Predictability in the Plata Basin: linkage to the THORPEX and GEWEX programs

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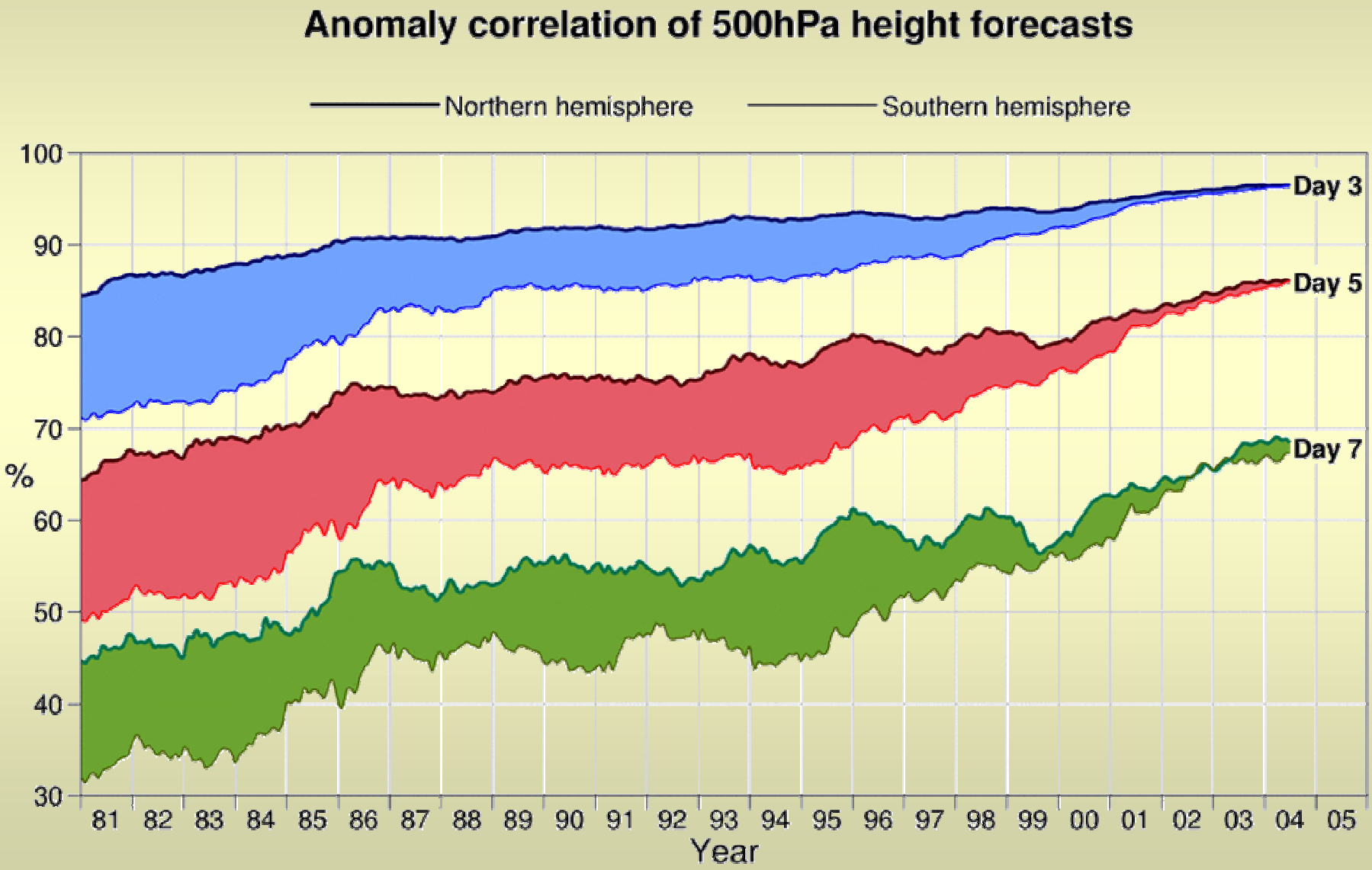
1st LPB Implementation Planning Meeting

Forecast predictability:

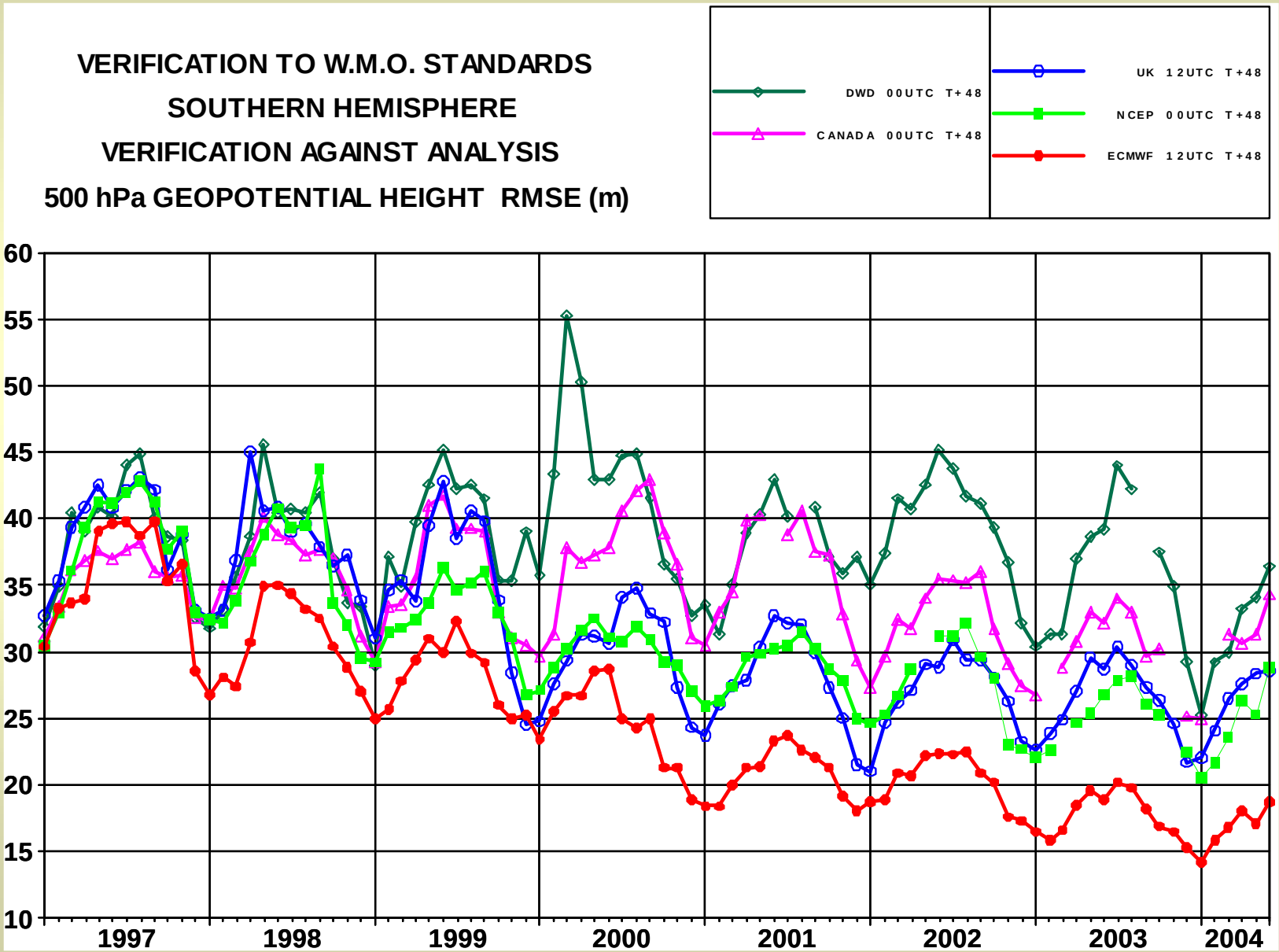
Southern versus Northern Hemisphere scores:

