The use of medium range and seasonal forecast at CPTEC

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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

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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:

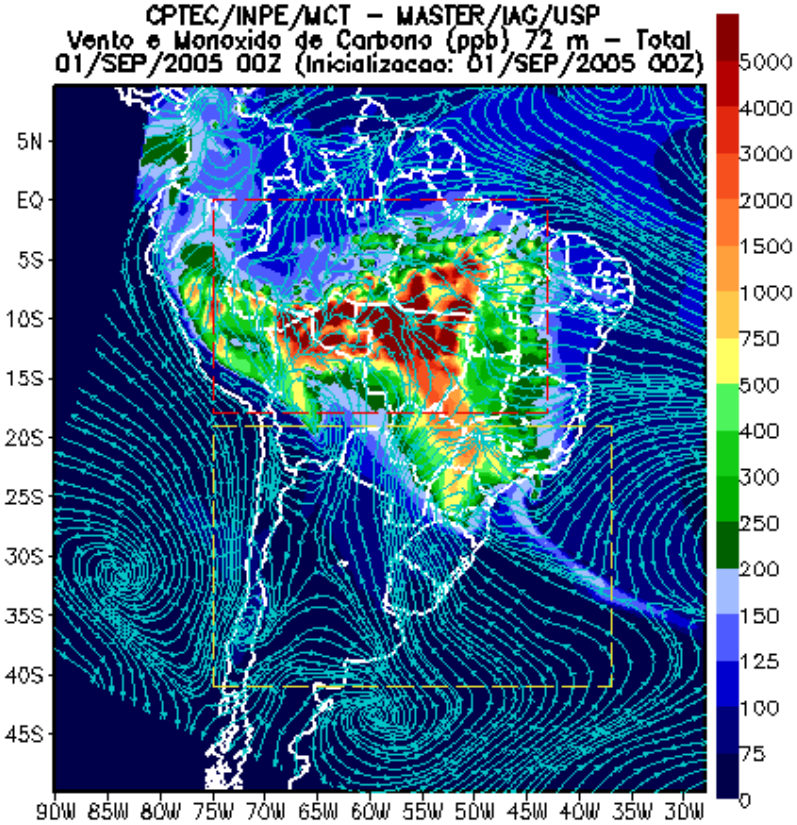
- Global Spectral Model, once a month
  T062L28 up to 6 months, 30 - 60 members each

Boundary conditions: Monthly SST persisted anomaly (observed) or predicted (Tropical Atlantic and/or Tropical Pacific)

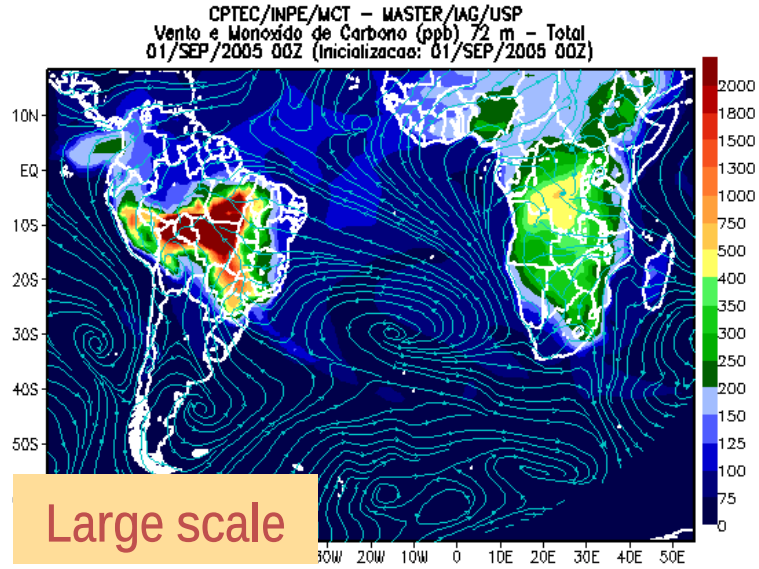
- Regional Eta Model, once a month
  40kmL38 up to 6 months, 1 member each

Environmental model

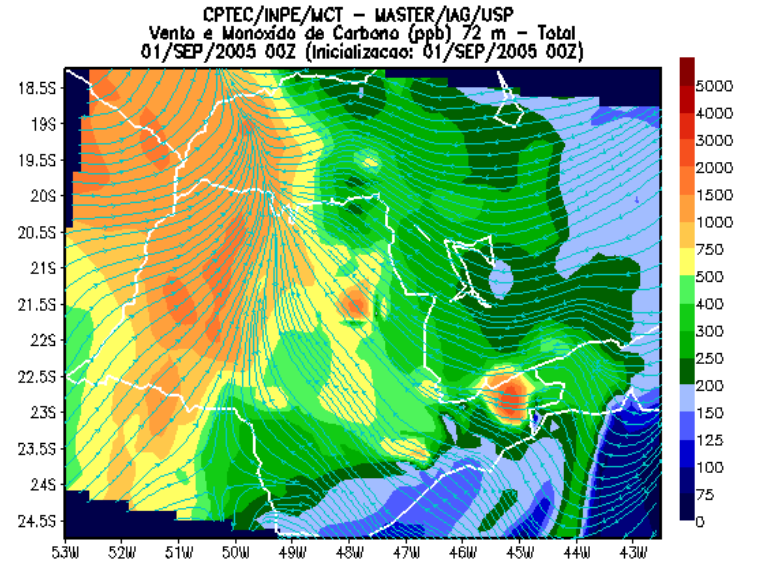
Air pollution due to biomass burning and urban areas



