WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

EXPERT TEAM MEETING ON INFRASTRUCTURE FOR LONG-RANGE FORECASTING

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INPUT TO ICTT ON CC, ON THE ESTABLISMENT OF APPROPRIATE OPERATIONAL INFRASTRUCTURE FOR THE PRODUCTION AND EXCHANGE OF LRF

(Submitted by the Secretariat)

Summary and purpose of document

This document was submitted to the ICTT on RCCs and has been given here as background information to participants who may not be aware of the capabilities of current major operational GDPS and other Centres.

Action proposed

The Team is invited to make its recommendations taking into account the proposals submitted in this document.

EXISTING CAPABILITIE OF RELEVANT GDPS CENTERS FOR GENERATION OF LONG-RANGE FORECAST (LRF) PRODUCTS

1. WMC/RSMC Melbourne (Australia)

Long-range Forecasts (30 DAYS - 2 YEARS):

A three-month rainfall seasonal climate outlook is prepared. Each month, a risk-assessment for three-month total rainfall across Australia is issued mid-month for the three-month period starting the following month. Probabilities are calculated for the three-month total rainfall being in the lowest one-third of historical falls (tercile 1), the middle one-third (tercile 2), and the upper one-third (tercile 3). The technique used is discriminant analysis, with the inputs being derived from recent Sea Surface Temperature (SST) patterns. Subsidiary techniques involved in the forecast model include principal component analysis of SSTs for the Pacific Ocean, Indian Ocean and Southern Ocean, and principal component analysis of rainfall patterns across Australia. SST EOF (Empirical Orthogonal Function) loadings, at one and three months lag, for the Pacific Ocean ENSO pattern and the Indian Ocean pattern are the current predictor inputs. The tercile probabilities, computed across Australia on a 1^0x1^0 grid are published in the form of contoured maps, tabulated averages for the 107 Australian rainfall districts, and tabulated interpolations for cities and towns around Australia. Similar outlooks are now provided for above/below median and for both maximum and minimum temperatures.

Additional guidance at the rainfall district level is presented in the form of stratified rainfall climatologies based on recent values of the SOI (Southern Oscillation Index). Rainfall outcomes for eastern Australia, obtained from SOI analogues, are also described.

Additional forecasts for NINO3 are provided based on an intermediate coupled atmosphere-ocean with sub-surface ocean temperature assimilation. A coupled atmosphere-ocean GCM (General Circulation Model) combined with a sub-surface ocean temperature data assimilation system has been developed and is currently being used to routinely provide forecasts which are currently being assessed.

2. RSMC Montreal (Canada)

Extended range forecasts (10-30 days)

2.1 Ten-day temperature anomaly forecasts (Verret *et al.* 1998) are generated once a day and fifteen-day temperature anomaly forecasts once a week using a perfect prog approach from the medium-range model described at section 7.2.2.

2.2 Monthly temperature forecasts based on numerical weather prediction techniques, are issued at the beginning and mid-month of every month. An ensemble of 5 runs, obtained from 24-hour time lag, is produced. The model used is very similar to the former operational spectral global model (Ritchie, 1991), except it has lower horizontal resolution (T63 L23) and has evolving geophysical forcing: the anomalies (analysis-climatology) of sea surface temperature (SST) and snow, observed during the previous 30 days, are added to the daily climatology during the integration. Direct model surface temperature outputs ensemble means are averaged over the 30-

day period and subtracted from model climatology obtained from a 26-year hindcast period (see section 7.6). These temperature anomalies are then normalised by the model standard deviation multiplied by .43 (to get equiprobable classes) and categorised in above, below and normal classes. Charts are produced, showing above normal, below normal and near normal temperature categories. Monthly forecast products are on the following Web address:

(http://www.cmc.ec.gc.ca/climate/htmletc/m_fcst-e.html).

Long-range forecasts (seasonal forecasts)

2.3 Seasonal forecasts are issued 4 times a year (at the beginning of March, June, September and December). Seasonal products are distributed internationally and nationally through Internet (address http://www.cmc.ec.gc.ca/~cmcdev/saisons/seasons.html on the Web). They are also distributed nationally on the National Telecommunications System and to selected users by facsimile and made available on electronic bulletin boards. The charts are accompanied by a verification chart giving the performance of the forecast over the hindcast period. Also, verification charts, showing the previous season's prediction and a preliminary analysis of the observed anomaly, are provided.