ECMWF

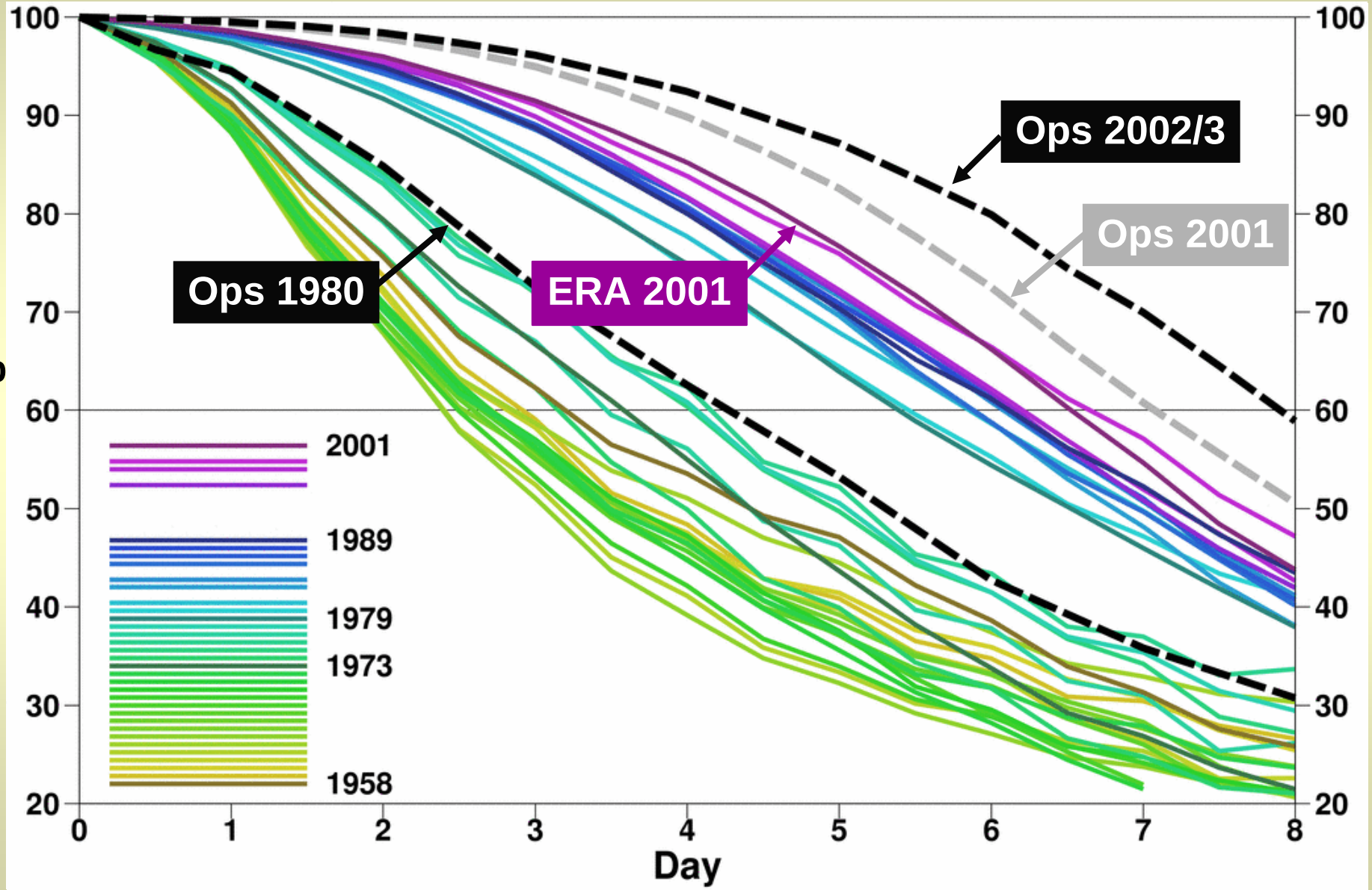
Forecasts Scores



Forecast Performance



Anomaly correlations of 500hPa height forecasts



Source : European Centre for Medium Range Weather Forecasting

•Most of the gain in predictability came from

- **better data assimilation techniques**

although significant improvement in model resolution and physics have been attained!

However, predictability according to the standard metrics is still restricted to less than 8 days....

- Research programs such as WCRP and WWRP have helped a lot improving predictability;
- LPB keeps a close link to ongoing programs
  - Example: THORPEX and GEWEX links to predictability

Objectives of the GEWEX Program

- Determine the hydrological cycle and energy fluxes by means of global measurements of atmospheric and surface properties.

- Model the global hydrological cycle and its impact on the atmosphere, oceans and land surfaces.

- Develop the ability to predict the variations of global and regional hydrological processes and water resources, and their response to environmental change.

- Advance the development of observing techniques, data management, and assimilation systems for operational application to long-range weather forecasts, hydrology, and climate predictions.

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GEWEX Research Foci

- Radiation - Determine atmospheric and surface radiation fluxes and heating with the precision needed to predict transient climate variations and decadal-to-centennial climate trends.

- Hydrometeorology - Demonstrate skill in predicting changes in water resources and soil moisture on time scales up to seasonal and annual as an integral part of the climate system.

- Modeling and Prediction - Develop accurate global model formulation of the energy and water budget and demonstrate predictability of their variability and response to climate forcing.

GEWEX Program Strategy

- **Build on existing programs and data**.(LBA and LPB in S.America)

- Conduct modeling programs to model all aspects of the hydrologic and energy cycles with evolving fully coupled atmosphere-land-ocean components.

- Make recommendations to space agencies with respect to instruments planned for satellite platforms.

- Conduct pilot studies with international participation encompassing the full range of experimental scales:

    - **small scale**
    - **continental scale**
    - global scale

Another example of a research program with close links to LPB:

THORPEX
A Global Atmospheric Research Programme

***www.wmo.int*/thorpex**

Resumé of Science Plan

- Research on weather forecasts from 1 to 14 days lead time
- Four research Sub-programmes
  - Predictability and dynamical processes
  - Observing systems
  - Data assimilation and observing strategies
  - Societal and economic applications
- Emphasis on ensemble prediction
- Interactive forecast systems “tuned” for end users – e.g. targeted observations and DA
- *THORPEX Interactive Grand Global Ensemble/TIGGE*
- Emphasis on global-to-regional influences on weather forecast skill

THORPEX is an international **research** programme of WMO aimed at extending the limits of predictability, and at increasing the accuracy of high-impact weather forecasts from day 1 to day 14.

THORPEX builds upon ongoing advances within the:

basic-research and operational-forecasting communities.

It will make progress by enhancing international collaboration between these communities, such as WGNE/WWRP/CBS and with users of forecast products.

Putting Weather into Climate Prediction

- Climate can only be predicted skillfully if the net effect of the weather on climate is quantitatively accurate – involves up-scale energy cascade: **small → large**, e.g. teleconnections forced from the small scale

- Effect of weather is only accurate if:
  - Weather systems are modeled explicitly, or
  - eddy statistics are parameterizable (convection - maybe, baroclinic waves - no)

- Current resolution of climate models precludes accurate simulation of the eddies and so extreme weather event statistics cannot be skillfully predicted $\Rightarrow$ no prediction of impacts of climate change

Putting Weather into Climate Prediction – a THORPEX and GEWEX goal

- The future: global models will have sufficient resolution to explicitly capture the motions responsible for the vast majority of the fluxes, *viz.* 1km x 100m [20 years from now?]. But society needs the answer now!

- "Seamless prediction" - inclusion of all relevant scales: a debatable proposal but ideal from a theoretical point of view.

Challenge to LPB: how to cope with the need for computer power?

CPTEC:

- **current position of plans for the future**

WGNE Overview of Plans at NWP Centres with Global Forecasting Systems

Part II: Global Modelling

Source: Majewski 2006

a) Deterministic Model (Resolution and number of layers)

Forecast Centre (Country)	2006	2007	2008	2009	2010	2011
ECMWF (Europe)	T_L799 L91	T_L799 L91	T_L799 L91	T_L799 L91	tbd	tbd
Met Office (UK)	40 km L50	40 km L70	40 km L70	25 km L90	25 km L90	25 km L90
Météo France (France)	T358c2.4 L46	T538C2.4 L60	T538c2.4 L60	T538c2.4 L60	T799c2.4 L90	T799c2.4 L90
DWD (Germany)	40 km L40	40 km L40	20 km L60	20 km L60	20 km L60	15 km L70
HMC (Russia)	T85 L31; 0.72°x0.9° L28	T169 L31 ; 0.72°x0.9° L28	T339 L31; 0.5°x0.4° L48	T339 L63; 0.5°x0.4° L48	T339 L63; 0.5°x0.4° L48	
NCEP (USA)	T382 L64 (7.5) T190 L64 (16)	T511 L80 (7.5) T254 L80 (16)	T511 L80 (7.5) T254 L80 (16)	20 km L90	20 km L90	20 km L100
Navy/NRL (USA)	T239 L30	T239 L30	T319 L36	T319 L48	T383 L48	T511 L64
CMC (Cnada)	35 km L58	35 km L58	35 km L80	35 km L80	35 km L80	15 km L80
CPTEC/INPE (Brazil)	60 km L42	40 km L64	30 km L80	20 km L80	20 km L80	10 km L100
MA (Japan)	T_L319 L40	T_L959 L60	T_L959 L60	T_L959 L60	T_L959 L60	T_L959 L80
CMA (China)	NO RESPONSE					
KMA (Korea)	T426 L40	T426 L40 (new model)	T426 L70	T426 L70 or T_L729 L70	T426 L70 or T_L729 L70	T426 L70 or T_L729 L70
NCMRWF (India)						
BMRC (Australia)	T_L359 L60	Met Office UM under ACCESS (?)	?	?	?	?