Regional scale

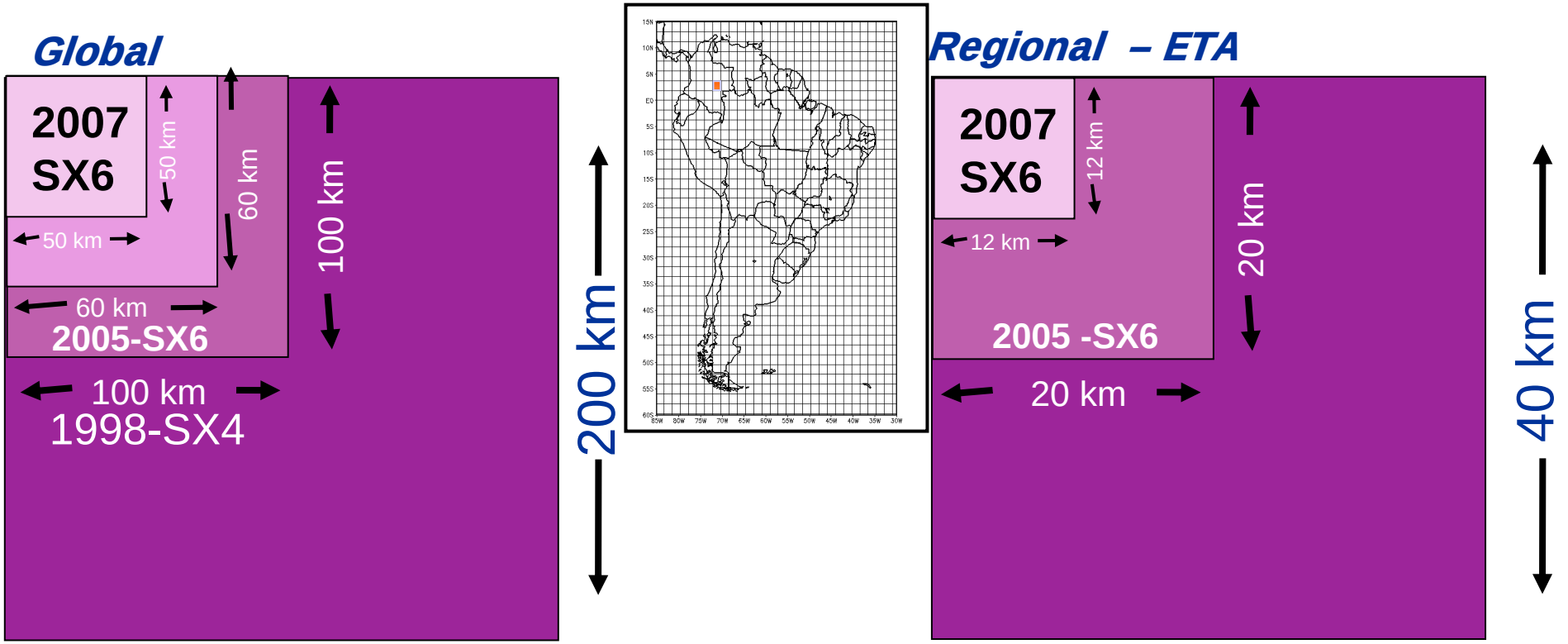


Large scale



Mega cities

Evolution of the CPTEC Models Resolution



200 km

1994-SX3

40 km

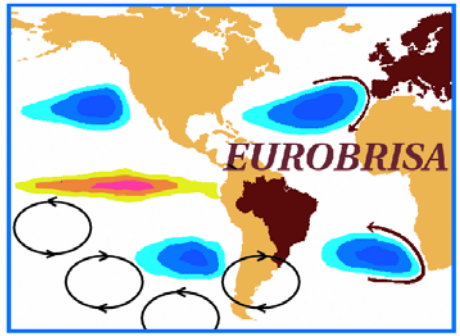
1996-SX3 and SX4

Number of vertical levels :	***1994*** - 28 ***2005*** - 42 ***2006*** - 64
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

EUROBRISA activities

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

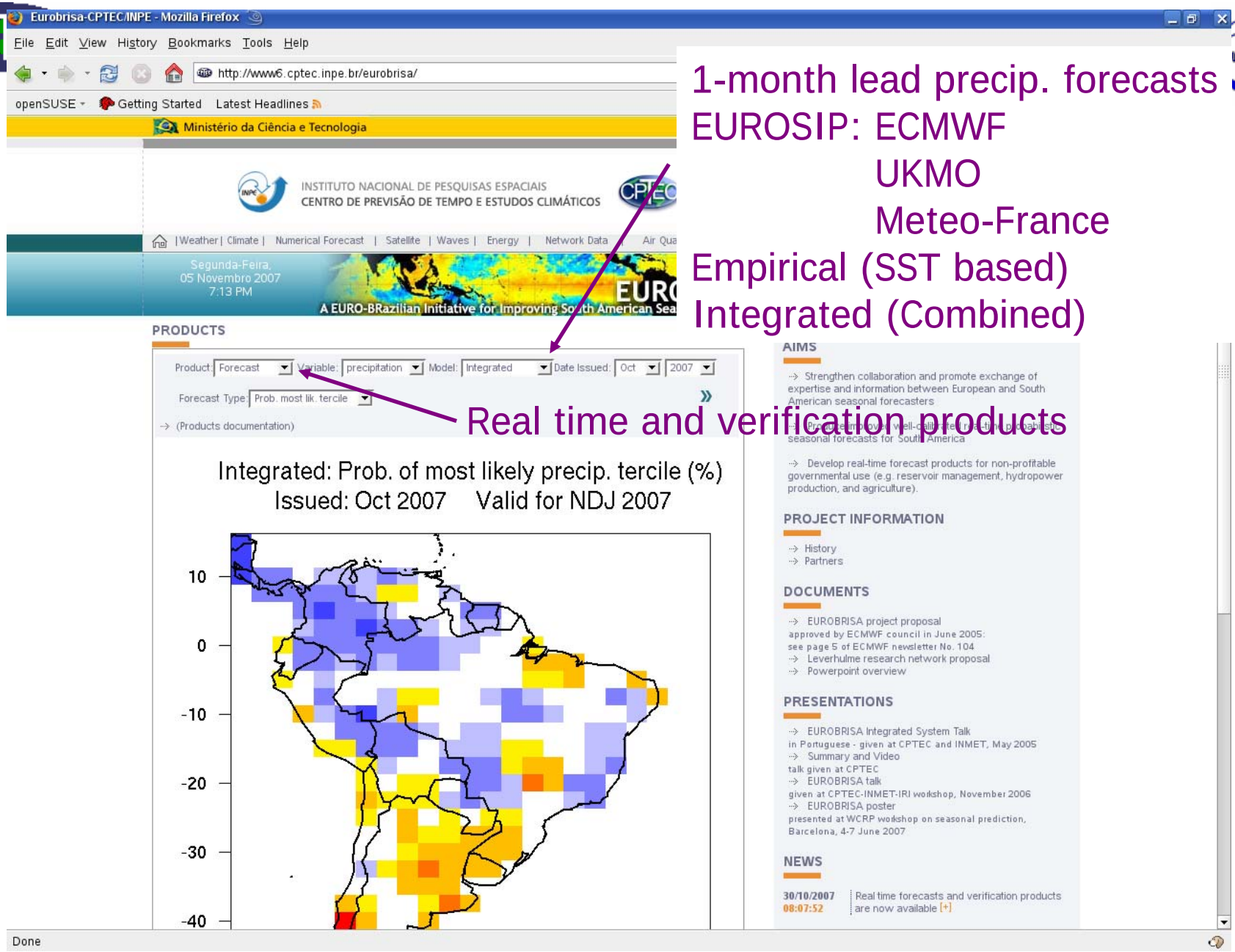
1-month lead precip. forecasts

EUROSIP: ECMWF
UKMO
Meteo-France

Empirical (SST based)

Integrated (Combined)

