can be used to successfully discriminate observations. In the simplest case of binary outcomes, it measures the probability with which the forecast can successfully discriminate an event from a non-event (regardless of whether the forecasts are binary, polychotomous, continuous, or probability distributions). In these cases the test is equivalent to calculating the area beneath the relative operating characteristics (ROC) curve. In the case of polychotomous outcomes, the 2AFC test measures the ability of the forecasts to successfully discriminate the observation in the higher category from the one in the lower category. The 2AFC test then becomes equivalent to a test called Somer's delta, which is a relatively poorly known adaptation of Kendall's correlation suitable for cases in which some of the observations are tied. If the forecasts are measured on a continuous scale, the 2AFC test measures the ability of the forecasts to successfully identify the case with the higher value. In this case the score becomes equivalent to Kendall's correlation.

11. Full details of the proposed scores have been presented in an annex attached to the original document and it has been submitted to Monthly Weather Review.