Instalation	# Procs	Top Speed (TFlop)	Processor
Korea Meteo Admin	1020	18,4	Cray X1E
China Meteo Admin	3200	21,7	IBM Power4+
ECMWF (2 systems; each has)	2176	16,5	IBM Power4+
Japan Meteo Agency (2 systems; each has)	80	10,7	Hitachi SR 11000/K1
Japan Meteo Agency	50	6,0	Hitachi SR 11000/J1
NCEP (2 systems; each has)	1152	7,8	IBM Power4+
DW (2 systems; each has)	416	3,1	IBM Power5
UKMO*	128	2,0	NEC SX-8
UKMO*	152	1,2	NEC SX-6
UKMO*	120	0,9	NEC SX-6

Source: **www.top500.org**, june06. Ordered by effective speed, not top speed

(*) not enough computing power to be at Top500

Jairo Panetta – 2006 personal comm.

Resumé of Science Plan

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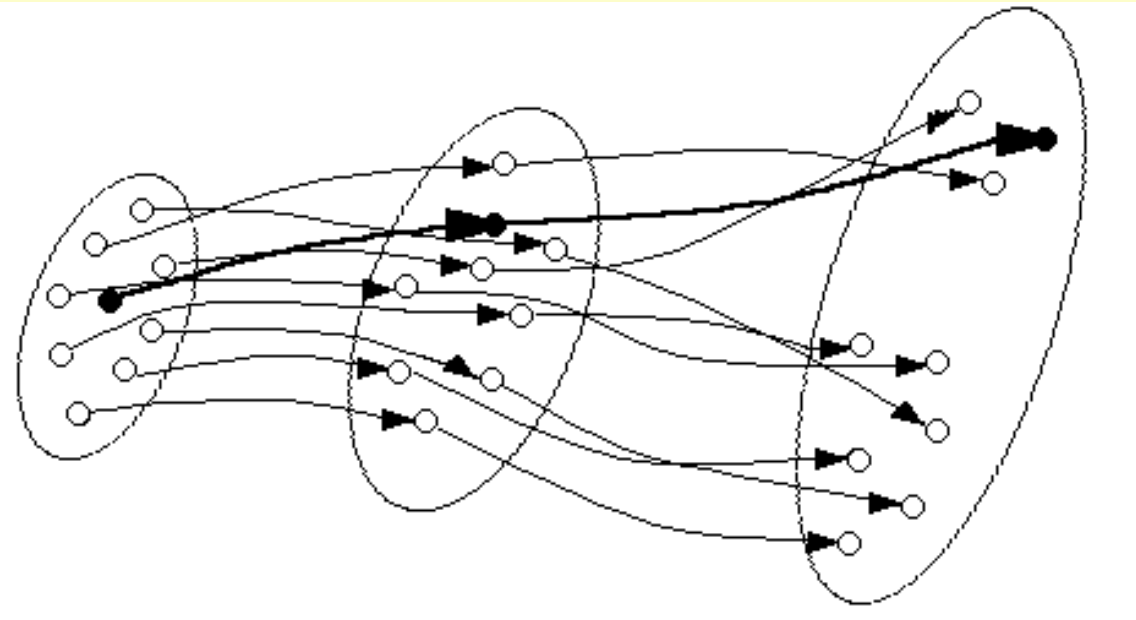
Lorenz (1963, 1965, 1969):

- Governing equations show strong dependency on the initial conditions;
- Slightly different initial conditions lead to significant changes in the forecast after a few days;



initial time

intermediate forecast

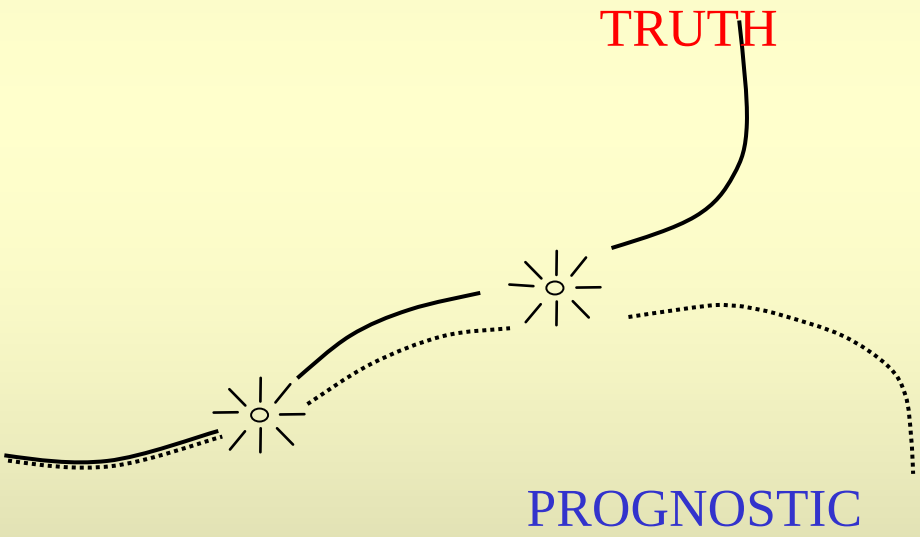
final forecast

Centreal Theorem (Lorenz, 1960s):

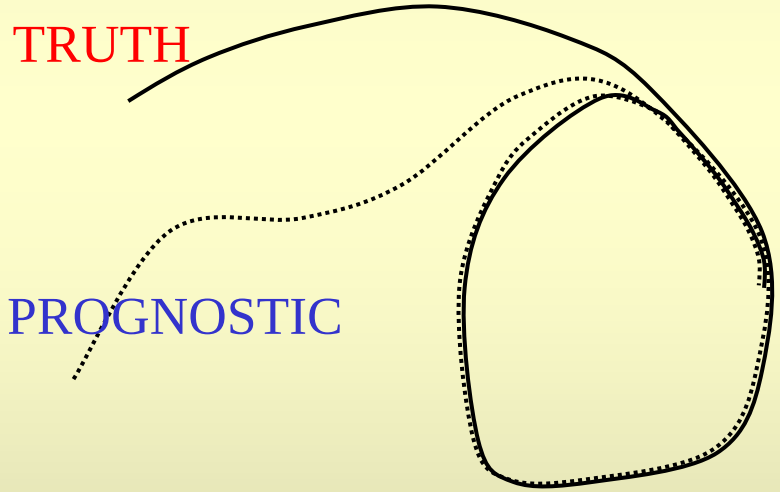
a) Unstable systems have finete predictability

b) Stable systems are infinitely predictable

a) Unstable dynamical system



b) Stable dynamical system



Institutions with NWP forecasting activities in S. America –

Academic with 'operational' activities

- Federal Univ. of Rio de Janeiro
- University of São Paulo
- University of Rio Grande Foundation
- CIMA - Argentina