Real time and verification products

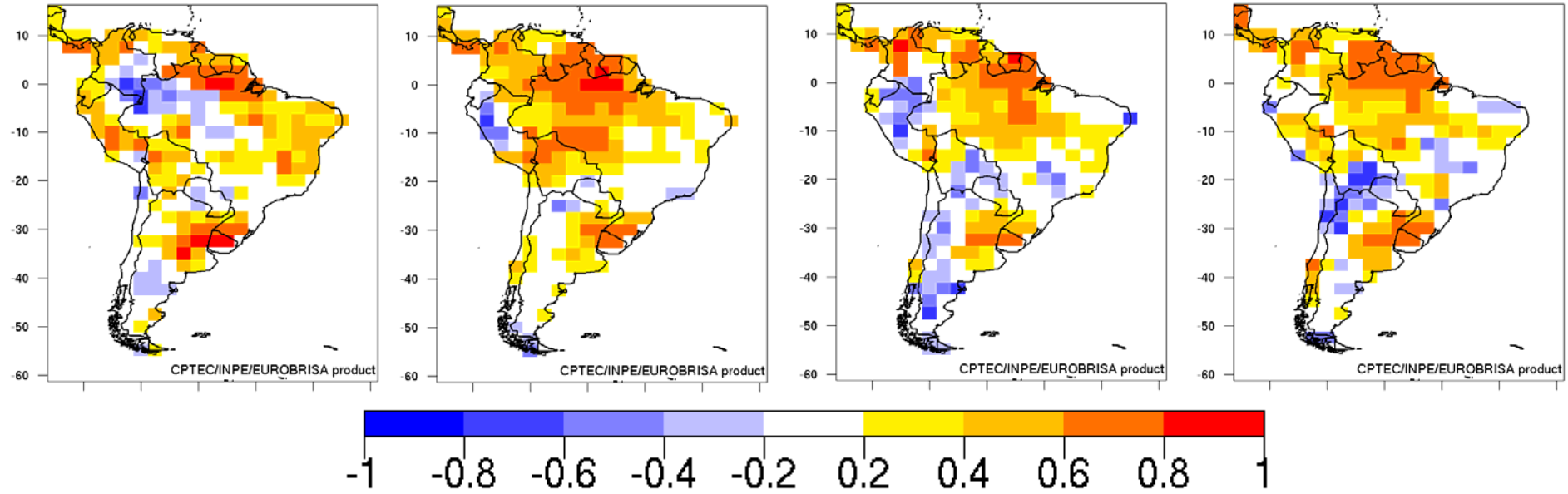


http://www6.cptec.inpe.br/eurobrisa/

Example of verification product

Correlation maps: NDJ precip. anomalies

ECMWF UKMO Empirical Integrated

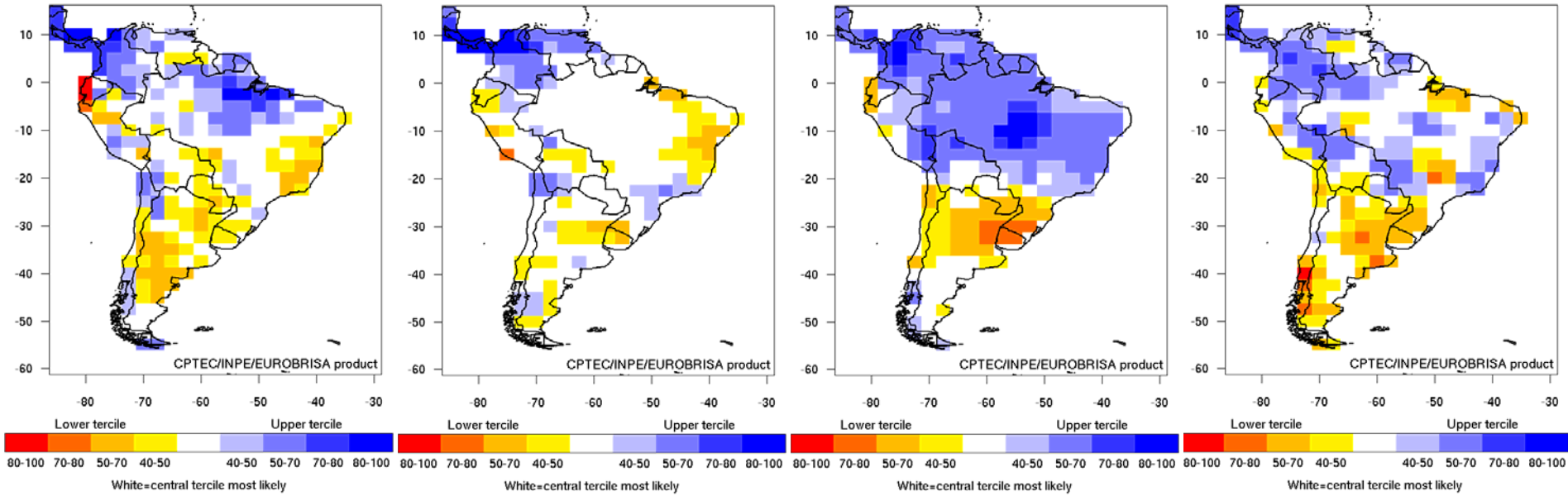


- Hindcast period: 1987-2001
- Coupled models with I.C. 1st Oct (1-month lead for NDJ)
- Empirical model uses Sep SST as predictor for NDJ precip.
- Integrated forecasts (coupled + empirical) with forecast assimilation (Stephenson et al. 2005)

→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;

EOF-based perturbation procedures

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;

Products

www.cptec.inpe.br

ensemble products available

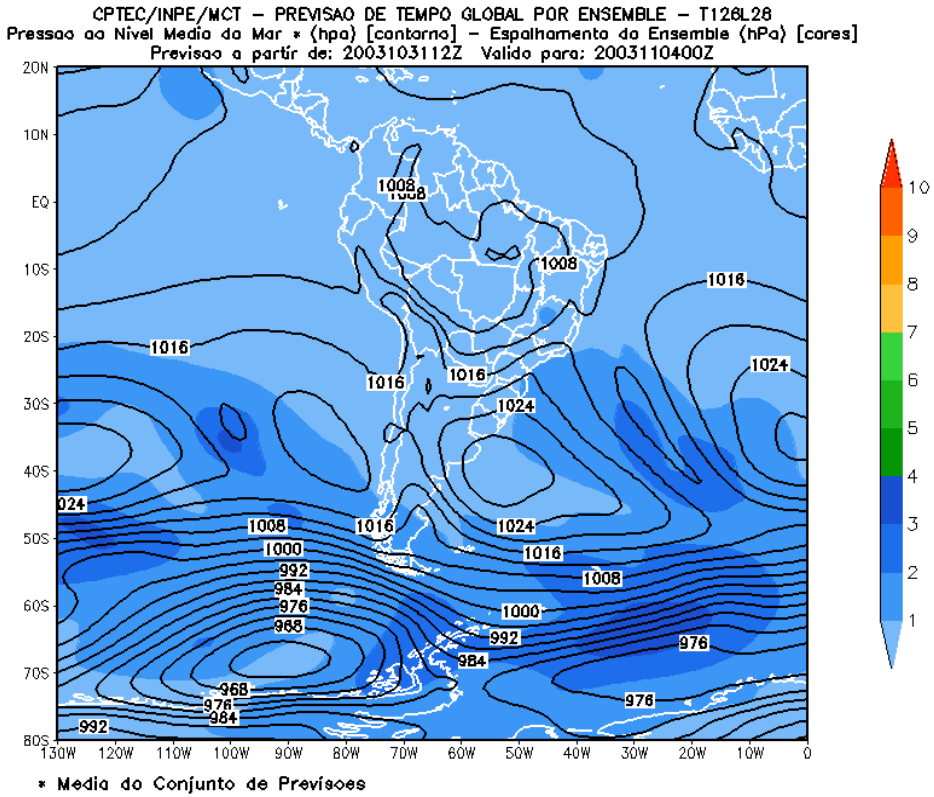
Main Products

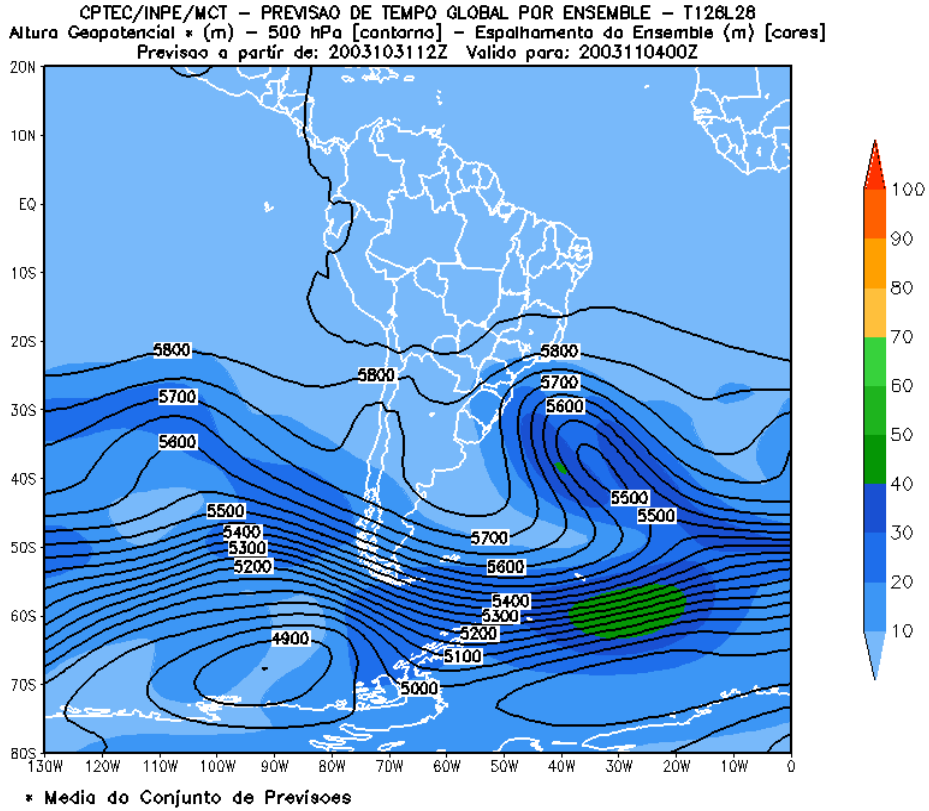
- ensemble mean
- ensemble spread
- spaghetti diagrams
- probability forecast
- probability plumes
- cluster analysis
- week mean precipitation anomaly
- evolution of high level potential velocity
- weather condition and temperature to support weather forecasting
- probability forecast of 5 days accumulated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

Example of Ensemble Products

Ensemble Mean (contours) + Spread (shaded)