Season 1 forecasts (zero lead time)

2.4 Season 1 forecasts are produced using a numerical approach (Derome *et al.,* 2000). Two ensembles of 6 runs, obtained from 24-hour time lag, are produced: 6 from the T63 L23 model described in section 7.5, 6 from a general circulation model (GCM) (McFarlane *et al.,* 1992) (T32 L10). Both models use the same initial operational analyses. SST anomalies, that have been observed over the previous 30 days, are added to climatological values over the period; snow is relaxed towards climatology at the end of the first month, except for the GCM, where it is a prognostic variable. A simple statistical linear regression equations relates the 1000-500 hPa thickness anomalies (forecast minus model climatology) to surface temperature anomalies, using regression coefficients for 90-day forecasts. Maps are similar to monthly ones: 3 classes, separated using the .43 standard deviation of observed climatology.

2.5 The precipitation forecast is produced using a more direct approach: the two ensemble means of forecast precipitation are subtracted from their respective models' climatologies, and normalised by models' standard deviations. These normalised forecasts are then added, divided by two and used to produce a map, categorised in 3 classes, using the .43 value for separation.

2.6 Skill maps of temperature and precipitation, as obtained over the 26 years of historical runs, are shown for each of the 4 seasonal forecasts periods.

Season 2, 3 and 4 forecasts

2.7 Seasonal forecasts at lead time of 3, 6 and 9 months are produced, using a Canonical Correlation Analysis technique (Shabbar and Barnston, 1996). The technique uses the SST anomalies observed over the last year to predict temperature and precipitation anomalies at Canadian stations (51 for temperatures, 69 for precipitation) for the following 3 seasons. Maps of above, normal and below temperature and precipitation are produced. These are accompanied by skill maps, as obtained from cross-validation over a 40-year period.

3. NMC/RSMC Toulouse (France)

Long range forecasts (3 months)

A specific version of ARPEGE model , called ARPEGE-Climat is used 3 times a month to run 125 days forecasts, starting from ARPEGE assimilation. The seasonal is using mainly the same ARPEGE software as short range forecast model, except the following points:

resolution, time step: This version of the ARPEGE model has a triangular truncature T63 without stretching. The collocation grid has 128x64 points with a reduction near the poles; it has 31 vertical levels like IFS model during ERA-15 ECMWF reanalysis. The time step is 1800 seconds.

radiation: Fouquart Morcrette scheme (1995)

clouds, vertical diffusion, stratified precipitations: Ricard Royer statistical scheme (1993).

4. RSMC Tokyo (Japan)

Long-range forecasting system

4.1 JMA started the operation of a coupled ocean-atmospheric model in 1998 for the outlook of El Niño and La Niña. The oceanic part of the coupled model is identical to the model for ODAS. The atmospheric part of the model is a lower resolution (T42) version of the previous operational global spectral model that was used until February 1996. In August 1999, JMA started to issue the monthly ENSO outlook based on the model results for end users. JMA makes the model results available through the DDB of JMA.

5. RSMC Pretoria (South Africa)

Extended range forecasts (10 to 30 days)

5.1 Two GCMs are used at the SAWB for monthly forecasting. The T30 version of the Center for Ocean-Land-Atmosphere Studies (COLA) GCM (COLA T30) is used for 30-day forecasts and the T62 version of the National Centers for Environmental Prediction (NCEP) GCM, implemented locally as the Global Spectral Model (GSM T62), is used for daily 14-day forecasts.

5.2 The GSM T62 model is used operationally at NCEP for global medium-range forecasts. Prognostic variables are represented by spherical harmonics of legendre polynomials with triangular truncation at wave number 62. This corresponds to a horizontal grid of 192 by 94 points, about 200 km. The vertical coordinate consists of 28 unevenly spaced sigma levels. Physical processes included in the model are deep and shallow convection, large-scale precipitation, radiation, surface physics, vertical diffusion and gravity wave drag.

5.3 The COLA T30 model is a spectral model with triangular truncation at wave number 30. This corresponds to a horizontal Gaussian grid of 96 by 48 points, roughly 400 km resolution. Physical processes included in this GCM are similar to those of the GSM T62 GCM. A simple biosphere model is also included to enable the model to be used for climatological studies. Data processed in this part of the model are deep soil temperature, ground temperature, canopy temperature, soil moisture, liquid water storage, latest computed precipitation, roughness, maximum mixing length and sea-ice temperature. This model is used mainly to study ocean-atmosphere processes.

