Inclusion of radiosondes data of the Campaign of LBA in the Regional Data Assimilation in CPTEC during October 15 to 29, 2002.

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The analysis system implemented at CPTEC to regional Eta model to make the initial condition using the Regional Physical-space Statistical Analysis System (RPSAS) developed at Global Modeling and Assimilation Office (GMAO), from GSFC/NASA, to improve the skill of this model. The RPSAS has been designed as an incremental improvement over the current Optimal Interpolation (OI) based in Data Assimilation System (DAS). The inclusion of the data from LBA campaign supplies additional support in the knowledge of the true state of the atmosphere in the observations grid of the data assimilation system. A comparison of Observation Data Stream (ODS) and the RPSAS analysis field and the Eta six hour forecast field (first guess) is made and the results were obtained for the period LBA campaign, October 15-29,2002 in southeast of Amazon. The Eta model was integrated daily for the 00, 06, 12 and 18 GMT using as initial condition from analyses of the RPSAS. The statistical indexes were calculated with the purpose of evaluating the quality of the analysis. The observations minus analysis and the observations minus first guess for variables: geopotential height and humidity to levels 850 and 500 were used to generate mean (bias score) and standard deviation (RMS) for each region resulting the statistical evaluating of the observing system from South America.

1.INTRODUCTION

Data assimilation has long being regarded primarily as a mean of providing initial conditions for Numerical Weather Prediction (NWP) in meteorological centers. Increasingly, it is now being recognized that, through the constant confrontation of theory (under the form of a numerical model that discretized the physical laws governing the atmospheric flow) with reality (as depicted by meteorological observations), the data assimilation process has the potential to bring major advances in our scientific understanding of the atmosphere.

The necessary **components** for a 3-dimensional data assimilation system are a forecasting model, an observing system and the statistics on the accuracy of the forecasts and measurements. At the mesoscale (1~100km), these statistics, and, in particular the information related to forecast errors, are certainly the least known and the most difficult to obtain of the three components. There is, therefore, an important research work to be accomplished in this domain and these notes describe the early results obtained in that domain with the Eta Model in CPTEC. Our researches has focused on the the PSAS and have the development of a mesoscale system.

The **Large Scale Atmosphere-Biosphere Experiment in Amazonia (LBA)** and the Tropical Rainfall Measuring Mission (TRMM) field campaign, known as TRMM/LBA, were conducted in the southwest corner of the Amazon basin during Spring, 2002. The goal of the field campaigns was to provide a detailed study of tropical Amazonia, with its different impacts, as well as on the regional response to the larger scale forcing.

The **observations** is a powerful tool for data assimilation system in this region, to improve the skill of the CPTEC regional model . In this paper, we present statistical indexes calculated with the purpose of evaluating the quality of the analysis, using radiossondes of LBA campaign.

A **Physical-space Analysis System (PSAS)** has been developed at Global Modelling and Assimilation Office (GMAO), GSFC/NASA. PSAS has been designed as na incremental improvement over the ccurrent Optimal Interpolation (OI) based in Data Assimilation System (DAS), and provide a framework to test advanced forecast error covariance model; a analysis Regional PSAS (RPSAS) resulting for the Eta System is being developed at Weather Forecast Center and Climate Studies (CPTEC).

2. DATA AND METHODOLOGY

Four times daily analyses (00, 06, 12, 18 GMT), for 15-29,October, 2002, from Regional Physical-space Statistical Analysis System (RPSAS). For this study we use Global Telecommunications System Observing, the sounding data from LBA and retrievals of NOAA Satellite produced in Satellite Division from CPTEC/INPE. Data are available on a horizontal resolution of 2.0° X 2.5° latitude-longitude grid at 14 pressure levels (1040,1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 40 hPa).

An important factor to show the stability of an assimilation system is the accompaniment of the temporary variation of **OMA** (observation less Analyzes) and **OMF** (observation less first-guess), after a wheeled static, to be verified that the values of O-A they are smaller than O-F, indicating that the fields of the analysis are approximately similar to the field of observations as the expected. This temporary variation is shown for the levels of 850 and 500 mb for the geopotential height, specific humidity and sea level pressure

It can be observed that the values of O-A are smaller than the values of O-F, being verified this way the stability of RPSAS, close to the observations for him used. This is the waited result of a Data Assimilation System.