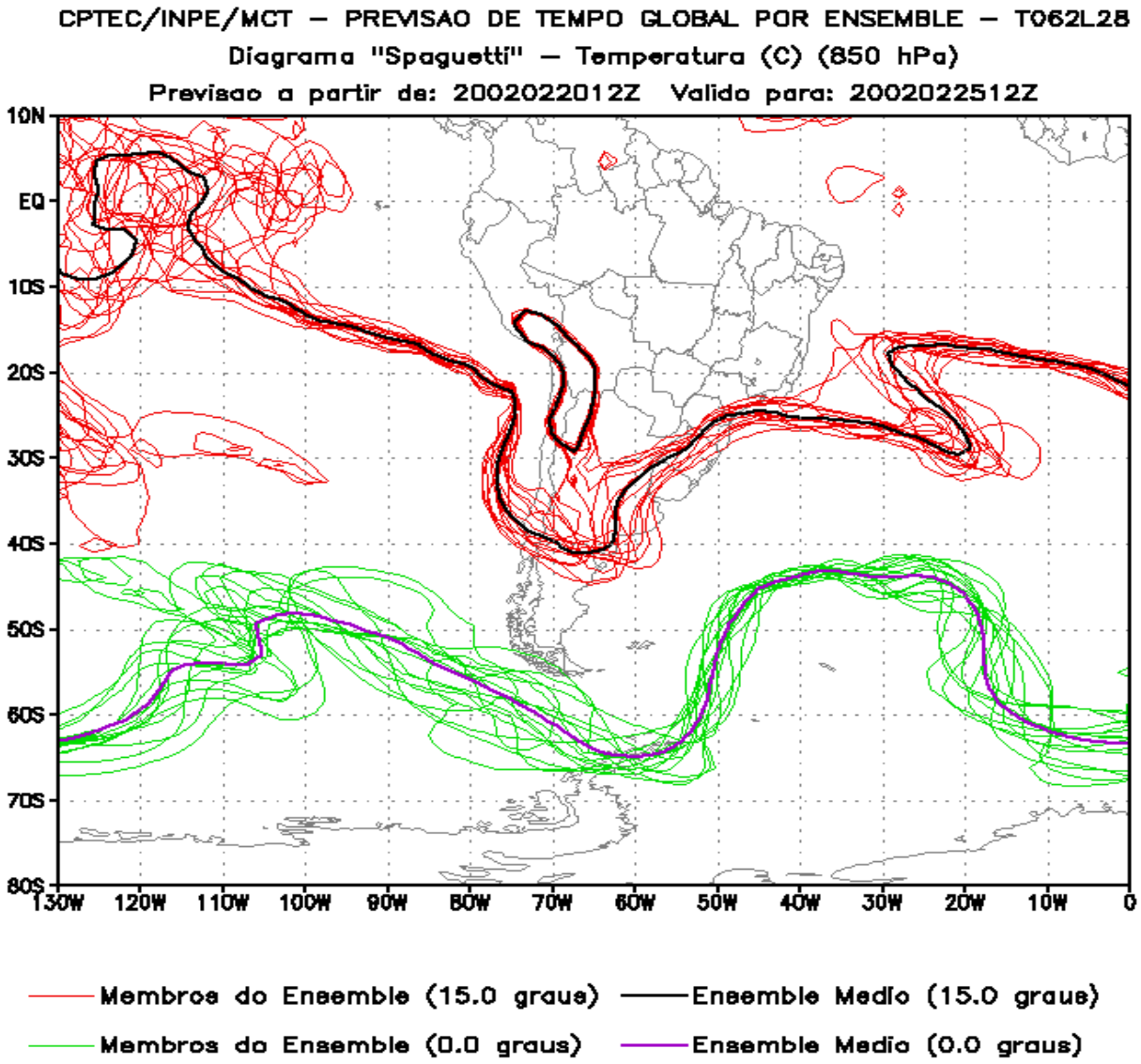
Sea Level Pressure





500 hPa Geopotential Height

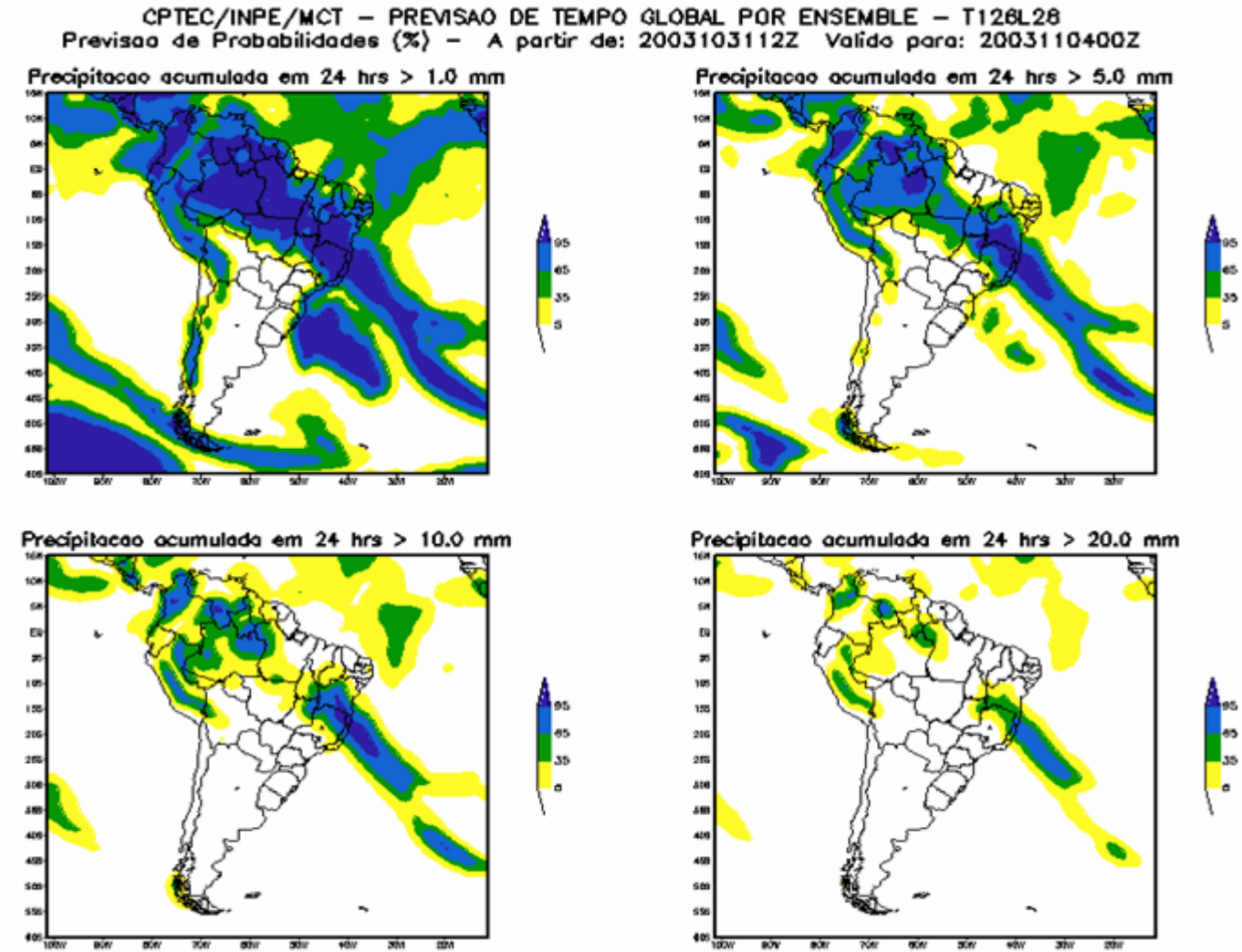
Example of ensemble Products: Spaghetti Diagram