5.4 Real-time initial conditions for GCM runs are available from the operational GDAS at the SAWB. Boundary condition data for the GCMs, including SSTs, snow and ice cover, are collected in re al-time from NCEP via the Internet and prepared for each model.

Long-range forecasts (seasonal)

5.5 Statistically-based techniques are used to study the variability and predictability of South African summer rainfall and temperature. These include Canonical Correlation Analysis (CCA) and Optimal Climate Normals (OCN). In the case of CCA, the country is divided into homogeneous regions on the basis of the inter-annual rainfall variability. Canonical variants are then used to make 3-month aggregate precipitation forecasts for South Africa from global-scale sea-surface temperatures. Four consecutive 3-month mean periods of sea-surface temperatures are used to incorporate evolutionary features as well as steady-state conditions in the global oceans.

5.6 The Optimal Climate Normal (OCN) technique is an empirical method that forecasts a continuation of the long-term trends already in progress. The OCN technique has been used as one of the prediction method in operational seasonal rainfall forecasts at the South African Weather Bureau. Further, sensitivity tests were done to investigate the seasonal temperature predictability over South Africa.

5.7 Furthermore, a multi-tiered method is introduced where the COLA GCM was forced by predicted monthly sea-surface temperatures from a CCA model. Using CCA again, GCM predicted atmospheric fields are down scaled to rainfall over South Africa.

6. RSMC Bracknell (UK)

Extended range forecasts (10 days to 30 days)

6.1 Extended range and experimental seasonal range forecasts (Section 7.6) are produced from the same 4-month-range, 9-member AGCM ensemble integrations forced with persisted Sea Surface Temperature (SST) anomalies. Forecasts are produced weekly on Thursdays.

Model: The HadAM3 climate version of the Met Office's Unified Model (UM Vn4.5) is used (Pope et al. 2000). The resolution used is 2.5^{o} latitude, 3.75^{o} longitude and 19 vertical levels. The timestep is 30 minutes. The model is run in a 9-member ensemble.

Atmospheric initial conditions: Initial conditions for the ensemble are provided by consecutive operational NWP analyses at 6-hour intervals. The first member being initialised with the 00Z analysis each Tuesday and the final member with the 00Z analysis on the following Thursday.

SST and sea-ice forcing: SST anomalies calculated from the Reynolds SST analysis for the 4-week period lagging the initialisation date by 10 days are persisted throughout the integration, updating every 24hrs. SST forcing is the same for all members. Projected changes in sea-ice cover are also represented.

Treatment of land surface variables: Initial conditions for soil moisture, soil temperature and snow cover are taken from climatology. Land surface exchanges are represented using the MOSES scheme (Cox et al. 1999).

Forecast variables: The main forecast variables are mean, maximum and minimum temperature, accumulated precipitation and sunshine amount averaged over three forecast periods; days 4-10, days 11-17 and days 18-31. For each ensemble member, global forecast values are derived from direct averaging of daily model output. For the UK region only, values are also derived using regression equations on the forecast period-averaged PMSL field and observed local SST.

Model calibration: Forecast anomalies are expressed relative to a model climatology defined for each month of the year from a set of integrations initialised at the beginning of each month over the 15-year period 1979-1993.

Forecast formats: Temperature and rainfall forecasts are mainly presented in terms of equi-probable quintile categories; Well Below, Below, Near Normal, Above, Well Above. Tercile categories are used for some forecasts. The forecast is expressed both in terms of the probability of each category and a single deterministic forecast based on the ensemble mean.

Long range forecasts (30 days up to 2 years)

6.2 The model ensemble system used for long (seasonal) range forecasts is identical to that used for extended range forecasts (Section 7.5). The seasonal forecast products are experimental and are available to National Met. Services through a password protected internet site.

Forecast variables: Forecasts are provided for anomalies in 3-month-average 850 hPa temperature (as a proxy for surface temperature) and precipitation. Forecasts at zero lead (months 1-3 of the integration) and 1 month lead (months 2-4 of the integration) are produced.

Model calibration: Forecast anomalies are expressed relative to a model climatology defined for each month of the year from a set of 9-member ensemble integrations initialised at the beginning of each season over the 19-year period 1979-1997. The same set of integrations has been analysed to assess seasonal prediction skill and to generate "skill templates" (see below).

