

The use of medium range and seasonal forecast at CPTEC

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BRAZIL**

Thanks to

**Dr. Horst Boettger (ECMWF)
Mr. Antonio Marcos Mendonça
Dr. Caio Coelho**



CENTER FOR WEATHER FORECAST AND CLIMATE STUDIES CPTEC



INPE

**NATIONAL
INSTITUTE FOR
SPACE
RESEARCH**



CPTEC

**MODELING AND
DEVELOPMENT
DIVISION**

**OPERATIONS
DIVISION**

**ENVIRONMENTAL
SATELLITES
APPLICATION
DIVISION**

**CLIMATE AND
ENVIRONMENT
DIVISION**



***GOES, METEOSAT,
NOAA,
Cachoeira Paulista, SP***

***TERRA, ACQUA,
CBERS***

Cuiabá, Mato Grosso

Role of CPTEC in Brazil

- Partnership with other institutions for research and development
- Provide computer services for environmental modeling in general through the National System for High Performance Computing (SINAPAD) – grid computing
- Provide model code for users
- Provide data for users
- Provide training for users

Supercomputing Facilities

Cluster MPP NEC-SUN

1100 processors – 72 TB storage

Supercomputador NEC SX-6

96 processors – 16 TB storage



Operational NWP and NCP at CPTEC

Weather Forecasting Operational Suite:

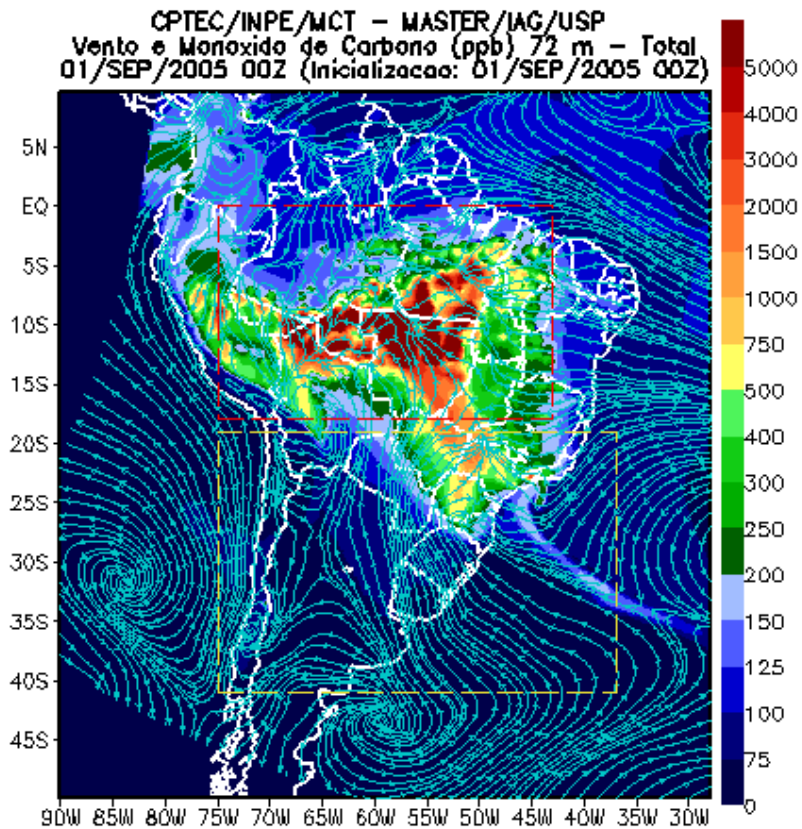
- Global Spectral Model, four times a day
 - T126L28 up to 15 days
 - T213L42 up to 7 days
- Regional Eta Model, two times a day
 - 40kmL38 up to 7 days
 - 20kmL38 up to 7 days
- Global Ensemble, once a day
 - T126L28 up to 15 days, 15 members CPTEC/FSU ensemble principal components scheme

Seasonal Prediction:

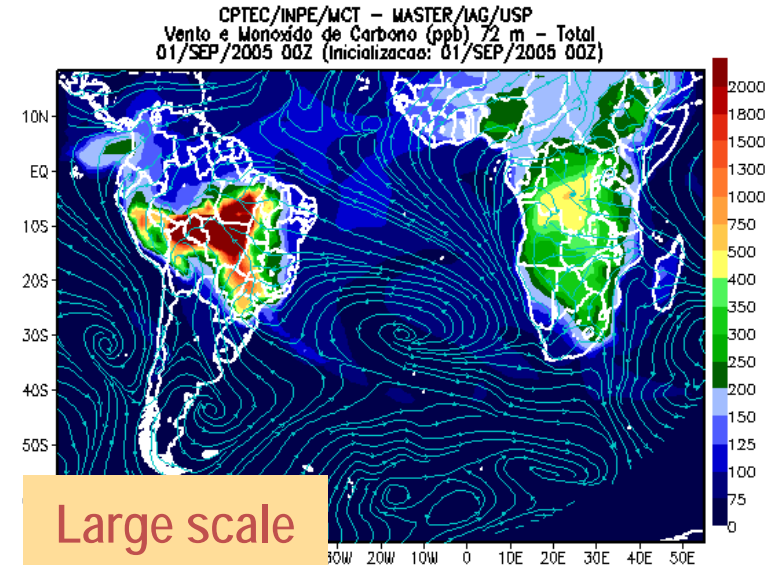
- Global Spectral Model, once a month
 - T062L28 up to 6 months, 30 - 60 members each
- Boundary conditions: Monthly SST persisted anomaly (observed) or predicted (Tropical Atlantic and/or Tropical Pacific)
- Regional Eta Model, once a month
 - 40kmL38 up to 6 months, 1 member each

Environmental model

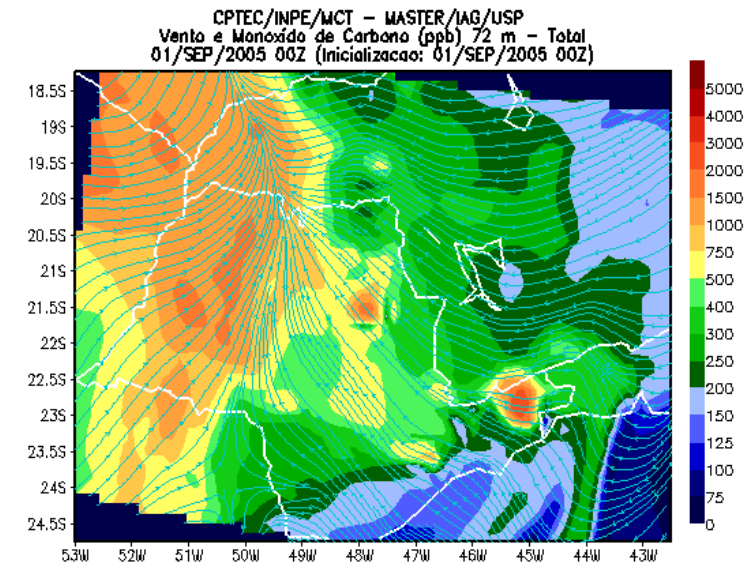
Air pollution due to biomass burning and urban areas