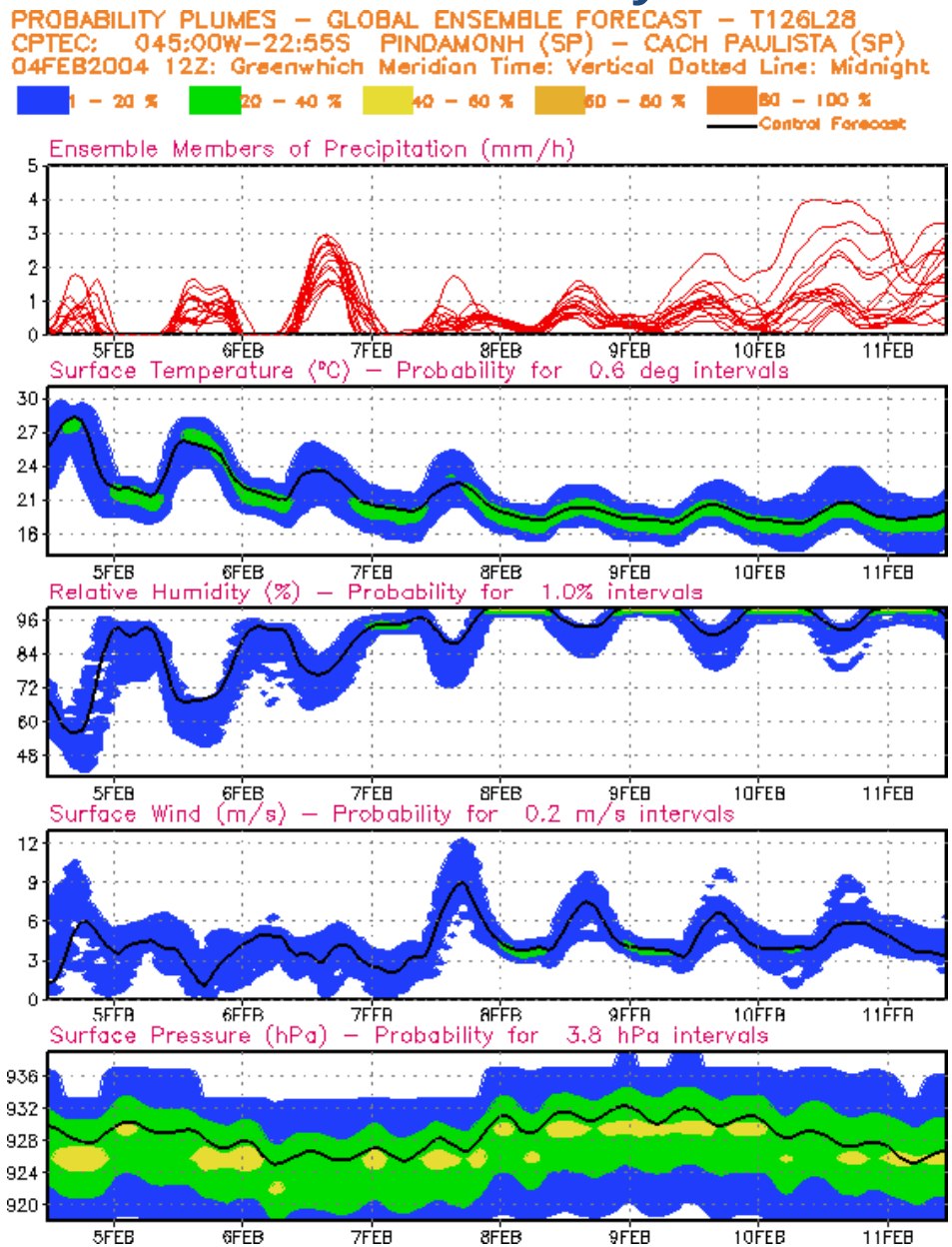
Example of Ensemble Products: Probability Forecasting

24 h Total Rainfall

From: 31/10/2003 12Z To: 04/11/2003 00Z



Example of Ensemble Products: Probability Plumes

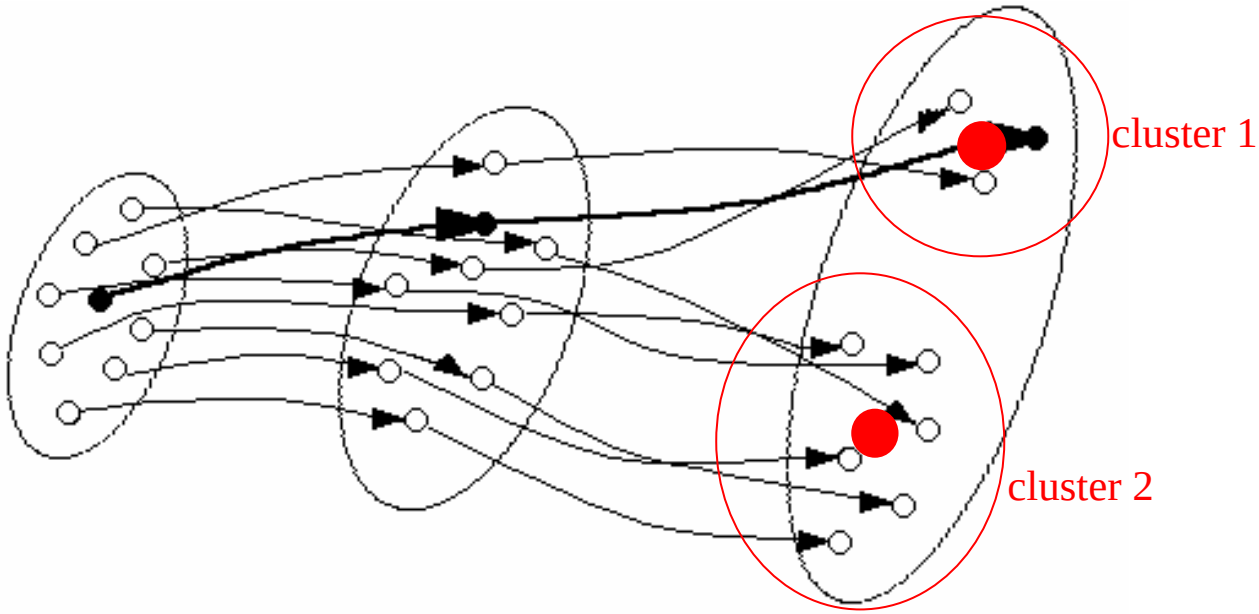


- Grid Point for Cachoeira Paulista
- Forecast from 04/02/2004 12Z

Also….. Clustering Analysis

- Goal:

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

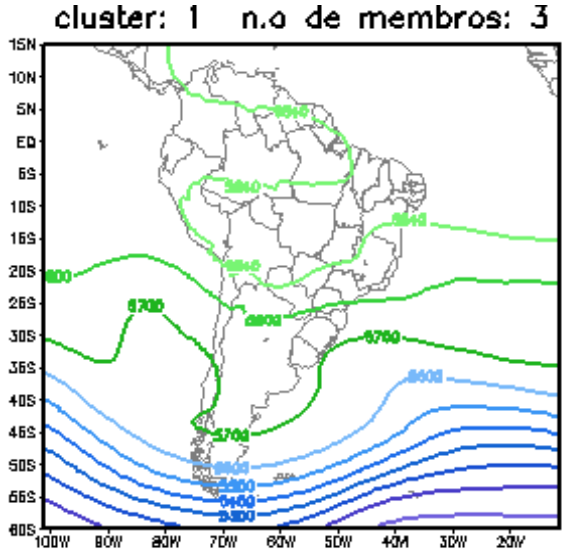


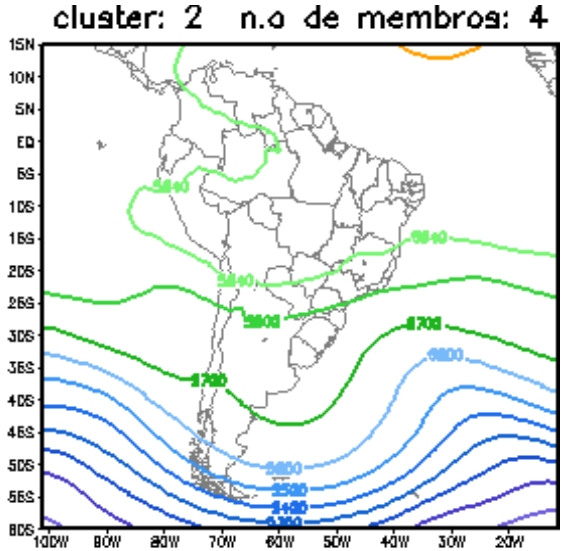
- Method utilized at CPTEC: Ward Minimum Variance

It is allowed a maximum of 5 clusters;