Forecast format: Both probability and deterministic forecasts are produced. For probability forecasts a two category format is used, i.e. probability that the anomaly will be above or below zero (based on the ensemble distribution). For deterministic forecasts the anomaly sign and magnitude is provided (based on the ensemble mean). Products are provided in map format for the globe and a number of regional areas and with optional skill templates, which mask out regions in which the model currently has no significant skill.

7. WMC/RSMC Washington (USA)

7.1. Status of the Global Forecasting System at the End of 1999

Global Forecast System Configuration: The global forecasting system consists of:

a) The final (FNL) Global Data Assimilation System (GDAS), an assimilation cycle with 6-hourly updates and late data cut-off times;

b) The aviation (AVN) analyses and 84-hour forecasts, run at 0000, 0600, 1200, and 1800 UTC with a data cut-off of 2 hours and 45 minutes using the 6-hour forecast from the FNL as the first guess;

c) A once per day 16-day medium-range forecast (MRF) from 0000 UTC using FNL initial conditions and producing high resolution T126 predictions to 7 days and lower-resolution T62 predictions from 7 to 16 days; and

d) Ensembles of global 16-day forecasts from perturbed FNL initial conditions (five forecasts from 1200 UTC, and twelve forecasts from 0000 UTC

Specialized Forecasts

7.2 Specialized forecasts and systems include the following:

a) A Hurricane (HCN) Run is performed when requested by NCEP's Tropical Prediction Center (TPC). The HCN forecast model is the Geophysical Fluid Dynamics Laboratory (GFDL) Hurricane Model (GHM), which is a triply-nested model with resolutions of 1.0, 1/3, and 1/6 degree latitude resolution and 18 vertical levels. The outermost domain extends 75 in the meridional and longitudinal directions. Initial conditions are obtained from the current AVN run. Input parameters for each storm are provided by the TPC and include the latitude and longitude of the storm's center, current storm motion, the central pressure, and radii of 15 m/s and 50 m/s winds. Output from the model consists primarily of forecast track positions and maximum wind speeds but also includes various horizontal fields on pressure surfaces (such as winds and sea-level pressure), and some graphic products such as a swath of maximum wind speeds and total precipitation throughout the 72 hour forecast occurring at each model grid point.

b) A Hawaii run of the Regional Spectral Model (RSM) provides forecasts over the Hawaiian Islands at a very high resolution (10 km) from 00 and 12 UTC out to 48 hours for distribution to Hawaii via FTP (INTERNET). The RSM is identical to the global spectral model used in the AVN, MRF and FNL, except it is run at much higher resolution. Initial conditions for this run are interpolated from the AVN initial conditions. During the post-fire period, the RSM was run on a smaller computer which delayed its output by several hours. It will be moved to the new IBM computer early in 2000. A 10 km nested version of the Eta is being prepared as a replacement for the RSM.

c) An easily reconfigured, multi-platform version of the Eta has been developed and made available (http://sgi62.wwb.noaa.gov:8080/wrkstn_eta/). This system allows a user to run the Eta at his own site on a UNIX/LINUX workstation and provides the ability to download initial and boundary data in real-time from NCEP models.

e) The global WAve Model (WAM) (WAMDI Group, 1988) runs twice daily with AVN forecast forcing on a 2.5 degree grid, and makes global wave height predictions out to 72 hours. A new Global ocean wave forecast model (NOAA WAVEWATCH III, NWW3) will be implemented early in 2000 to be run twice daily on a 1.25 x 1.00 degree latitude/longitude grid from 78N to 78S, producing wave directions, frequencies and heights out to 72 hours (http://polar.wwb.noaa.gov/waves/Welcome.html).

f) Daily global Sea Surface Temperature (SST) analyses are made with an optimum interpolation technique which combines in-situ and satellite observations. Weekly SST analyses derived with this system are used as lower boundary conditions in the global assimilation and forecasts.

g) A storm surge model makes twice daily predictions for the East Coast of the United States out to 48 hours. The model has also been applied to the Gulf of Mexico, Virgin Islands, Puerto Rico, Guam, and Oahu, HI.

h) Wave models are run twice daily to provide sea state forecasts for the Gulf of Mexico and the Gulf of Alaska. Regional models, one covering the western half of the Atlantic Ocean and the Gulf of Mexico and the other covering the Gulf of Alaska and the Bering Sea, based on the new NWW3, have been developed and will be implemented early in 2000 to replace the current models.

i) A once per day forecast of an Ultraviolet Index (UVI) (Long, et al., 1996).

j) A seasonal ensemble climate forecast run consisting of a 20 member ensemble of an atmospheric general circulation model (AGCM). The forecasts are run once per month with 28 levels and a horizontal resolution of approximately 300 km (T42). It produces seasonally averaged forecasts out to 7 months.

k) A sea ice drift model provides guidance for the drift distance and direction over the northern hemisphere, and along the ice edges in both hemispheres. This year the guidance was extended from day 7 out to day 16.