Regional scale



Large scale

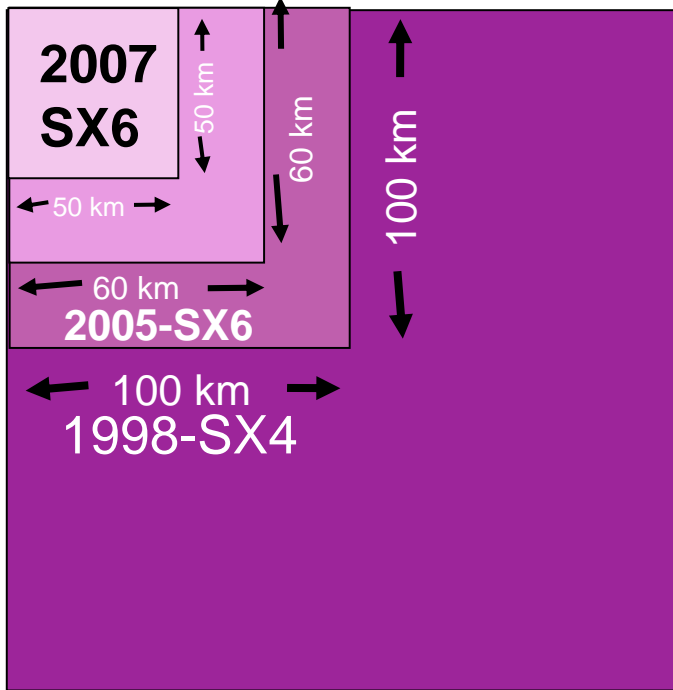


Mega cities



Evolution of the CPTEC Models Resolution

Global

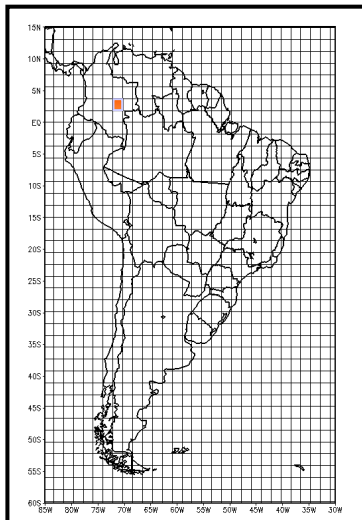


200 km

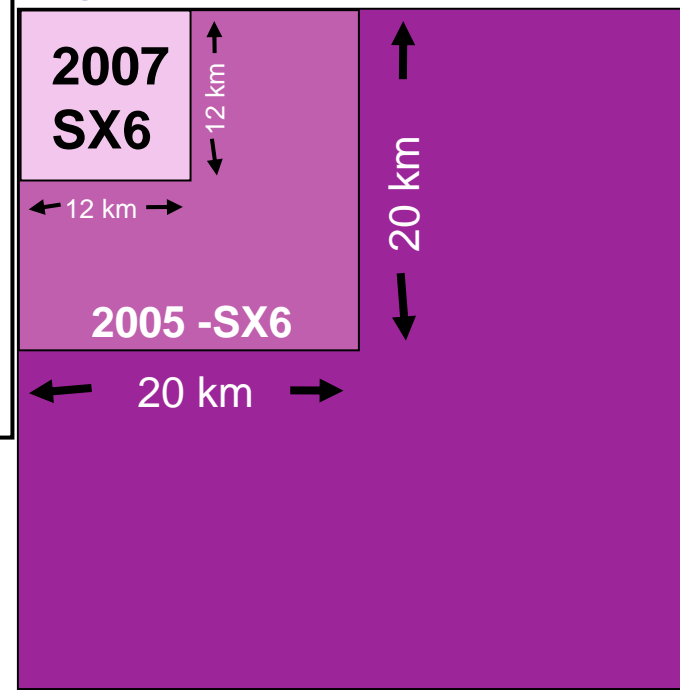
1994-SX3

Number of vertical levels :

1994 - 28
 2005 - 42
 2006 - 64



Regional – ETA



40 km

1996-SX3 and SX4

Number of vertical levels:

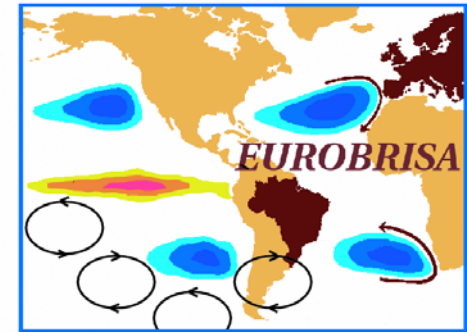
1994 - 38
 2006 - 50

International Programs

- **PIRATA**: Program of Moored Buoys in the Tropical Atlantic
- **LBA**: Large Scale Biosphere Atmosphere Experiment in Amazonia
- **LPB/GEF**: Climate Change and Variability in La Plata Basin – Global Environmental Facility
- **GPM-Brazil** – National Space Programa – Meteorological Mission
- **ThorpeX/TIGGE**: World Meteorological Organization
- **ECMWF**: Ensemble forecasts with ocean atmosphere coupled models

EUROBRISA: An EURO-Brazilian Initiative for improving South American seasonal forecasts

key Idea: To improve seasonal forecasts in S. America: a region where there is seasonal forecast skill and useful value.



Aims

- Strengthen collaboration and promote exchange of expertise and information between European and S. American seasonal forecasters
- Produce improved well-calibrated real-time probabilistic seasonal forecasts for South America (i.e. combine and calibrate coupled [ECMWF, UKMO, Meteo-France] and empirical forecasts)
- Develop real-time forecast products for non-profitable governmental use (e.g. reservoir management, hydropower production, agriculture and health)

Involved institutions	Country	Partners
CPTEC	Brazil	Coelho, Cavalcanti, Costa Silva Dias, Pezzi
ECMWF	EU	Balmaseda, Doblas-Reyes, Stockdale
INMET	Brazil	Moura, Silveira, Lucio
Met Office	UK	Graham, Colman
Météo France	France	Déqué
UFPR	Brazil	Guetter
Uni. of Exeter	UK	Stephenson
Uni. of São Paulo	Brazil	Ambrizzi, Silva Dias

Affiliated institutions

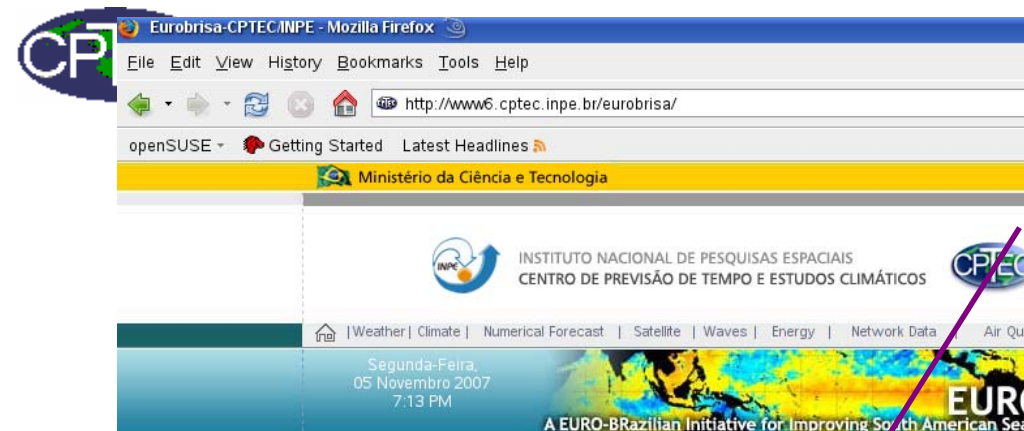
CIIFEN	Ecuador	Camacho
IRI	USA	Goddard
UFRGS	Brazil	Bergamaschi

Climate prediction research and development

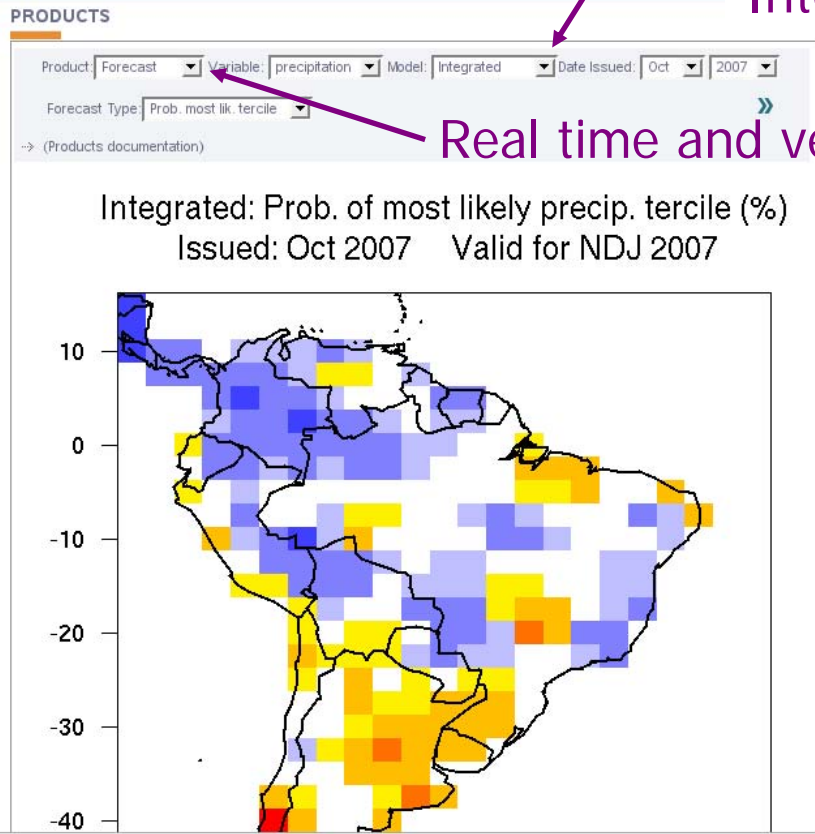
- Probabilistic seasonal forecasts with empirical and dynamical coupled models
- Production of objectively combined (dynamical + empirical) well-calibrated *integrated* forecasts
- Skill assessment of empirical, dynamical and combined forecasts using deterministic and probabilistic measures
- Dynamical and statistical downscaling
- Seasonal predictability studies

Impacts (collaborative work with users)

- Hydrology: Downscaling of seasonal forecasts for river flow predictions and use in hydrological models
- Agriculture: Research on the use of seasonal forecasts in agricultural activities; Downscaling of seasonal forecasts for use in crop models



1-month lead precip. forecasts
EUROSIP: ECMWF
UKMO
Meteo-France
Empirical (SST based)
Integrated (Combined)



Real time and verification products

AIMS

- Strengthen collaboration and promote exchange of expertise and information between European and South American seasonal forecasters
- Produce improved, well-calibrated, real-time probabilistic seasonal forecasts for South America
- Develop real-time forecast products for non-profitable governmental use (e.g. reservoir management, hydropower production, and agriculture).