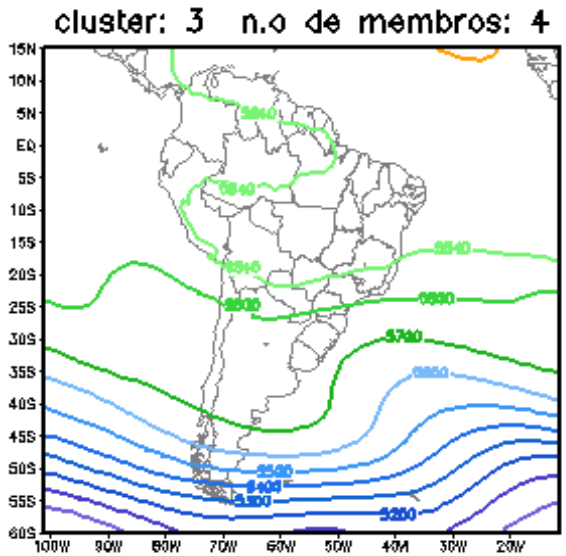
Example of CPTEC Clusters

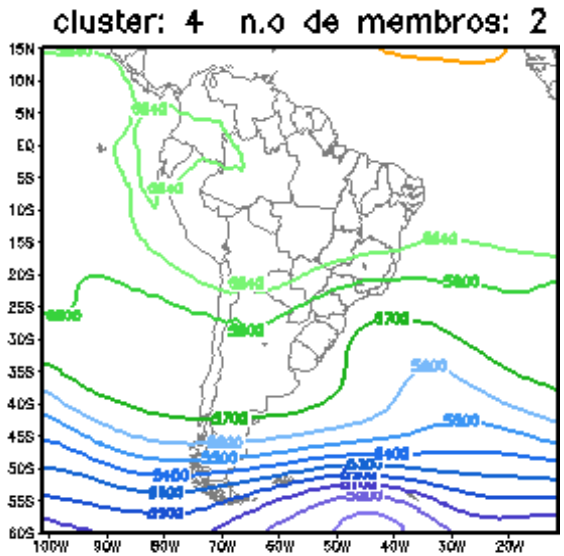
500 hPa Geopotential Height
252 h forecasting - From 24/10/2003 12Z to 04/11/2003 00Z

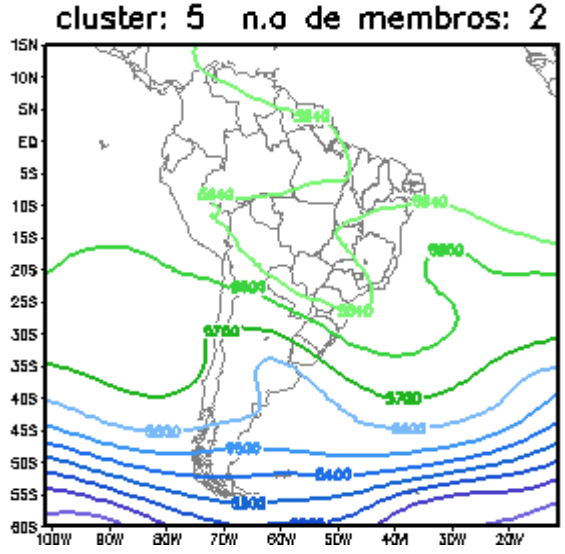




From: CPTEC/INPE



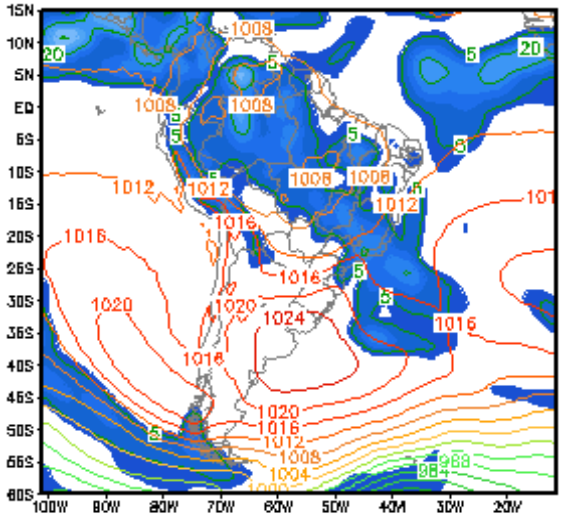


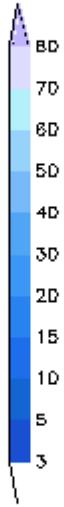


Example of CPTEC Clusters

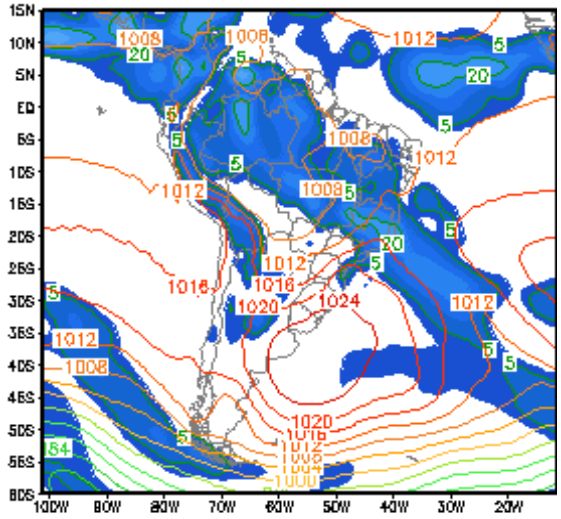
Sea Level Pressure (contours) and 24 h Accumulated rainfall (shaded)
252 h forecasting - From 24/10/2003 12Z to 04/11/2003 00Z

cluster: 1 n.o de membros: 3



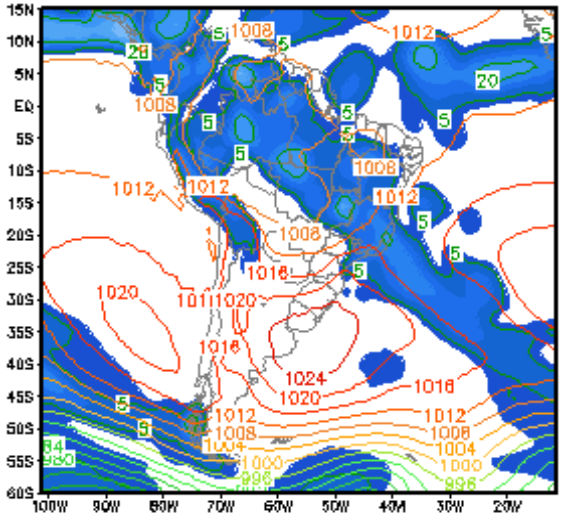


cluster: 2 n.o de membros: 4

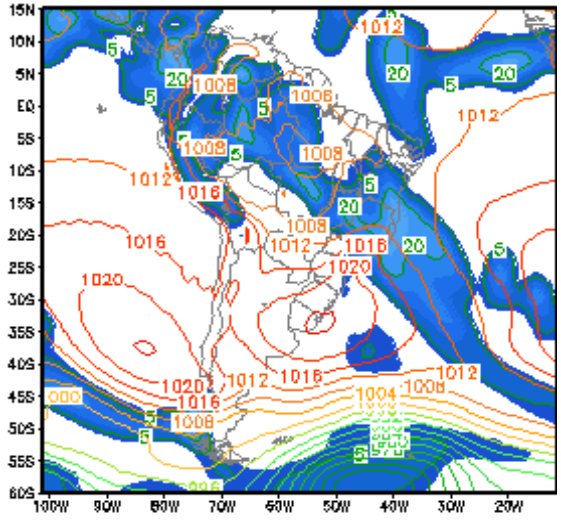


From: CPTEC/INPE

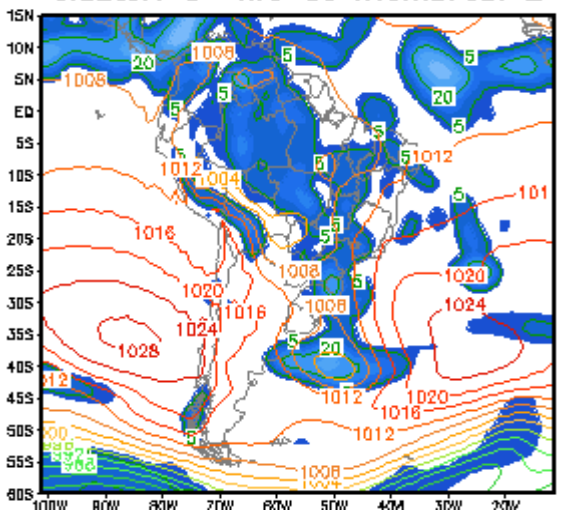
cluster: 3 n.o de membros: 4



cluster: 4 n.o de membros: 2



cluster: 5 n.o de membros: 2



Ensemble Evaluation

- 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:

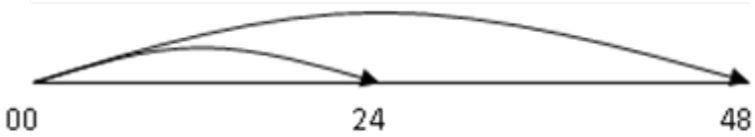
  - monthly mean tables to send to JMA Lead Centre

- CPTEC is sending the EPS information in test mode and are preparing the operational suite to send data in production mode

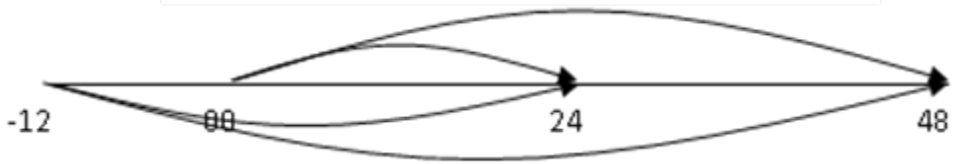
Future Developments

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

OPERATIONAL ENSEMBLE: most recent 15 members

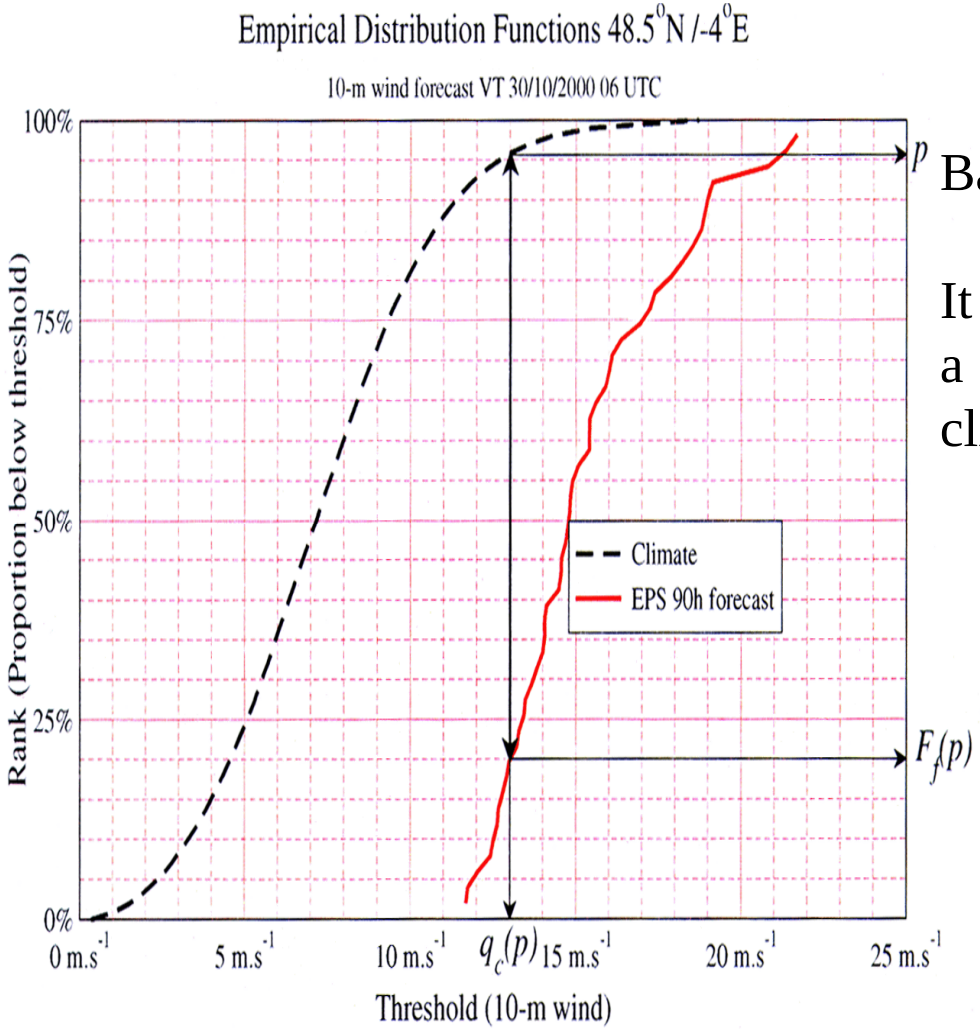


PROPOSED ENSEMBLE: 30 members



Future Developments

Extreme Forecast Index (EFI)



Based on Lalaurette (2003):

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

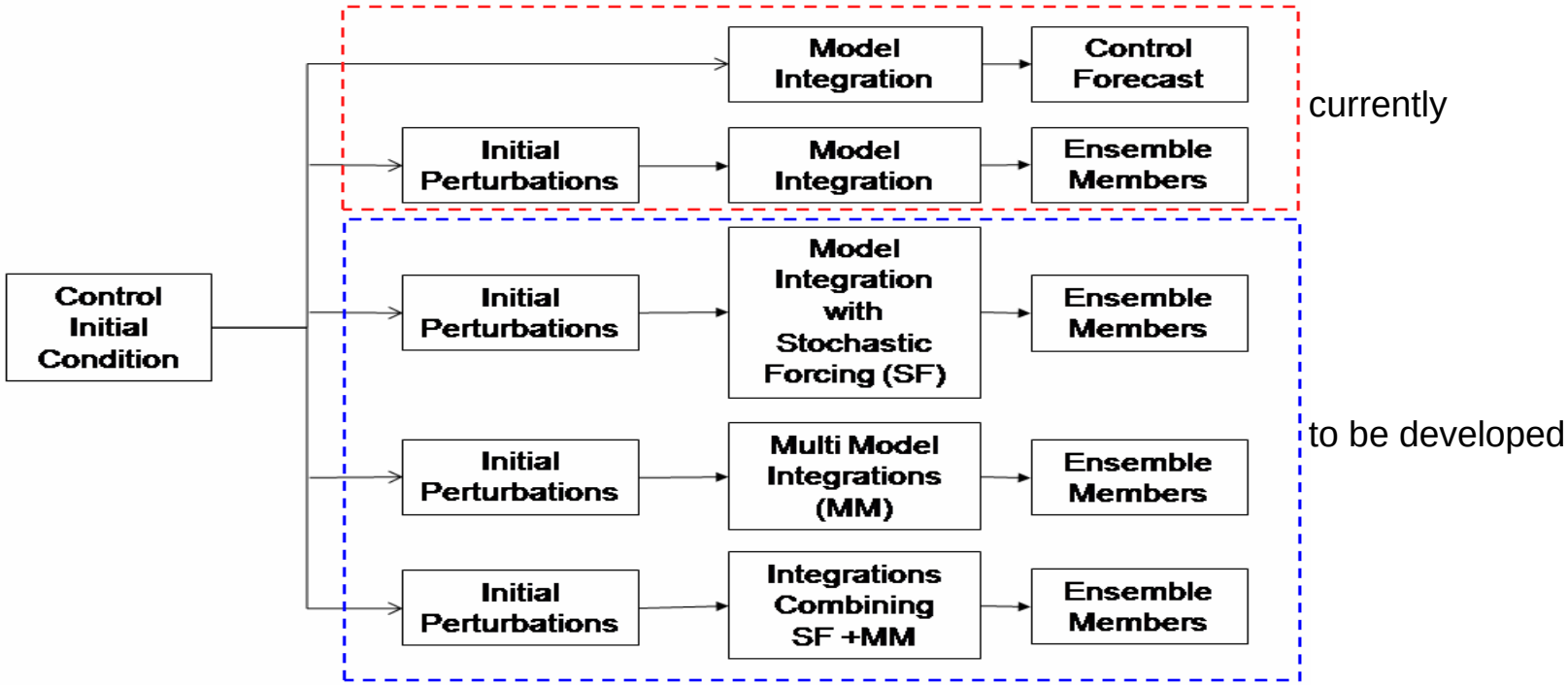
Future Developments

- Use the Local Ensemble Kalman Filter to Data Assimilation and Ensemble Forecasting (Ott et al, 2003; Szunyogh et al, 2004; Sauer et al 2004)