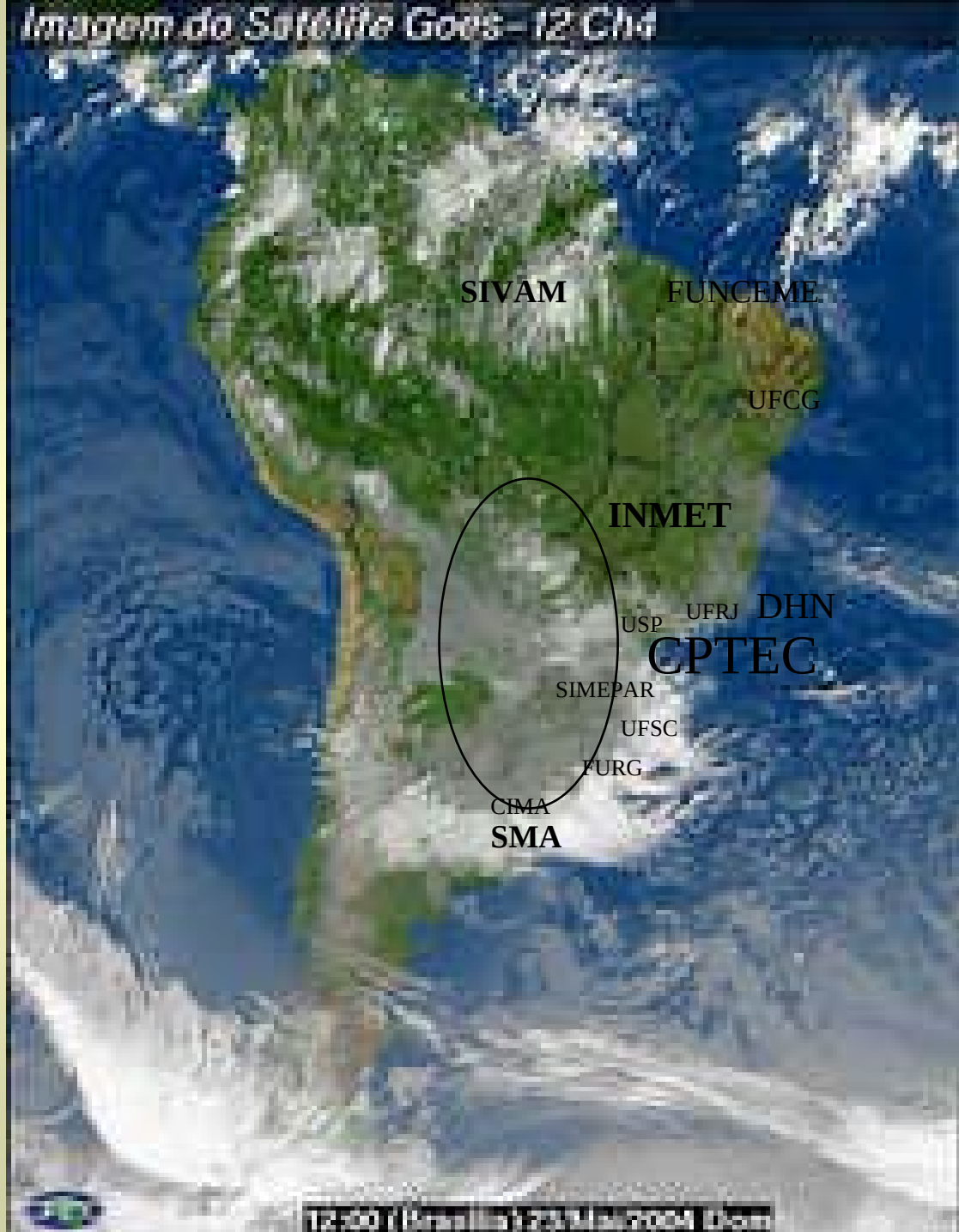
Operational/Research:

- Center for Weather Forecasting and Climate Studies - CPTEC

National Services:

- INMET - Brasil
- SMA – Argentina

Other services: Chile, Peru (preliminary); Paraguay, Venezuela…(NWP installation by private companies)



Instituition	Main Character	Model	Domain	Forecast time	Resolution km	Frequency	Initial/ Bound Cond.	Data Assim.
INMET	National Service	DWD regional	S. America	72hr	25	00 and 12	DWD	No
CPTEC	Oper/research	Global/CPTEC	global	15 days	100	00 and 12	NCEP GPSAS	Yes
CPTEC	Oper/research	ETA/CPTEC	S. America	7 days	40	00 and 12	CPTEC/GLOBAL RPSAS	No Yes
UFRJ	Semi-op/ research	MM5	SE S. Bra America	60 hr	30,10	00 and 12	AVN/NCEP	No
USP	Semi-op research	BRAMS	Central/SE S. America	72hr	20,4	00 and 12	CPTEC AVN/NCEP	Surface only
SIMEPAR	Operational/ research	BRAMS ARPS	SE/SBra N. Arg.	60hr	64,16	00 and 12	CPTEC AVN/NCEP	Surface
UFSC	Irregular op. research	ARPS	SE/SBra N. Arg	60hr	36,12,4	00 and 12	AVN/NCEP	No (possible)
FURGS	Semi-op research	BRAMS	S/Bral/ N.Arg	60hr	64,16.4	00 and 12	AVN/NCEP	No
CIMA	Semi-op Research	LAHM	S.S.America	72hr	65	00 and 12	AVN	No
UMD	Semi-op Research	ETA	Most of S. America	72hr	80 to 22	00 and 12	AVN	No

Model Intercomparison – Super Model Ensemble

Participants:

- **Center for Weather Prediction and Climate Studies (CPTEC/INPE)**
- **Brazilian National Meteorological Institute - INMET**
- **Laboratory of Meteorology Applied to Regional Weather Systems (MASTER) – Univ. of São Paulo**
- **Laboratory of Mesoscale Forecasting (LPM/Fed Univ. of Rio de Janeiro)**
- **Center of Land-Ocean-Atmosphere (CATO/LNCC)**
- **Department of Meteorology of University of Maryland**
- **Brazilian Marine Meteorological Service (SMM/CHM)**
- **Center of Environmental Resources Information and Hydrometeorology (CIRAN/EPAGRI)**
- **UKMO, ECMWF (shortly)**
- **Public available information from NCEP and other institutions**

This is work has been supporting regional activities on the THORPEX/TIGGE - WMO.

Initial Page

Intercomparação de Modelos

O laboratório MASTER do IAG/USP, o Centro de Previsão de Tempo e Estudos Climáticos do INPE, o Laboratório de Progóstricos em Mesoescala do IGEO/UFRJ, o Centro de Modelagem do Sistema Atmosfera Tera/Oceano do LNCC, o Department of Meteorology of University of Maryland, o Serviço Meteorológico Marinho (SMM) do Centro de Hidrografia da Marinha (CHM), o Centro de Informações de Recursos Ambientais e de Hidrometeorologia do EPAGRI, o Grupo de Estudos em Previsão Regional Atmosférica da EURO, o Centro de Investigaciones del Mar y la Atmosfera da UBA e o Grupo de Modelagem Atmosférica de Santa Maria da UFSM, participam de um esforço coordenado para avaliar as previsões numéricas de tempo disponíveis para o público em geral e desenvolver esquemas de previsão baseados na multiplicidade dos produtos de previsão, disponíveis em tempo real. Produtos públicos disponibilizados por instituições estrangeiras (como o NCEP/EUA) são também incluídos no processo de avaliação. Este trabalho está em sintonia com os objetivos do programa THORPEX/TIGGE da OMM. Este esforço é parcialmente financiado pela FINEP no projeto BRAMSNET.

MODELOS REGIONAIS

- **RAMSC/MASTER** (Modelo BRAMS iniciado com o Global do CPTEC - Resolução de 25 km)
- **RAMSV/MASTER** (Modelo BRAMS iniciado com o ETA20 - Resolução de 2 km)
- **TEB/MASTER** (Modelo BRAMS acoplado ao TEB iniciado com o Global do AVN - Resolução de 4 km)
- **BR_ET_g1/MASTER** (Modelo BRAMS iniciado com o Global do CPTEC - Resolução de 14 km)
- **RAMSB_g2/MASTER** (Modelo BRAMS iniciado com o Global do AVN - Resolução de 10 km)
- **RAMSQ/MASTER** (Modelo BRAMS iniciado com o Global do AVN - Operação para o Rio Grande - Resolução de 32 km)
- **RAMSS/MASTER** (Modelo BRAMS iniciado com o Global do CPTEC - Resolução de 20 km) - Experimental
- **RAMSM/MASTER** (Modelo BRAMS iniciado com o Global do AVN (acoplado com o 5tilt) - Resolução de 12 km)
- **GEPRA/GEPRA-FURG** (Modelo BRAMS - Resolução de 10 km)
- **GRUMA/GRUMA-UFSM** (Modelo BRAMS - Resolução de 20 km)
- **B_UBA_g1/BRAMS-UBA** (Modelo BRAMS - Resolução de 80 km)
- **B_UBA_g2/BRAMS-UBA** (Modelo BRAMS - Resolução de 20 km)
- **WRFAR_g1/CIMA-UBA** (Modelo WRF - Resolução de 60 km)
- **WRFAR_g2/CIMA-UBA** (Modelo WRF - Resolução de 20 km)
- **CATT_g2/CPTEC** (Modelo CATT-BRAMS iniciado com o Global do CPTEC - Resolução de 30 km)
- **CATT_g3/CPTEC** (Modelo CATT-BRAMS iniciado com o Global do CPTEC - Resolução de 15 km)
- **RPSAS/CPTEC** (Modelo ETA com assimilação de dados observados - Resolução de 40 km)
- **rPSAS/CPTEC** (Modelo ETA com assimilação de dados observados - Resolução de 40 km) - Experimental
- **ETA/CPTEC** (Modelo ETA - Resolução de 40 km)
- **ETA20/CPTEC** (Modelo ETA - Resolução de 20 km)
- **ETAIN_SE/CATO-LNCC** (Modelo ETA - Grade para a região Sudeste - Resolução de 17 km)
- **ETAIN_RJ/CATO-LNCC** (Modelo ETA - Grade para o Rio de Janeiro - Resolução de 10 km)
- **ETA40km/UMD** (Modelo ETA - Resolução de 80 km - provê somente a precipitação)
- **ETA22km/UMD** (Modelo ETA - Resolução de 22 km - provê somente a precipitação)
- **HRM/CHM** (Modelo HRM - iniciado com o Modelo Alemão (GME)) - Resolução de 30 km)
- **HRM_zoo/CHM** (Modelo HRM - iniciado com o Modelo Alemão (GME)) - Resolução de 13 km)