PROJECT INFORMATION

- History
- Partners

DOCUMENTS

- EUROBRISA project proposal approved by ECMWF council in June 2005: see page 5 of ECMWF newsletter No. 104
- Leverhulme research network proposal
- Powerpoint overview

PRESENTATIONS

- EUROBRISA Integrated System Talk in Portuguese - given at CPTEC and INMET, May 2005
- Summary and Video talk given at CPTEC
- EUROBRISA talk given at CPTEC-INMET-IRI workshop, November 2006
- EUROBRISA poster presented at WCRP workshop on seasonal prediction, Barcelona, 4-7 June 2007

NEWS

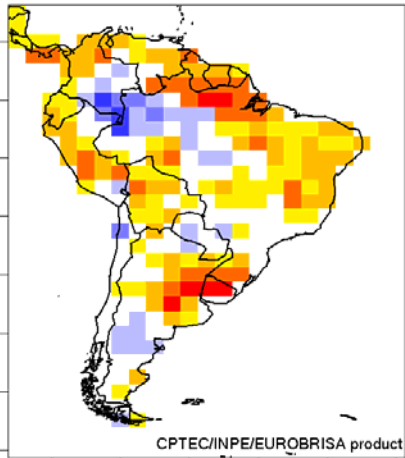
30/10/2007 08:07:52 Real time forecasts and verification products are now available [+]

<http://www6.cptec.inpe.br/eurobrisa/>

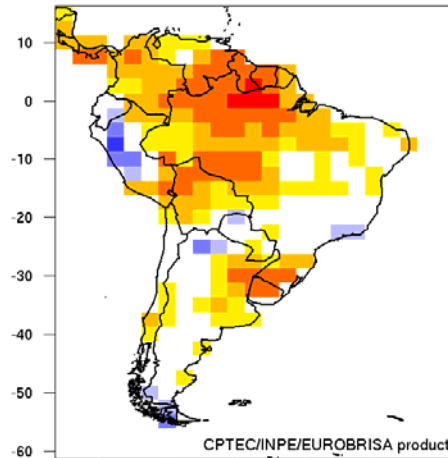
Example of verification product

Correlation maps: NDJ precip. anomalies

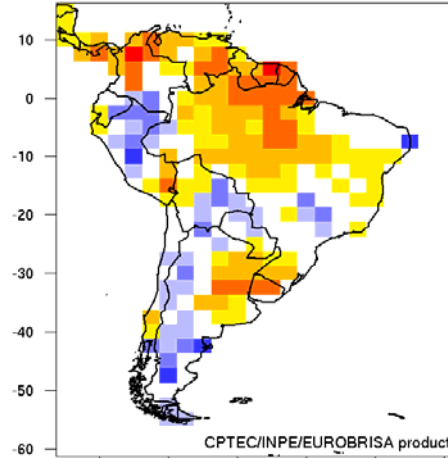
ECMWF



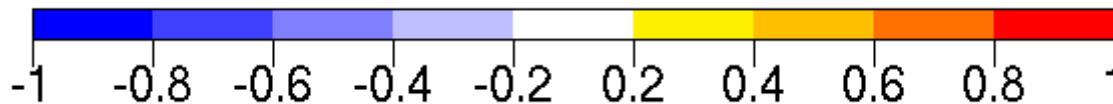
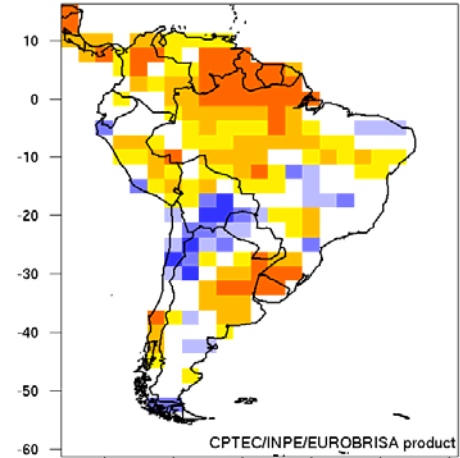
UKMO



Empirical



Integrated



- Hindcast period: 1987-2001
- Coupled models with I.C. 1st Oct (1-month lead for NDJ)
- Empirical model uses Sep SST as predictor for NDJ precip.
- Integrated forecasts (coupled + empirical) with forecast assimilation
(Stephenson et al. 2005)

→ Best skill in tropical and southeast South America

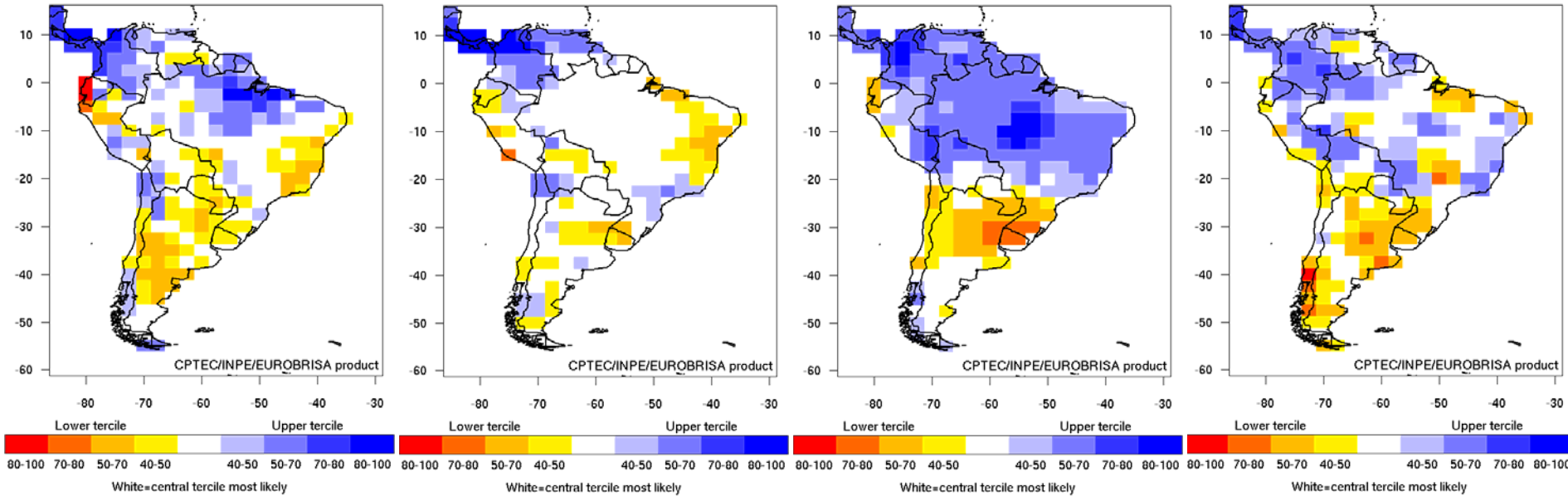
Example of real time product: NDJ 2007 precipitation forecast

ECMWF

UKMO

Empirical

Integrated



Issued: Oct 2007

Most likely tercile category forecast:

upper tercile (wet conditions) in North South America and
lower tercile (dry conditions) in southeast and south
South America



ENSEMBLE WEATHER FORECAST AT CPTEC

Perturbation Method

- It is based on the method developed by Zhang and Krishnamurti (1999) and modified by Coutinho (1999);
- It is supposed that model is perfect;
- A set of perturbed initial conditions are generated using the “EOF-Based Perturbation” method;
- The model is integrated starting from each perturbed initial condition to produce an ensemble forecasting;

- 1) random perturbations are added to control initial condition to generate a random perturbed initial condition;
- 2) the full model is integrated for 36 h starting from the control and from the perturbed initial conditions saving results each 3 h;
- 3) a time series is constructed for the successive differences between forecasts started from the control and perturbed initial conditions;
- 4) an EOF analysis is performed for the time series of difference fields in order to obtain the fastest growing perturbation;
- 5) the eigenmode associated to the largest eigenvalue is considered as the fastest growing mode;
- 6) the fastest growing mode is normalized to pre-fixed amplitudes;
- 7) the “optimum” ensemble of initial conditions is generated by adding (subtracting) this fastest eigenmode to (from) the control analysis;

Ensemble Weather Prediction at CPTEC

Main Features

- Started operationally in October 2001
- Two runs are performed starting from 00 and 12 UTC analysis
- Each run represents a set of 15 forecasts (1 control plus 14 perturbed) up to 15 days
- Domain: Global
- Resolution: T126L28
- Perturbed region: 45S-30N/0-360E
- Perturbed fields: T, U and V;



CPTEC

www.cptec.inpe.br

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:: Outros Links

:: Produtos do CPTEC

 Tempo Previsão de Tempo para todo o país. Boletins por regiões e para as capitais.	 Clima Cond. climáticas para o Brasil e no Mundo, Mapas, gráficos e boletins.	 Previsões Numéricas Previsão Global, Brasil e várias cidades. Previsão Oceânica e Meteogramas.
 Satélite Imagens e produtos de satélite: Global, Brasil e Regional.	 Ondas Previsão Oceânica para cidades litorâneas, Tábua de Marés e Meteogramas.	 Energia Monitoramento de chuva e nível dos rios nas principais bacias do Brasil.
 Observações & Instrumentação Observ. Meteorológicas, hidrometeorológicas, ambientais e PCDs.	 Pesquisa & Desenvolvimento Experimentos de campo, modelagem atmosférica.	 Qualidade do Ar Monitoramento de emissões de poluentes atmosféricos e previsão da qualidade do ar.