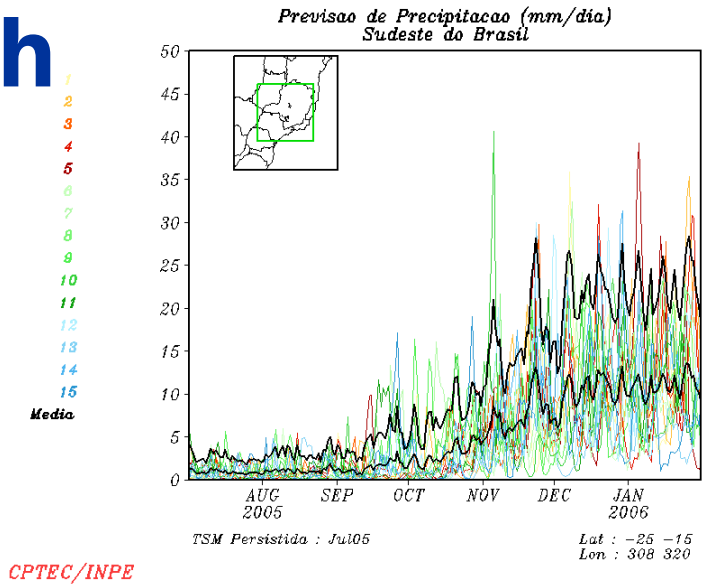
- Consider the uncertainty on model formulation through perturbation in physics:

• use different parametrizations for model integration (multi-model)

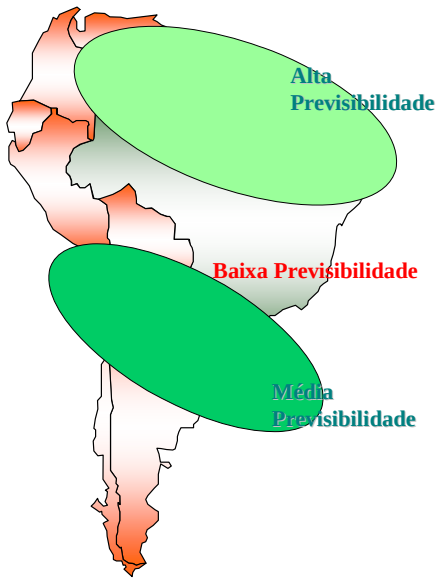
• use stochastic perturbations on the tendency of physical process



Climate Forecasting with CPTEC Global Model



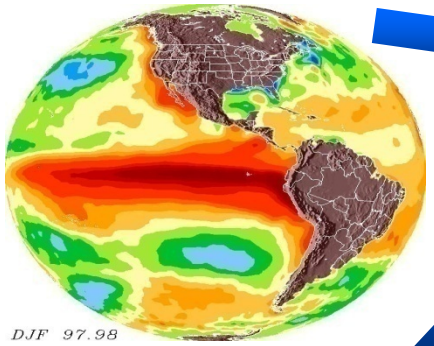
- Global spectral model (T62L28) for 7 month (2+5), state of the art physics
- Ensemble forecasting (25 members) - T062L28 for 7 months (2+5)
- T095L42

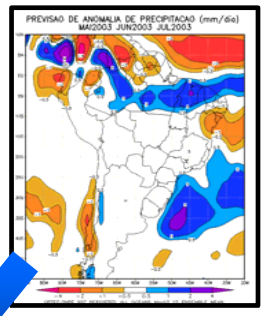


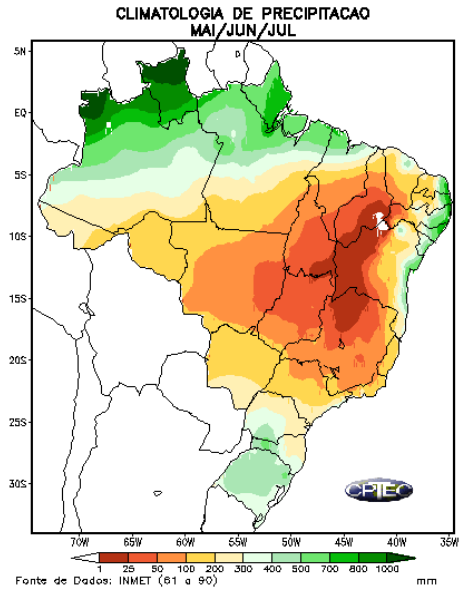
High Predictability

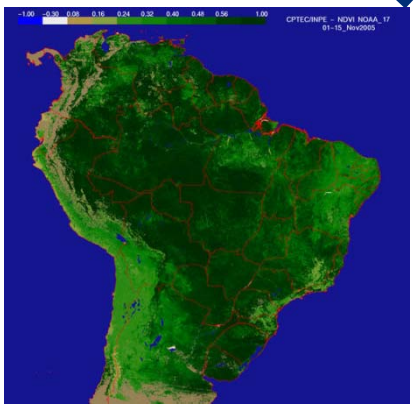
Seasonal Climatic Forecast

Sea Surface Temperature

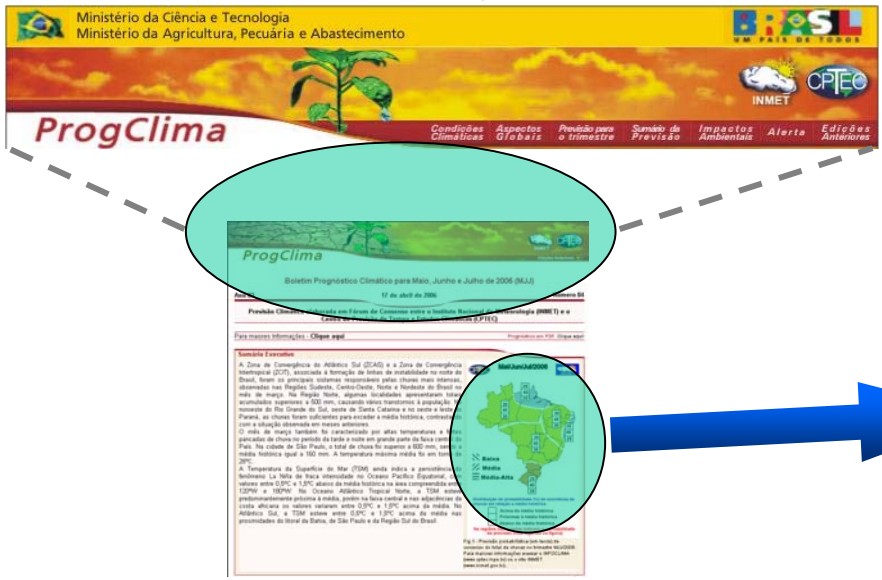


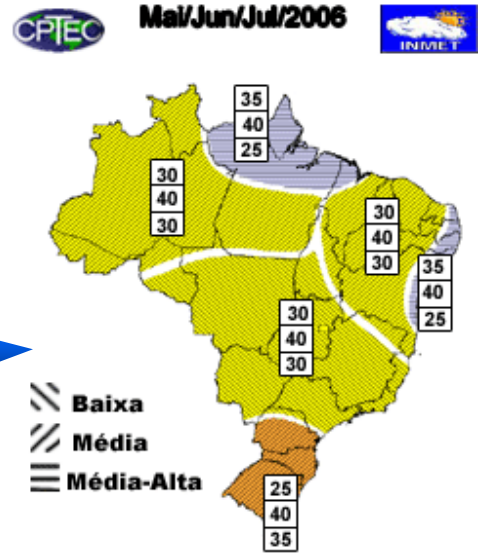






Meeting of Experts





Thank you!