MODELOS GLOBAIS

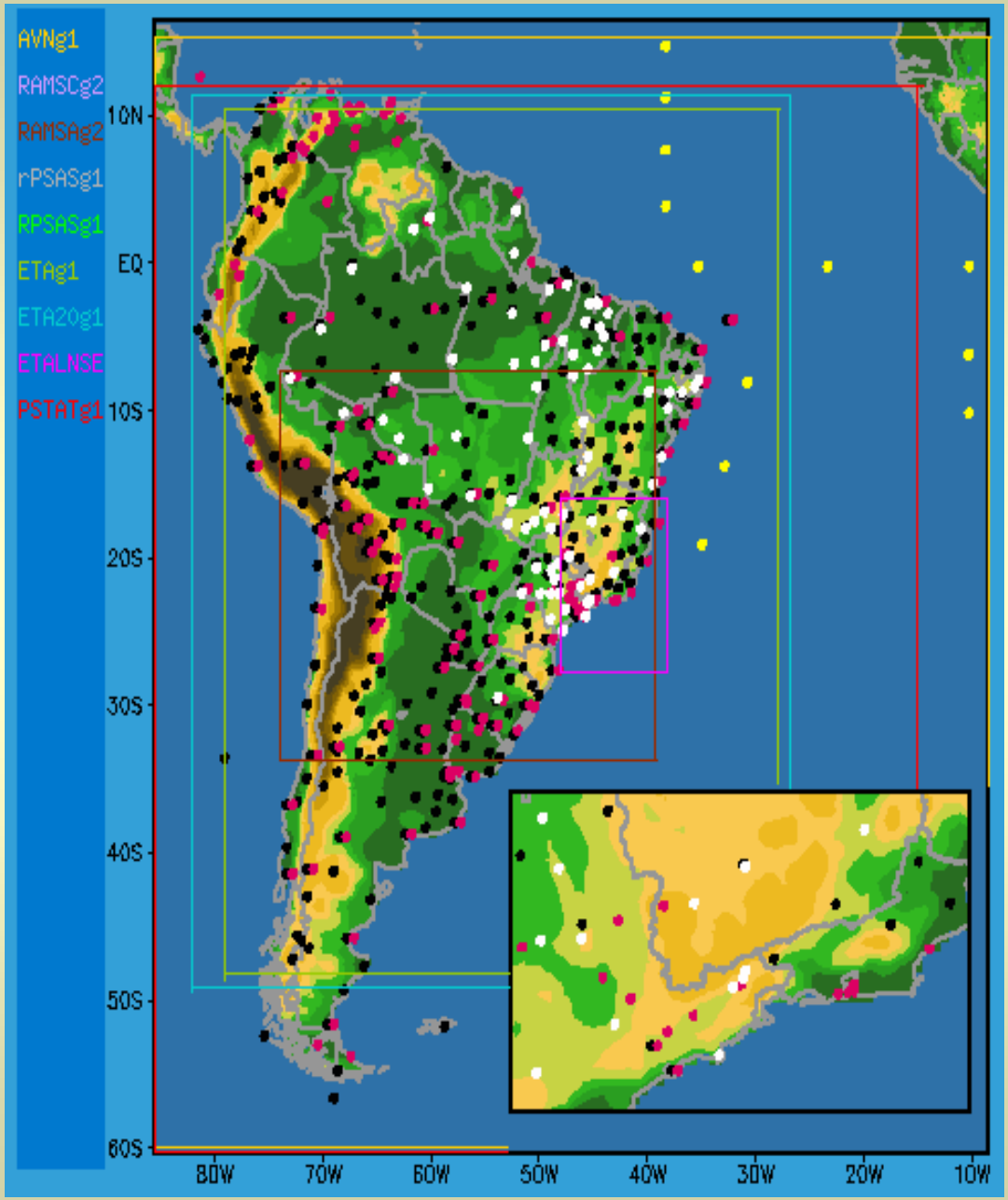
- **MRF/NCEP** (Modelo MRF - Resolução de 2.5°)
- **AVN/NCEP** (Modelo GLOBAL do NCEP - Resolução de 1°)
- **Conjunto Médio/NCEP** (Média dos membros do conjunto - Resolução de 1°)
- **T126/CPTEC** (Modelo GLOBAL do CPTEC - Resolução de 100 km)
- **Acoplado/CPTEC** (Modelo T126 acoplado com modelo oceânico - Resolução de 100 km) - Experimental
- **"Conjunto" Acoplado/CPTEC** (Conjunto obtido via 10 previsões consecutivas do modelo Acoplado/CPTEC) - Experimental
- **T213/CPTEC** (Modelo GLOBAL do CPTEC - Resolução de 63 km)
- **GPSAS/CPTEC** (Modelo com análise do CPTEC - Resolução de 100 km)
- **Conjunto Médio/CPTEC** (Média dos membros do conjunto - Resolução de 100 km)

PREVISÃO ESTATÍSTICA

- **MSMES** - *MASTER Super Model Ensemble System* (Previsão média de todos os modelos disponíveis, ponderada pelo erro médio quadrático com remoção prévia do viés) - clique **aqui** para mais informações.

Submeter

Configurações pré-definidas:



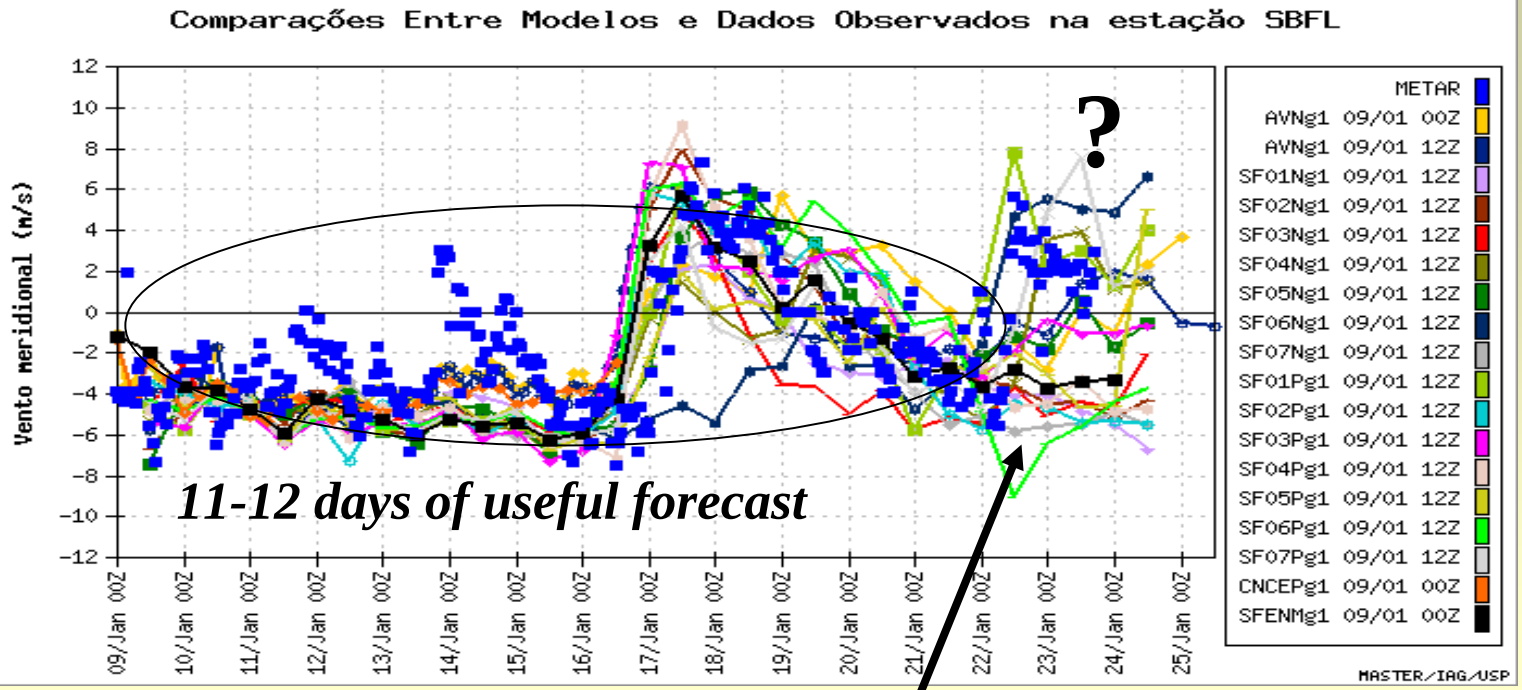
Metric:

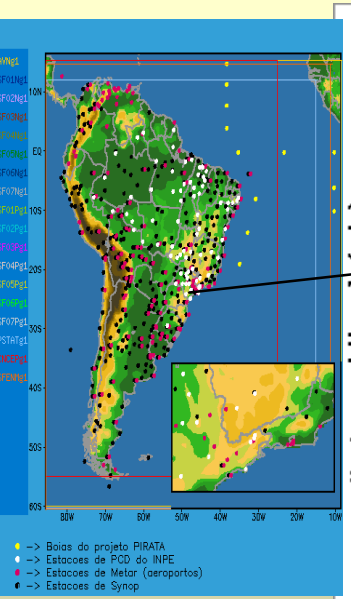
Fit to Surface Data:

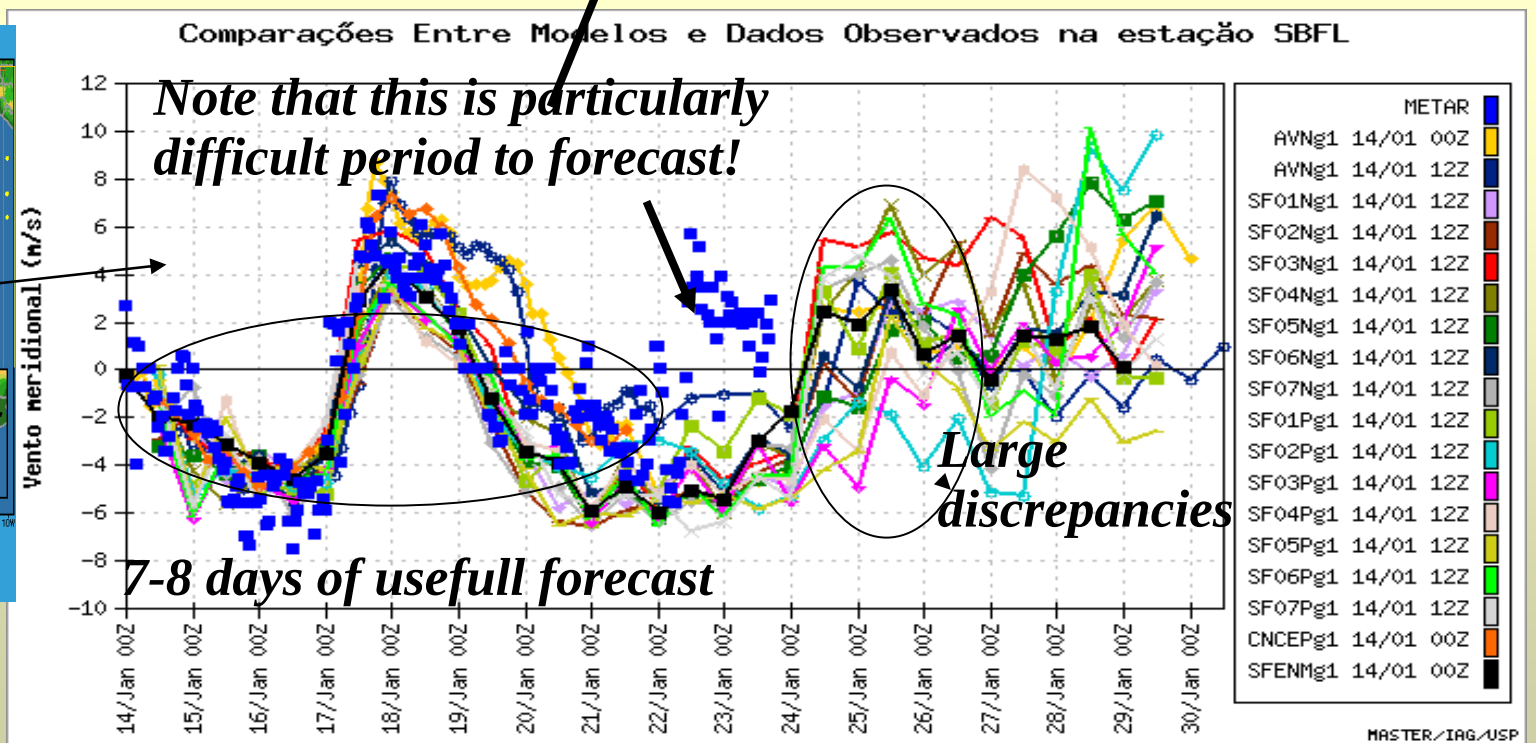
METAR, SYNOP, Autom. Stations and PIRATA buoys

-> Boias do projeto PIRATA
-> Estacoes de PCD do INPE
-> Estacoes de Metar (aeroportos)
-> Estacoes de Synop

Complex case...