8. RSMC ECMWF

CBS-XII was informed and noted with appreciation that the ECMWF Council decided in December 1999 to make available global seasonal forecasts products to NMHSs of the WMO via its web site subject to obtaining a user ID and password. This ensures NMHSs advance access to the web site before the forecast become public. The twelfth session of the WMO Commission for Basic Systems (December 2000) noted with satisfaction that the 53rd session of the ECMWF Council had approved most of the submitted requirements of WMO for the dissemination of several additional ECMWF products including Ensemble Prediction System (EPS) Products to WMO Members. Information on dissemination of the new products as from 2 May 2001 has been notified to all GTS users. This dissemination by ECMWF of more products in the medium-range including a set of products for the probabilistic forecasting of severe weather in this range will no doubt address needs for such products from ECMWF in its functions as the designated Regional Specialized Meteorological Centre for Medium Range Forecasting.

OTHER CENTRES

9. CENTRO DE PREVISÃO DE TEMPO E ESTUDOS CLIMÁTICOS (CPTEC) INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (INPE) - Brazil

Long-range or seasonal forecast products (1 – 6 months)

(a) Global precipitation anomaly for four three-month periods. (Ex. if the forecasts are issued in January, the three month periods are Jan-Feb-Mar, Feb-Mar-Apr, Mar-Apr-May and Apr-May-June.)
(b) Global precipitation monthly anomaly forecasts for 6 months. Areas with little statistical significance are masked out.
(c) Global mean seasonal surface temperature anomaly for four three-month periods. (Ex. if the forecasts are issued in January, the three month periods are Jan-Feb-Mar, Feb-Mar-Apr, Mar-Apr-May and Apr-May-June.)
(d) Global mean monthly surface temperature anomaly forecasts for 6 months. Areas with little statistical significance are masked out.
(e) Precipitation anomaly evolution forecast for six months for specific critical areas in Brazil (Ex. Northeast Brazil), all members of the ensemble and the ensemble mean.
(f) Same as (e) but for several river basins in Brazil.

User products

9.1 They are of three types: graphical, tabular or textual. Usually a product for an end user is a combination of all the three types. (Ex. A sectorized satellite IR image + Table of weather condition icons for three days + text explaining the predicted significant weather for a region or for selected locations)

(a) Catchment area forecasts (graphical)
(b) Highway meteorological conditions (graphical) forecasts
(c) Agricultural cooperative bulletins (graphical + textual)
(d) Utilities bulletins (graphical, tabular and text)
(e) Civil defense bulletins (severe condition alerts and warnings)
(f) Bulletins for decision makers

Internet products (www.cptec.inpe.br)

Meteorological products

9.2 These are essentially four types: binary fields, charts and graphs in gif format, satellite pictures and textual bulletins.

(a) Satellite pictures derived from NOAA, GOES and METEOSAT satellites. The pictures are of many sizes: subregional, regional, full Disks and GOES+METEOSAT joint pictures covering the region between central Pacific and western Indian Ocean.

- Nocturnal fog detection in satellite imagery (hourly pictures for southeastern Brazil)
- Wind fields in high, middle and low troposphere over SA assessed from GOES imagery (in the process of installation)
- Convective complexes tracking using GOES satellite imagery over SA (in the process of installation)
- TOVS products over SA (temperature at 1000 and 500 hPa, geopotential at 500 hPa, precipitable water, lifted index, OLR) and temperature and dew point profiles

(b) Gridded data (GRIB format) and GIF format forecast maps of rainfall, temperature, winds, humidity at the surface and upper levels and many derived fields such as vorticity and divergence, mostly over the South American region. GIF format maps for the whole globe are also available for Mean Sea Level Pressure, 925 hPa Relative Humidity, 1000 hPa Temperature, 500 hPa – 1000 hPa Thickness, 24- hr accumulated Precipitation.