:: Notícias

- 28/08/2007 - VII EPGMET - Encontro dos Estudantes de Pós Graduação em Meteorologia do INPE
» [Notícia Completa](#)
 - 28/08/2007 - Parceria com emissora de tevê amplia divulgação das previsões do CPTEC/INPE
» [Notícia Completa](#)
 - 17/08/2007 - Pesquisadora brasileira é eleita vice presidente de organização meteorológica internacional
» [Notícia Completa](#)
 - 09/08/2007 - Monitoramento de Queimadas do INPE conta com maior número de satélites
» [Notícia Completa](#)
- [Veja as Notícias ▶](#)

:: Previsões

Digite o nome da Cidade:

Obs: **Busque cidades com no mínimo 3 letras!**

▶ Cidades	min.	máx.	cond.
São Paulo	18°C	31°C	
Rio de Janeiro	18°C	34°C	
Belo Horizonte	16°C	30°C	

Previsão para: 21/09

▶ **Para o Litoral (12Z)**

Paranaguá-PR	0.8 m	
Rio de Janeiro-RJ	1.5 m	
Santos-SP	0.8 m	

[Previsão Oceânica ▶](#)

:: Produtos Especiais

:: Programas Especiais

ensemble products available

Main Products

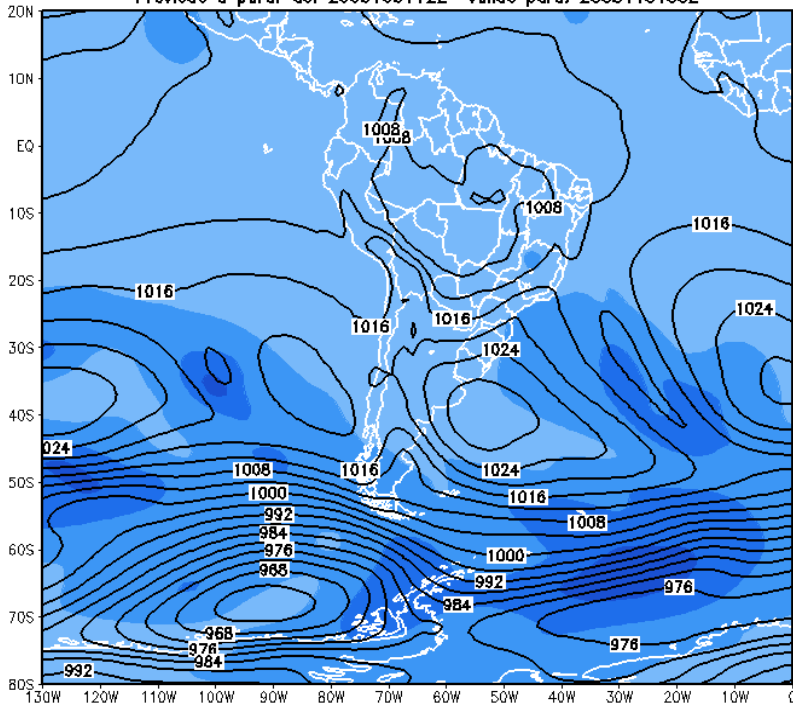
- ensemble mean
- ensemble spread
- spaghetti diagrams
- probability forecast
- probability plumes
- cluster analysis
- week mean precipitation anomaly
- evolution of high level potential velocity
- weather condition and temperature to support weather forecasting
- probability forecast of 5 days accumulated precipitation (higher than 10 mm) for agriculture applications

Example of Ensemble Products

Ensemble Mean (contours) + Spread (shaded)

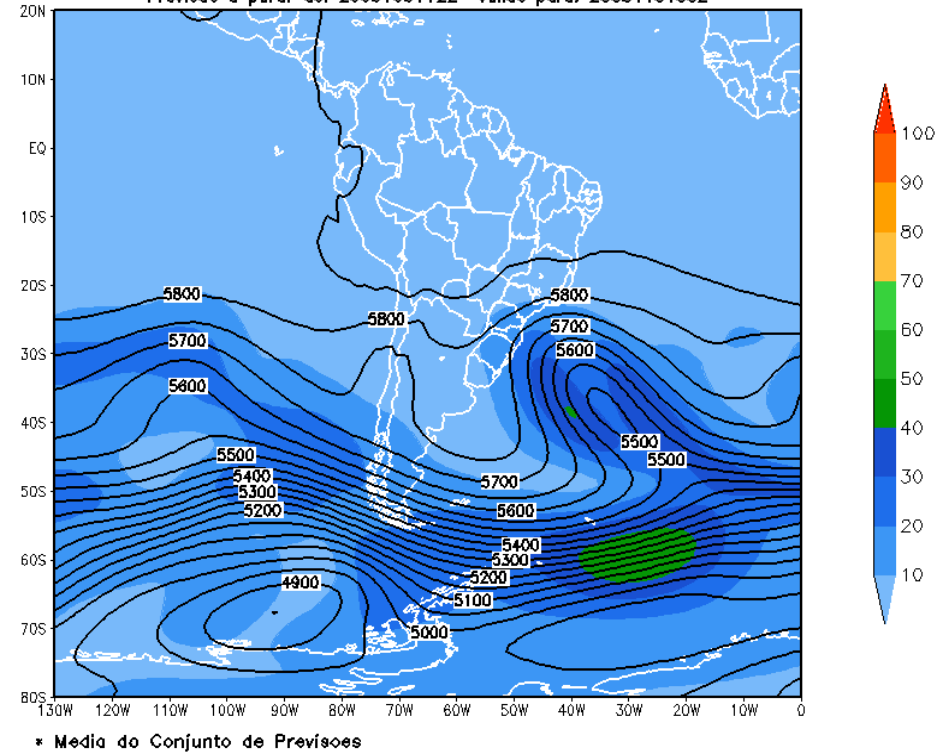
Sea Level Pressure

CPTEC/INPE/MCT – PREVISÃO DE TEMPO GLOBAL POR ENSEMBLE – T126L28
 Pressão ao Nível Médio do Mar * (hpa) [contorno] – Espalhamento da Ensemble (hPa) [cores]
 Previsão a partir de: 2003103112Z Valido para: 2003110400Z



* Média do Conjunto de Previsões

CPTEC/INPE/MCT – PREVISÃO DE TEMPO GLOBAL POR ENSEMBLE – T126L28
 Altura Geopotencial * (m) – 500 hPa [contorno] – Espalhamento da Ensemble (m) [cores]
 Previsão a partir de: 2003103112Z Valido para: 2003110400Z



500 hPa Geopotential Height

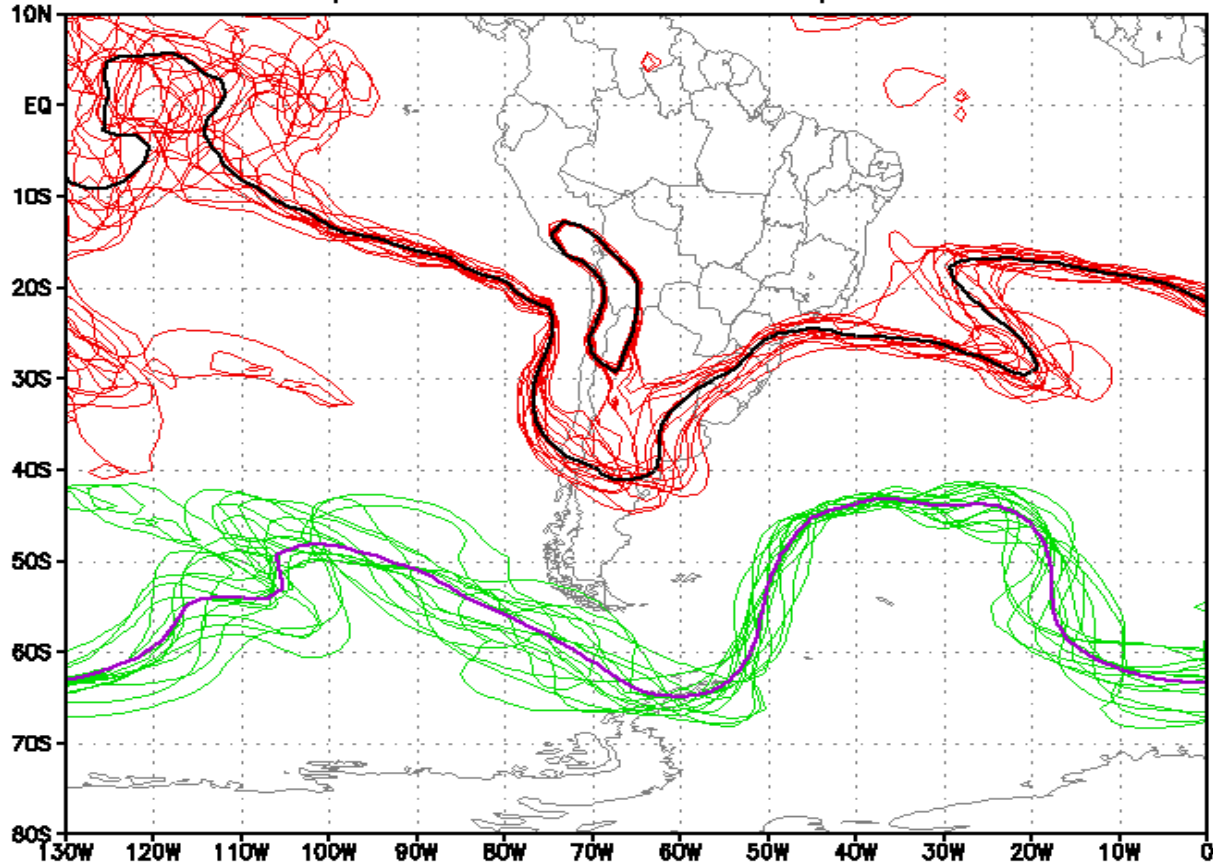
* Média do Conjunto de Previsões

Example of ensemble Products: Spaghetti Diagram

CPTEC/INPE/MCT – PREVISAO DE TEMPO GLOBAL POR ENSEMBLE – T062L28

Diagrama "Spaguetti" – Temperatura (C) (850 hPa)