Goal: improve predictability in the intraseasonal range

- Large impact in water management
- Agriculture

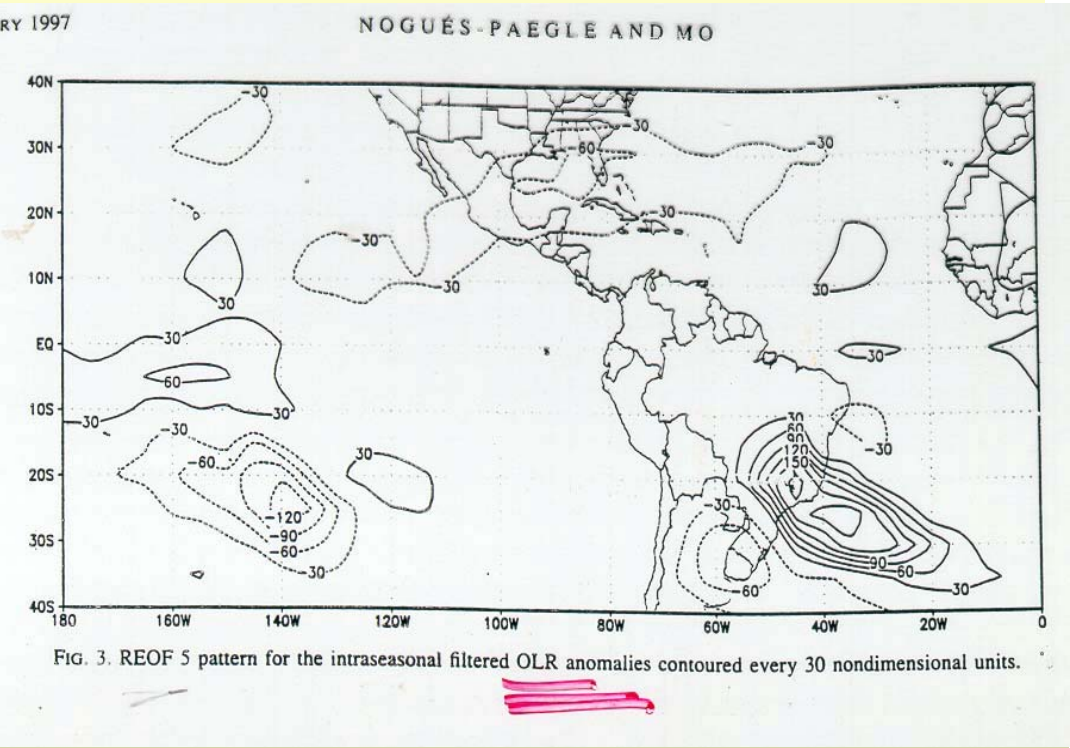
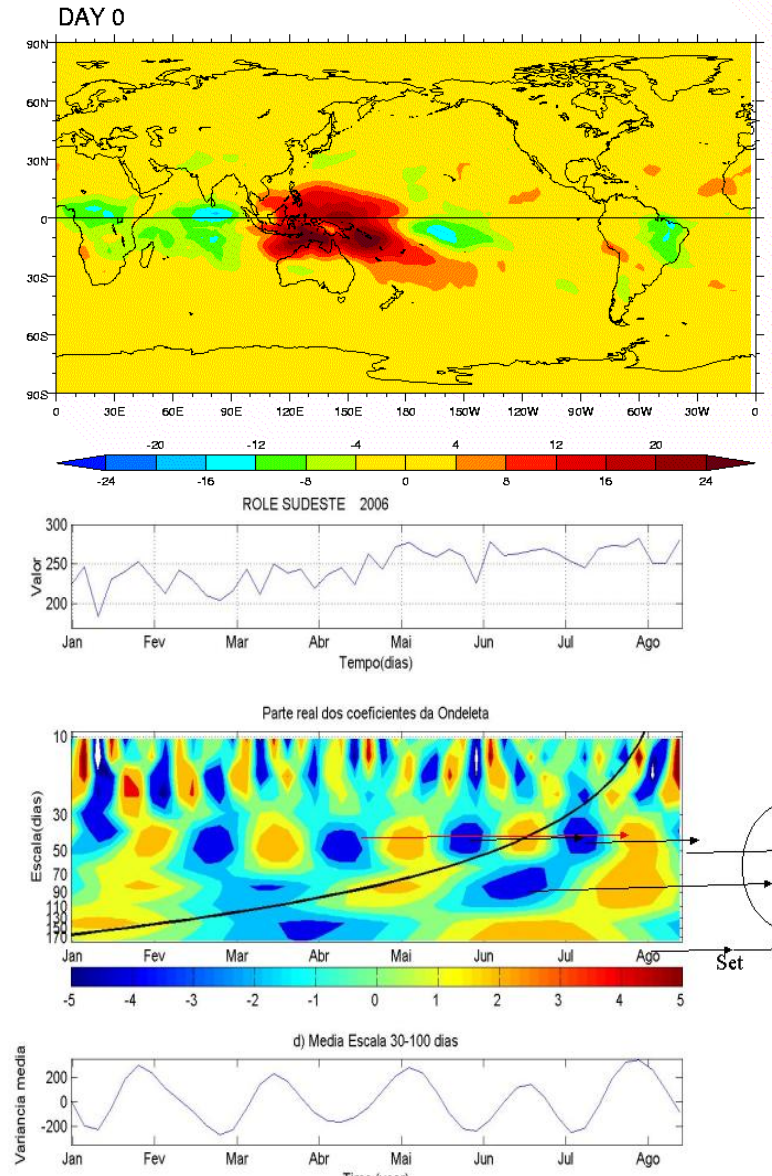
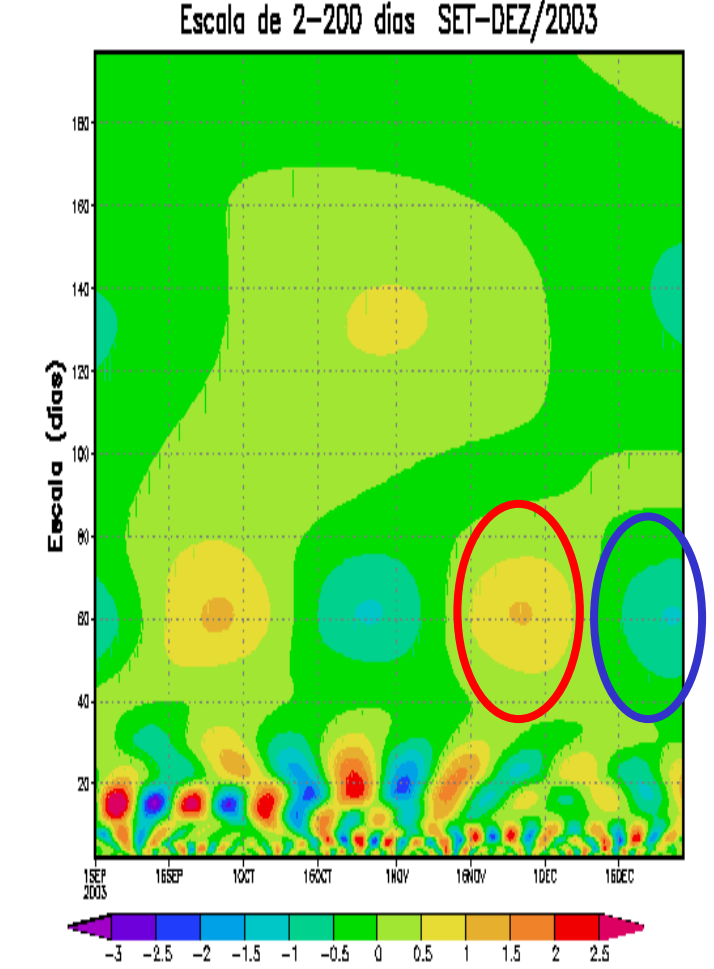
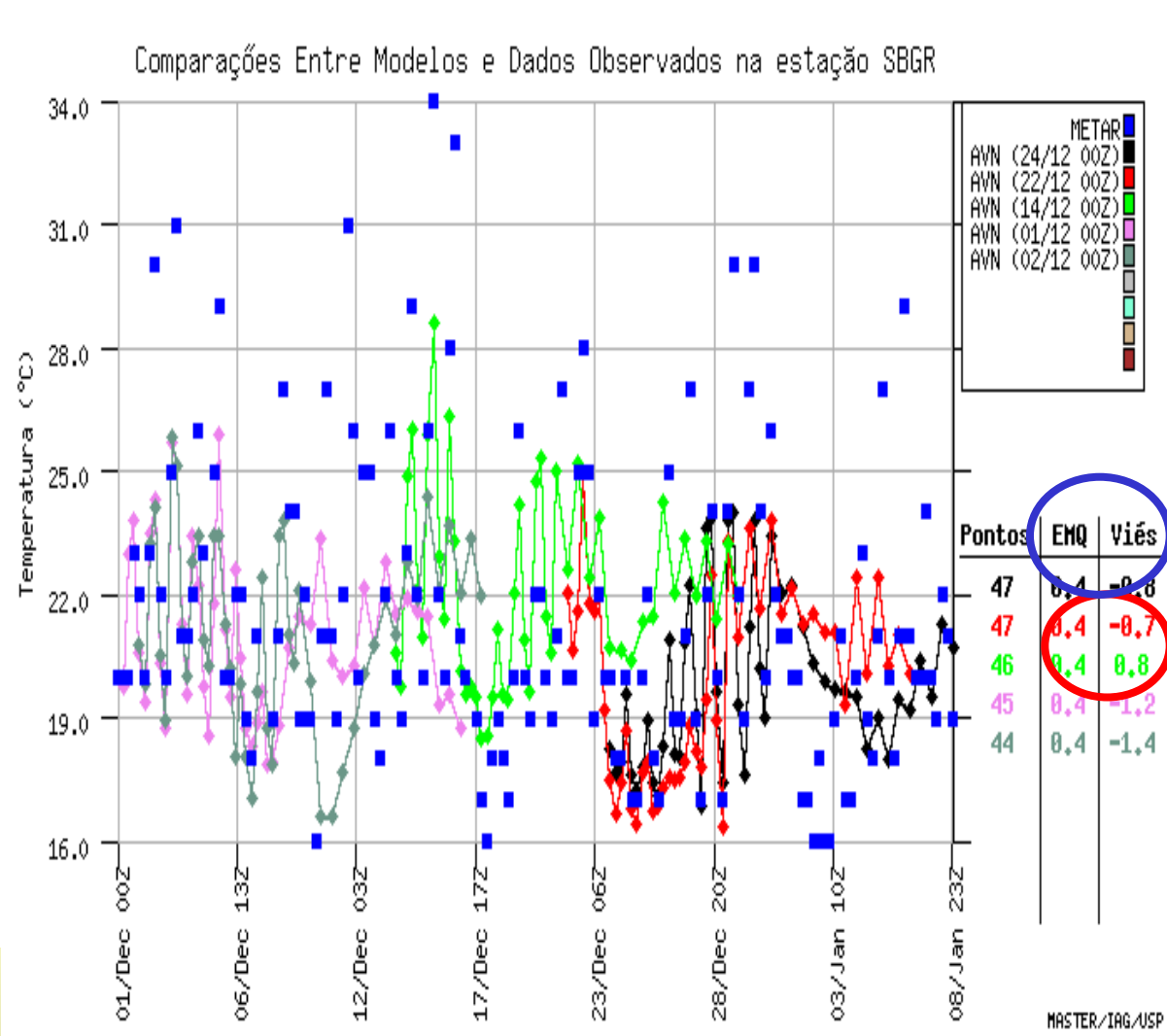


FIG. 3. REOF 5 pattern for the intraseasonal filtered OLR anomalies contoured every 30 nondimensional units.