(c) Meteograms for 315 locations (Brazilian, South American and Global stations) from global model and for 89 locations (Brazil and South America region) from Regional model.

(d) Daily weather bulletins and forecasts (text) for all the regions in Brazil

(e) Model evaluation statistics: (i) Regional model: Monthly mean values of Mean error (Bias) for Pmsl, T850, U850, u and v at 10 m level, Ts, and root mean square error and standard deviation of Pmsl, T850 and U850, (ii) Global Model: Monthly mean values of Mean error (Bias) for Pmsl, T850 and U850, and root mean square error and standard deviation of Pmsl, T850 and U850.

(f) Climate products

- (i) Accumulated rainfall in the last 5, 10 and 30 days
- (ii) Monthly rainfall and anomalies
- (iii) Monthly mean temperature and anomalies
- (iv) Observed SST anomalies in the Equatorial Pacific and Atlantic
- (v) Infoclima
- (vi) Longrange seasonal rainfall and temperature anomaly forecasts (access with password)
- (vii) Forest fire risk maps for Brazil
- (viii) Observed forest fire density maps for South America

(g) Climanálise: Journal reporting the monthly weather and climate information over Brazil and neighborhood and scientific articles.

Environmental products

a) Fire pixel density charts derived from the NOAA (polar orbiting) satellites updated every 8 hours for South America (SA)

b) GOES-8 derived fire pixel density graphs (experimental product) for SA

c) Forest fire risk charts, observed and forecast for SA, updated once a day

d) Vegetation index (NDVI) over SA obtained monthly from NOAA-AVHRR imagery (resolution: 4-6 km)

e) Solar radiation fields (weekly and monthly means) assesses from GOES-8 visible channel (Northeast, South-South-Eastern brazil and South America are being installed.)

f) Sea-surface temperature over Atlantic Ocean near Brazil, assessed from GOES-8 imagery (daily, weekly and monthly fields)

g) Observed soil water storage charts for Northeast Brazil, derived from observed rainfall data, daily, weekly, fortnightly and monthly (experimental product).

Verification of prognostic products

9.2 Global runs

(a) The performance statistics used to evaluate the global model are obtained for four sectors of the globe: Northern Hemisphere (NH, 20N-80N), Southern Hemisphere (SH, 80S-20S), South America (SA, 60S-15N; 100-10W) and Tropical Belt (TB, 20S-20N) for 24, 48, 72, 96, 120, 144 hour forecasts. Anomaly Correlation (or Skill), Mean Error (BIAS) and Root-Mean-Square Error (RMSE) are calculated for geopotential and zonal and meridional wind components at 850, 500 and 250 hPa, for virtual temperature at 1000, 850, 500 and 250 hPa, specific humidity at 925 hPa, surface pressure and precipitable water, for 24, 48, 72, 96, 120, 144 hour forecasts of the 00 and 12 UTC runs.

(i) NH: Skill of geopotential, virtual temperature, mean sea level pressure, precipitable water and specific humidity.
(ii) SH: Skill of geopotential, virtual temperature, mean sea level pressure, precipitable water and specific humidity.
(iii) TB: zonal and meridional wind components at 850, 500 and 250 hPa levels.
(iv) SA: all statistics at all the levels mentioned above.

Fig. 4 shows the yearly mean anomaly correlations of 500 hPa geopotential seasonwise and for NH, SH and SA.

(b) Subjective evaluation of the positions and trajectories of the pressure centers and frontal systems in the South American region for 00 UTC run.

9.3 Regional runs

(i) Equitable threat score for the precipitation forecast for 00 and 12 UTC runs
(ii) Standard deviation
(iii) Monthly mean error (Bias) and RMSE of the prognostics for Pmsl, temperature and humidity at 850 hPa for 00 and 12 UTC runs separately

11.3 Visual comparison of forecasts and observations
(i) Daily precipitation forecast charts for forecast ranges up to 60 hours of both models and the observation chart
(ii) Same as (i) except for monthly accumulated precipitation.

Validation of CPTEC/INPE model

9.4 The use of CPTEC/COLA global atmospheric general circulation model for seasonal prediction is validated by processing a 10-year long run and evaluating the results. The model successfully reproduced the seasonal cycles, the regional climatologies and the interannual climate variability due to low frequency phenomena such as El Niño and La Niña. These results are being reported to the scientific community in the Congresses, Symposia and Workshops and also through specialized scientific journals.