Previsao a partir de: 2002022012Z Valido para: 2002022512Z



- Membres do Ensemble (15.0 graus) — Ensemble Medio (15.0 graus)
- Membros do Ensemble (0.0 graus) — Ensemble Medio (0.0 graus)

Example of Ensemble Products: Probability Forecasting

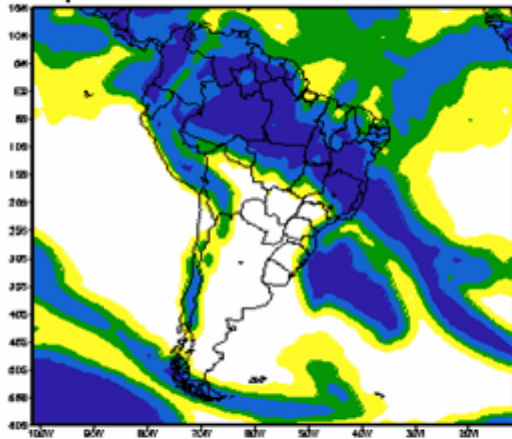
24 h Total Rainfall

From: 31/10/2003 12Z

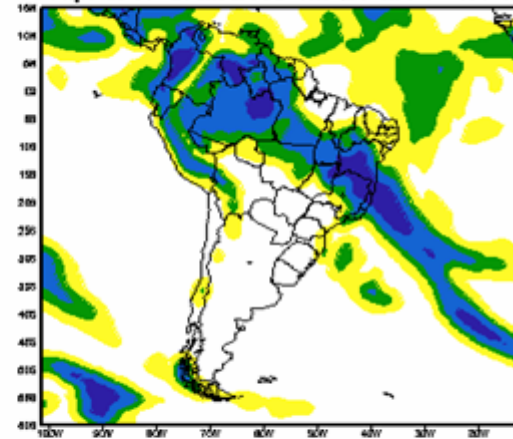
To: 04/11/2003 00Z

CPTEC/INPE/MCT – PREVISAO DE TEMPO GLOBAL POR ENSEMBLE – T126L28
Previsao de Probabilidades (%) – A partir de: 2003103112Z Valido para: 2003110400Z

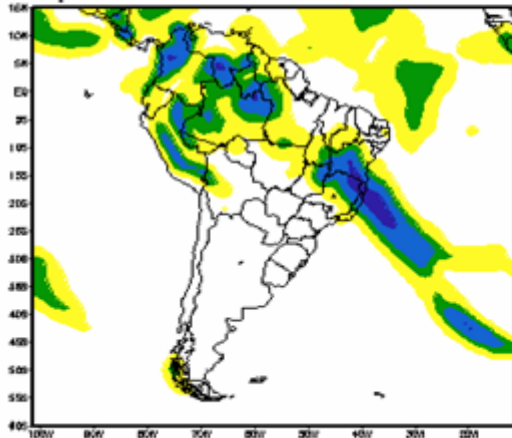
Precipitacao acumulada em 24 hrs > 1.0 mm



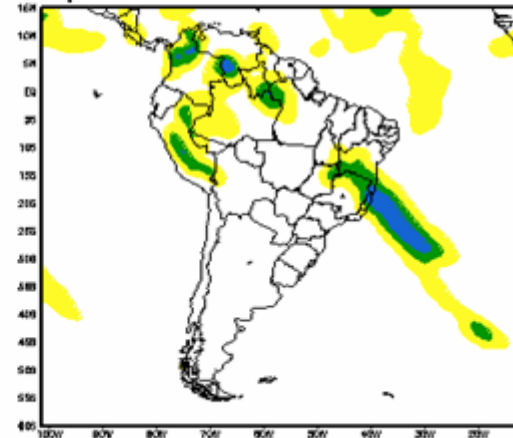
Precipitacao acumulada em 24 hrs > 5.0 mm



Precipitacao acumulada em 24 hrs > 10.0 mm



Precipitacao acumulada em 24 hrs > 20.0 mm

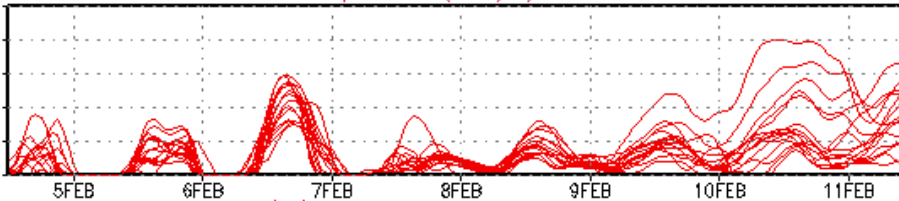


Example of Ensemble Products: Probability Plumes

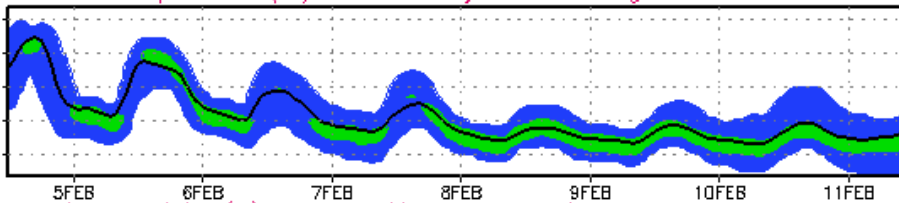
PROBABILITY PLUMES - GLOBAL ENSEMBLE FORECAST - T126L28
CPTEC: 045:00W-22:55S PINDAMONH (SP) - CACH PAULISTA (SP)
04FEB2004 12Z: Greenwich Meridian Time: Vertical Dotted Line: Midnight



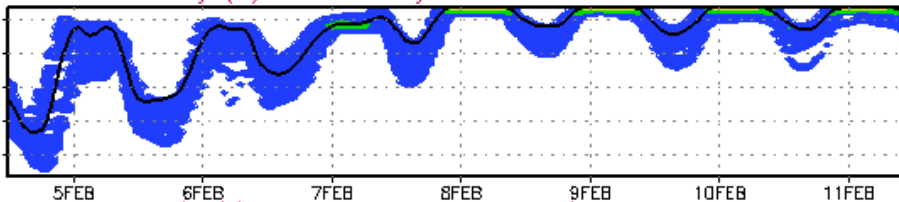
Ensemble Members of Precipitation (mm/h)



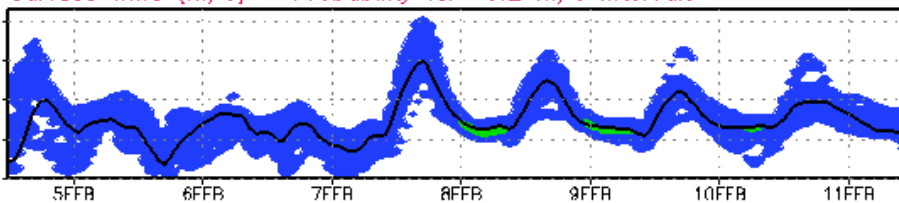
Surface Temperature (°C) - Probability for 0.6 deg intervals



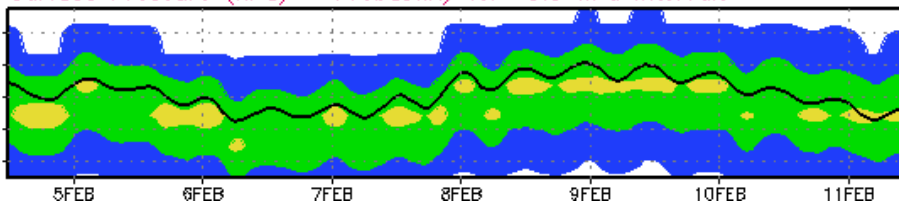
Relative Humidity (%) - Probability for 1.0% intervals