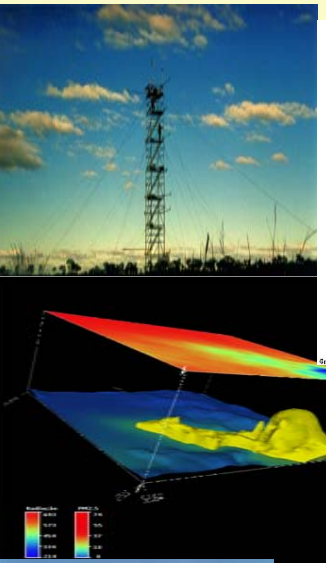


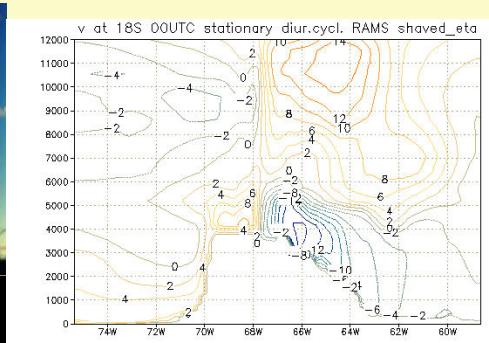
Note that the bias from 15/Dec to 06 Jan < 01/Dec to 15/Dec

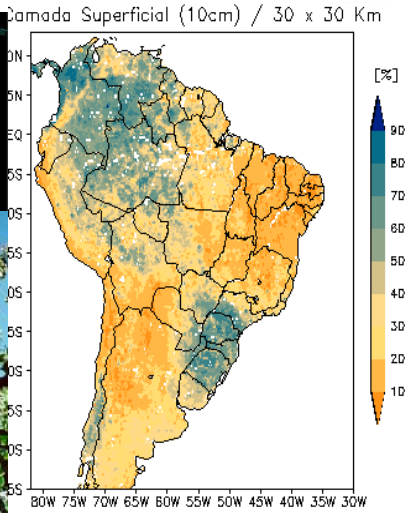
Operational forecasters ask the question: why are there periods with much higher model forecast skill?

Improvement in Model Physics

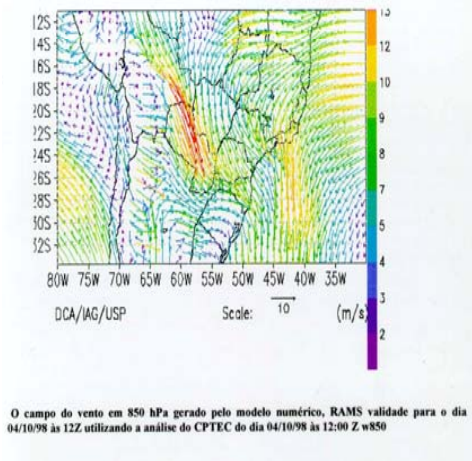
- How to deal with steep orography
- Parameterization of convective rain: MCC's are challenging!
- Role of wetlands areas : Pantanal issue and extensive flooding
- Role of biomass burning and megacity emissions in the precipitation





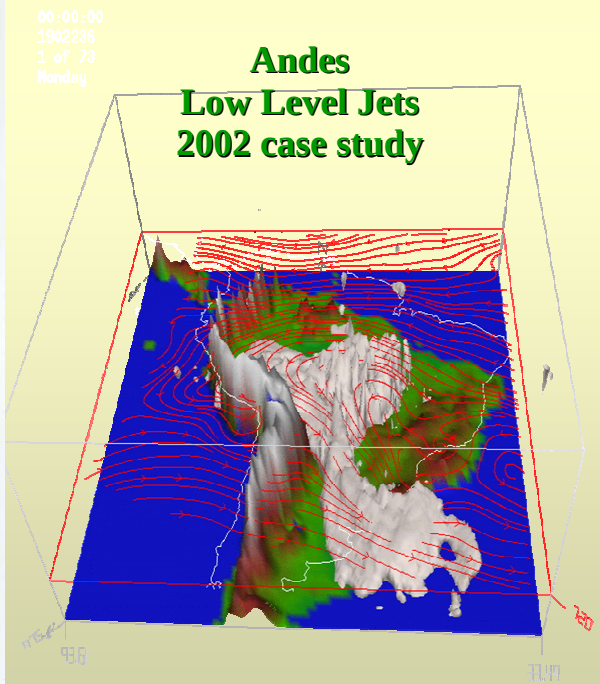



A imagem de satélite no canal infravermelho do dia 04/10/98 às 12:00 UTC



O campo do vento em 850 hPa gerado pelo modelo numérico, RAMS validade para o dia 04/10/98 às 12Z utilizando a análise do CPTEC do dia 04/10/98 às 12:00 Z w850

Low Troposphere and Long Distance Transport of PM2.5 and CO

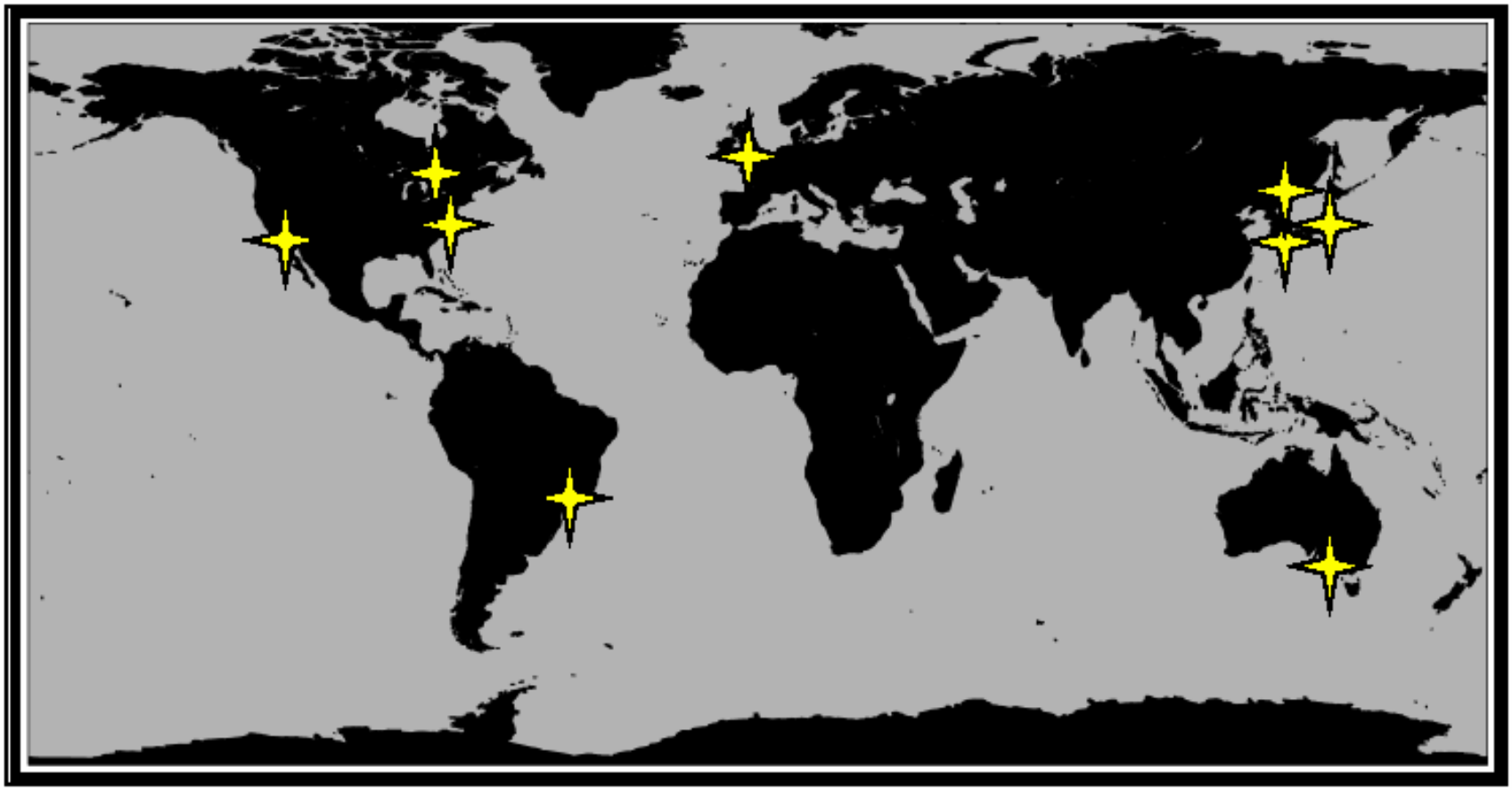


CPTEC/INPE role in TIGGE

- **receive global super-ensemble outputs**
- **produce regional subset for South America**
- **distribute regionally**

TIGGE – THORPEX Grand Global Ensemble
WMO – World Meteorological Organization

Operational Global Ensemble Prediction



Conclusions

- Improvement in model predictability from short to medium time-scales: LPB should stress the need for super-ensembles and statistical correction of NWP products

- Needs much more work in improving data assimilation in LPB – observational effort, implementation of new techniques, better use of surface and remote sensing info.

- Improvement in model phys.: water and heat balance, role of flooded areas and biomass burning in precipitation (GEWEX)

- Regional and international collaborative work (academic and operational institutions) -> Model improvement!!! Quite a progress!!!!

- Real time applications: synergism with the THORPEX and GEWEX goals