Surface Wind (m/s) - Probability for 0.2 m/s intervals



Surface Pressure (hPa) - Probability for 3.8 hPa intervals

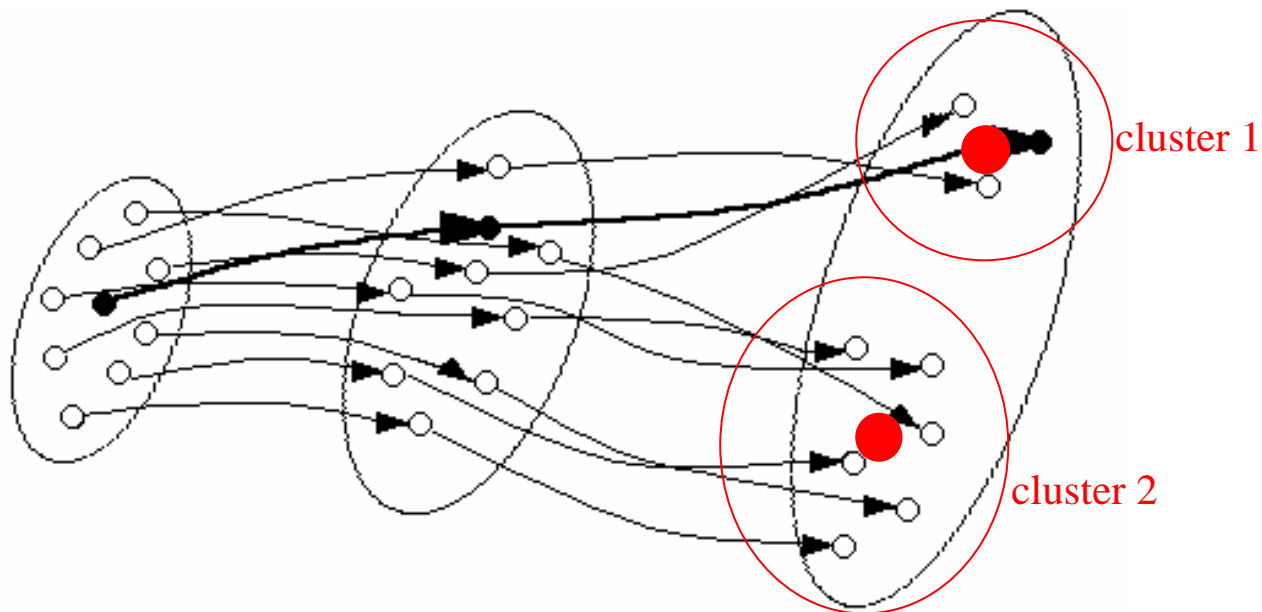


- Grid Point for Cachoeira Paulista
- Forecast from 04/02/2004 12Z

Also..... Clustering Analysis

➤ Goal:

- to reduce the number of possible future atmospheric scenarios merging similar ensemble members;



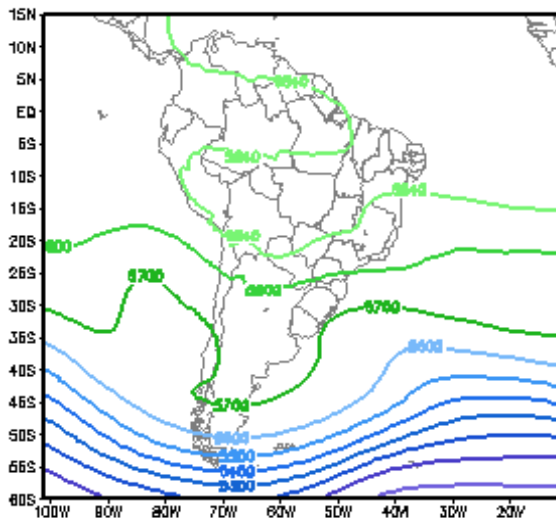
➤ Method utilized at CPTEC: Ward Minimum Variance

It is allowed a maximum of 5 clusters;

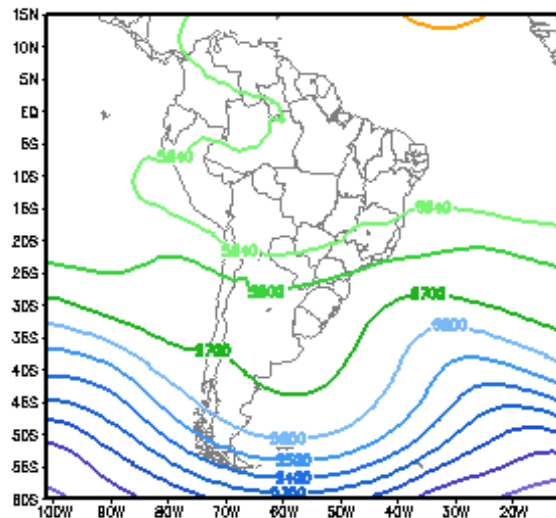
Example of CPTEC Clusters

500 hPa Geopotential Height
 252 h forecasting - From 24/10/2003 12Z to 04/11/2003 00Z

cluster: 1 n.o de membros: 3

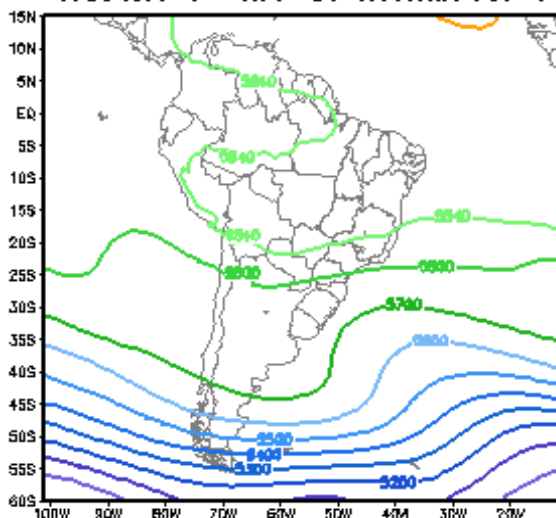


cluster: 2 n.o de membros: 4

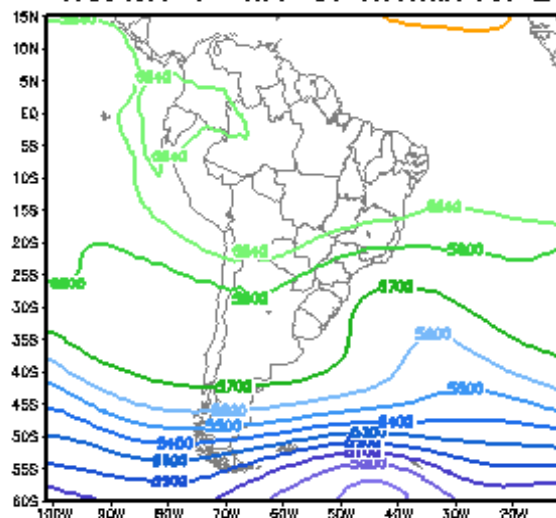


From: CPTEC/INPE

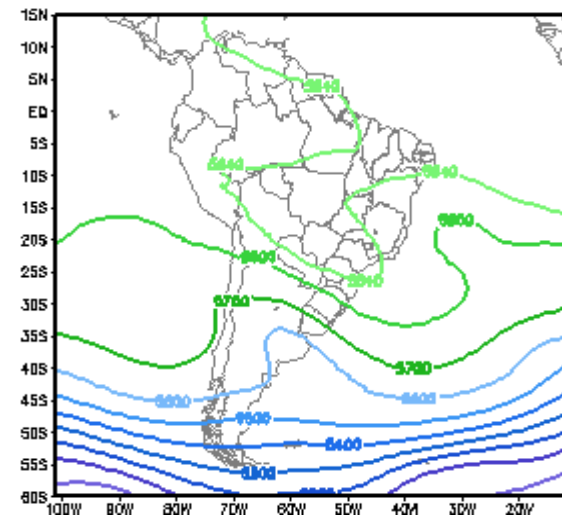
cluster: 3 n.o de membros: 4



cluster: 4 n.o de membros: 2



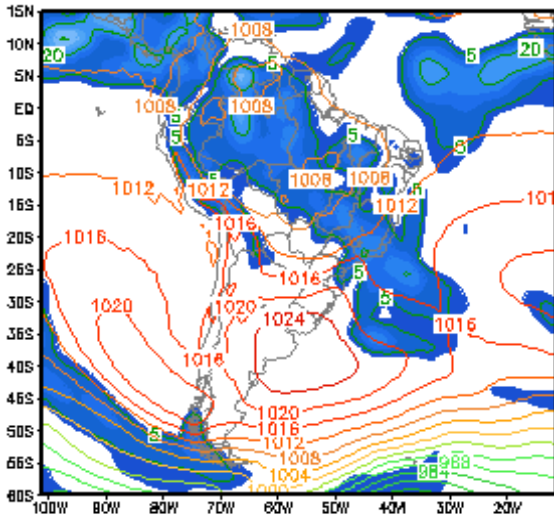
cluster: 5 n.o de membros: 2



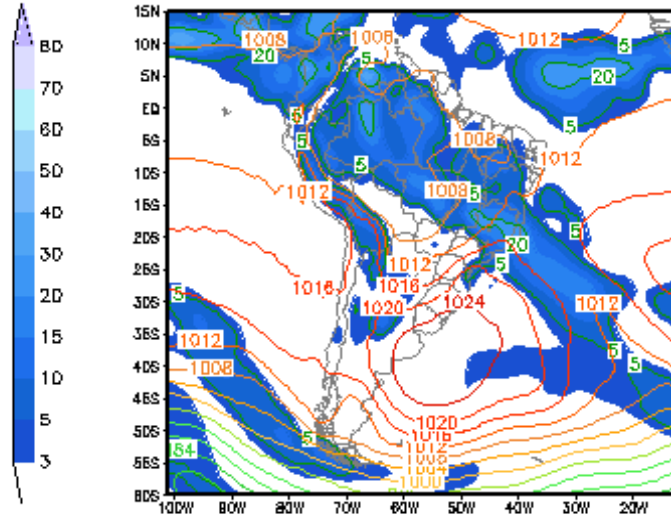
Example of CPTEC Clusters

Sea Level Pressure (contours) and 24 h Accumulated rainfall (shaded) 252 h forecasting - From 24/10/2003 12Z to 04/11/2003 00Z

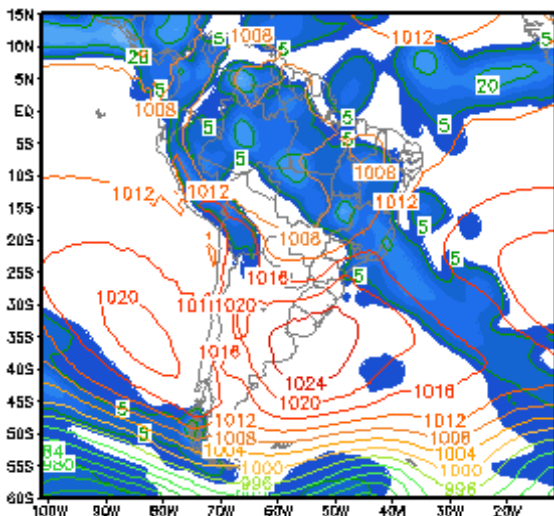
cluster: 1 n.o de membros: 3



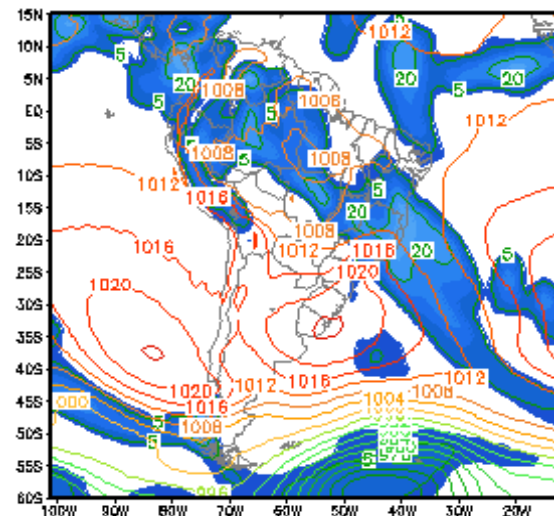
cluster: 2 n.o de membros: 4



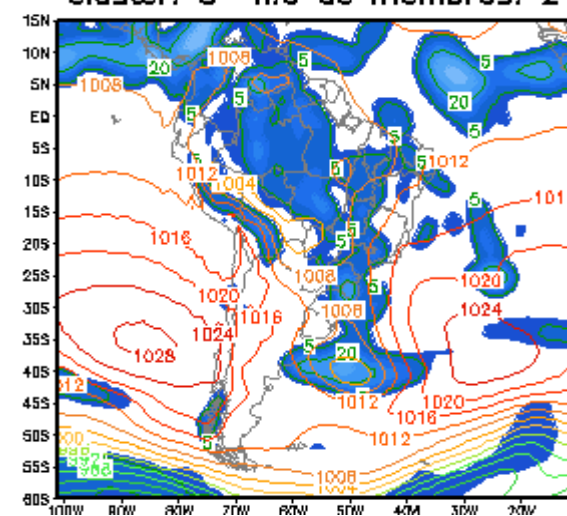
cluster: 3 n.o de membros: 4



cluster: 4 n.o de membros: 2



cluster: 5 n.o de membros: 2

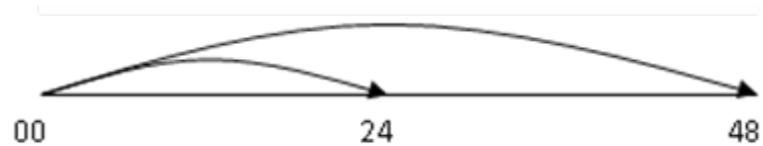


From: CPTEC/INPE

- Daily statistical indexes estimation:
 - anomaly correlation of ensemble mean
 - root mean square error of ensemble mean
 - mean error (bias) of ensemble mean
 - ensemble spread
 - deterministic and reliability tables for exchange EPS verification results following the instructions of WMO for EPS producers:
 - monthly mean tables to send to JMA Lead Centre
- CPTEC is sending the EPS information in test mode and are preparing the operational suite to send data in production mode

To use the last 12-hours lagged forecasts to increase the number of ensemble members

OPERATIONAL ENSEMBLE: most recent 15 members



PROPOSED ENSEMBLE: 30 members

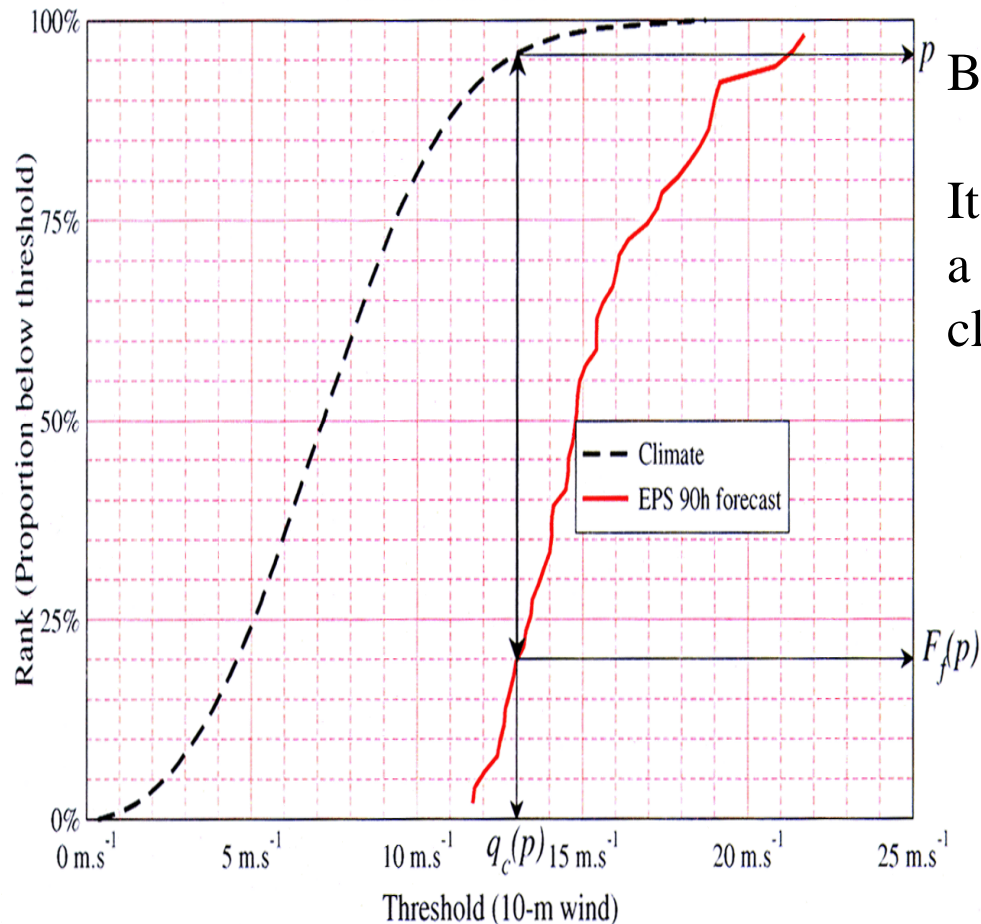


Future Developments

Extreme Forecast Index (EFI)

Empirical Distribution Functions 48.5°N / -4°E

10-m wind forecast VT 30/10/2000 06 UTC

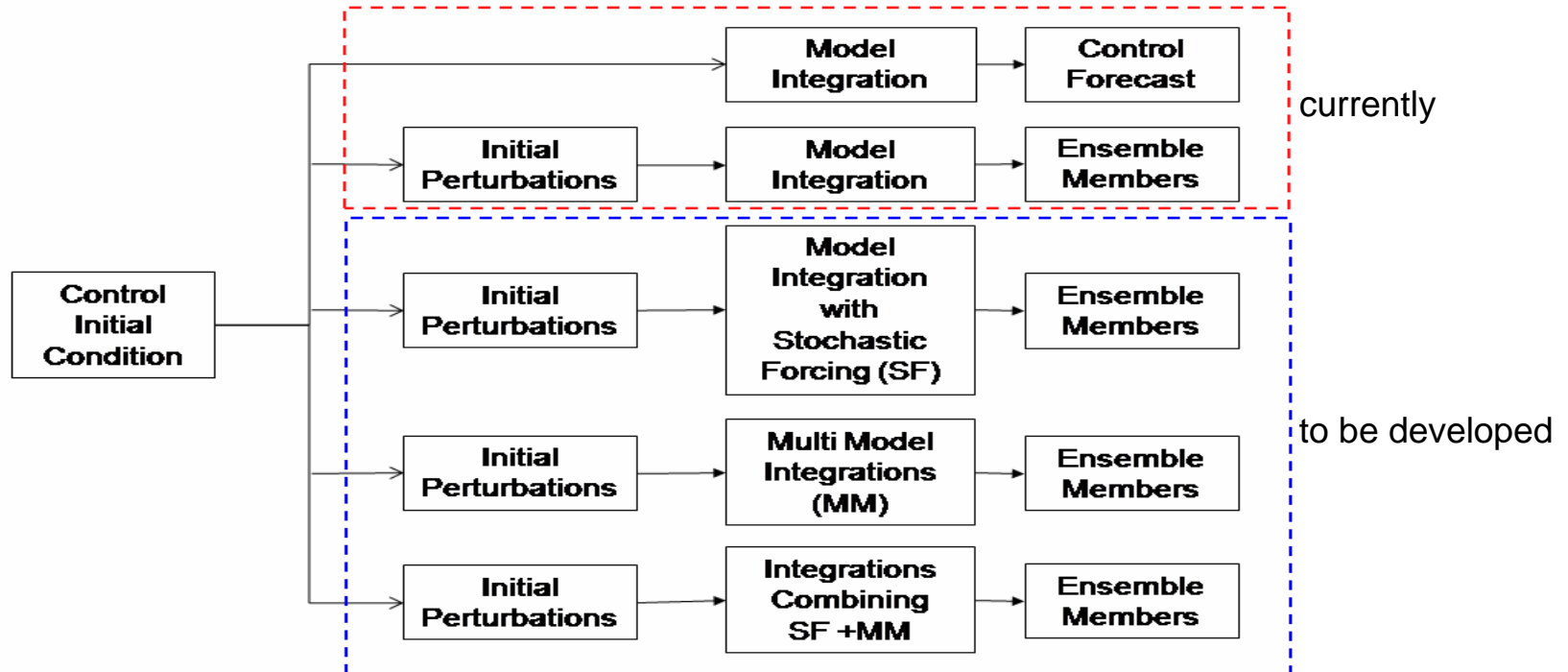


Based on Lalaurette (2003):

It is a measure of the difference between a probabilistic forecast and a model climate distribution

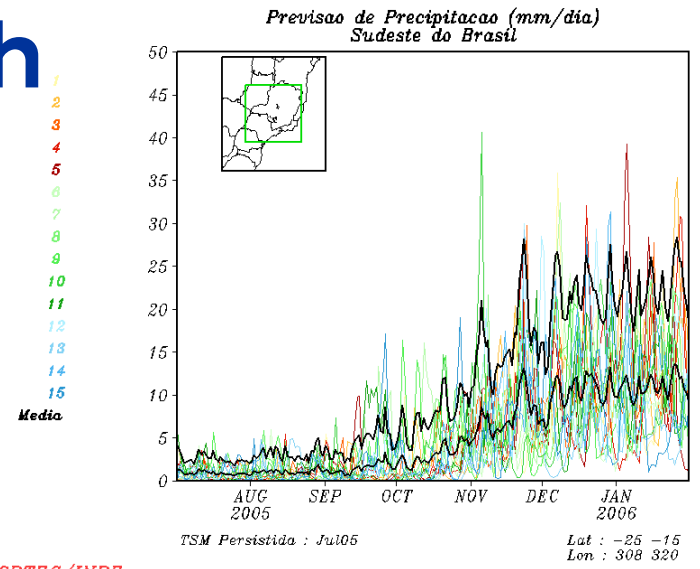
Future Developments

- Use the Local Ensemble Kalman Filter to Data Assimilation and Ensemble Forecasting (Ott et al, 2003; Szunyogh et al, 2004; Sauer et al 2004)
- Consider the uncertainty on model formulation through perturbation in physics:
 - use different parametrizations for model integration (multi-model)
 - use stochastic perturbations on the tendency of physical process

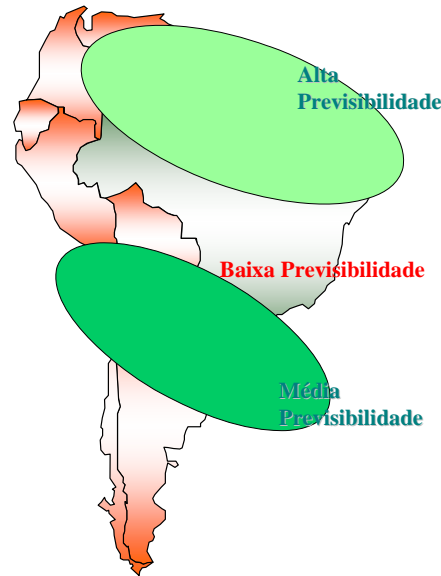


Climate Forecasting with CPTEC Global Model

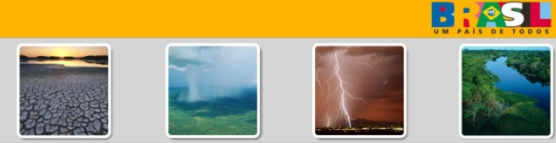
- Global spectral model (T62L28) for 7 month (2+5), state of the art physics
- Ensemble forecasting (25 members) - T062L28 for 7 months (2+5)
- T095L42



CPTEC/INPE

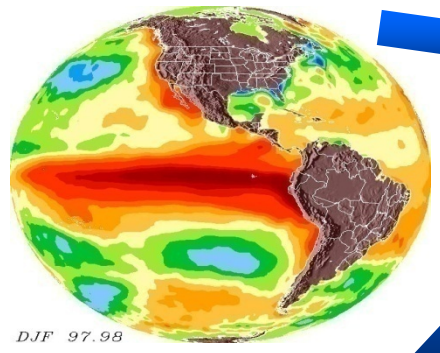


High Predictability

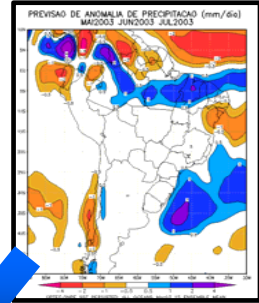


Seasonal Climatic Forecast

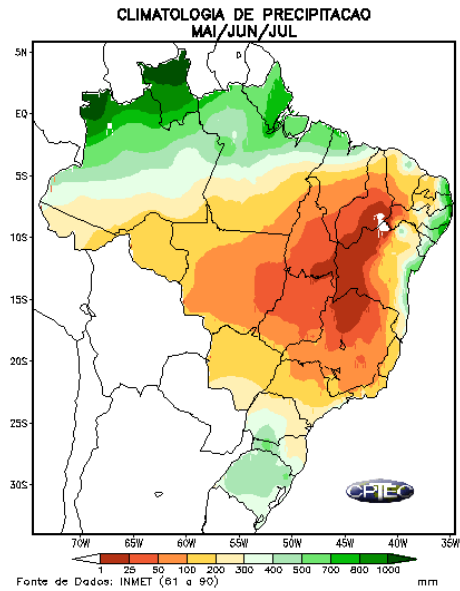
Sea Surface Temperature



DJF 97.98



Meeting of Experts



Fonte de Dados: INMET (81 a 90)



ProgClima

Boletim Prognóstico Climático para Maio, Junho e Julho de 2006 (MJJ)

17 de abril de 2006

Para acessar informações, clique aqui

Síntese Executiva

A Zona de Convergência do Atlântico Sul (ZCAS) e a Zona de Convergência Intertropical (ZCIT), associada à formação de bolhas de instabilidade no norte do Brasil, estão os principais sistemas responsáveis pelas chuvas mais abundantes nas Regiões Sudeste, Centro-Oeste, Norte e Nordeste do Brasil no início de março. No Nordeste Norte, algumas localidades apresentaram totais acumulados superiores a 500 mm, causando sérios transtornos à população residente do Rio Grande do Sul, estado da Santa Catarina e no oeste e norte Paraná, as chuvas foram suficientes para exceder a média histórica, contribuindo para a situação observada em meses anteriores.

O mês de março também foi caracterizado por altas temperaturas e altas pressões de chuvas no período da tarde e noite em grande parte do Brasil, com exceção na colina de São Paulo, o total de chuva foi superior a 800 mm, com o pico, variando ligeiramente a 300 mm. A temperatura máxima média foi em torno de 30°C.

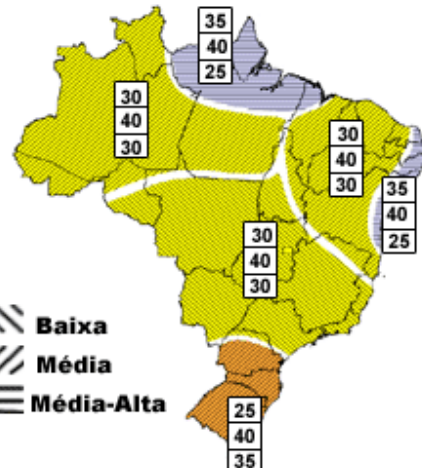
A temperatura da Superfície do Mar (TSM) média média e pontualizada, seguindo a TSM de baixa intensidade no Oceano Pacífico Equatorial, variou entre 0,5°C a 1,5°C acima da média histórica na área compreendida entre 120°W e 180°W no Oceano Índico-Tropical Norte, a TSM foi predominantemente próxima a média, porém na faixa central e nas adjacentes da costa africana os valores superaram entre 0,5°C a 1,0°C acima da média. No Atlântico Sul, a TSM variou entre 0,5°C a 1,0°C acima da média nas proximidades da borda do Brasil, de São Paulo e na Região Sul do Brasil.

Mapa de Maio/2006

Mapa de Maio/2006

Mapa de Maio/2006

Mapa de Maio/2006



Thank you!