Description of the PSAS Solver

Analysis equation:

$$w^a = w^f + K\left(w^o - Hw^f\right)$$

where

w^a	analysis state vector	$\in \mathbb{R}^n$
w^f	forecast state vector	$\in \mathbb{R}^n$
w^o	observation vector	$\in \mathbb{R}^p$
H	observation operator	$\in \mathbb{R}^{p\times n}$
K	weight ("gain") matrix	$\in \mathbb{R}^{n\times p}$
	$n \sim 10^6$, $p \sim 10^5$	

Weights K determined by minimizing $\langle \|\varepsilon_a\|^2 \rangle$:

$$\left(HP^fH^T + R\right)K^T = HP^f$$

where

$P^f = \langle \varepsilon_f \varepsilon_f^T \rangle$ Fcst. error cov.

$R = \langle \varepsilon_o \varepsilon_o^T \rangle$ Obs. error cov.

Main assumptions: unbiased observations and forecast, normaly distributed errors.

PSAS: Problem is solved in physical space in two steps:

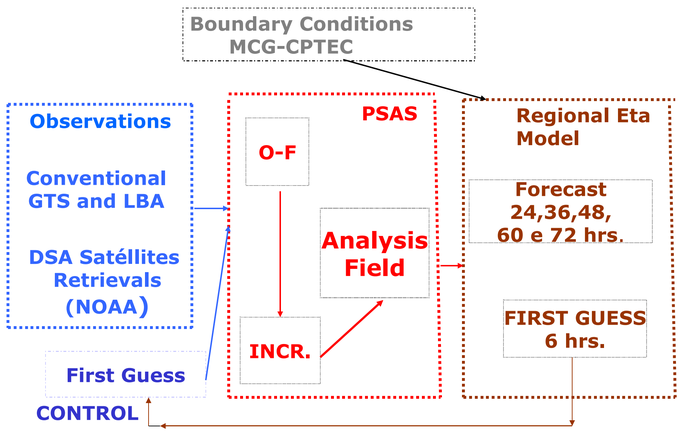
$$(HP^fH^T + R)x = w^o - Hw^f \quad (*)$$
$$w^a = w^f + P^fH^Tx$$

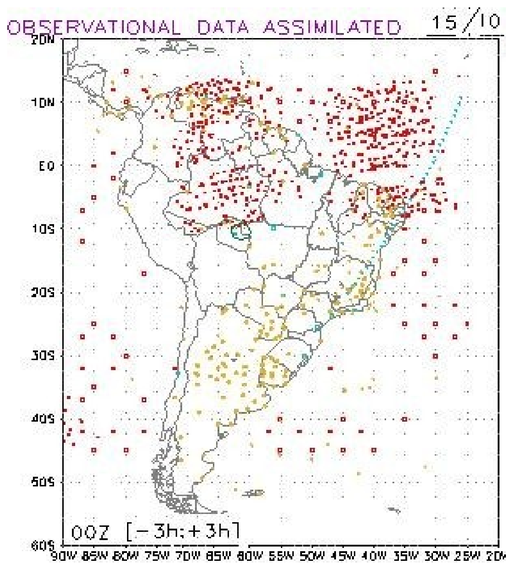
The linear system is solved globally with an iterative pre-conditioned Conjugate Gradient algorithm. As in 3D-VAR weights K are not calculated.

Pre-conditioner: sphere is divided in several regions and (*) is solved locally in each region.

Approximations: A compactly supported correlation function is assumed. Regions separated by more than a pre-determined distance (usually 6,000 km) are assumed not correlated.

RPSAS- Regional Physical-Space Statistical Analysis System





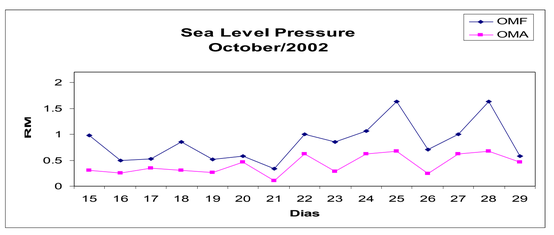
Observing System

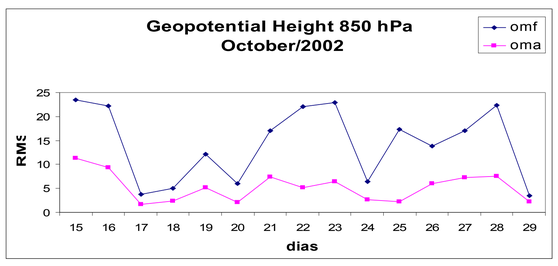
Land Surface observations: slp
Ocean surface observations: slp, u, v, and q
Rawinsondes: h, u, v and q at mandatory levels
Aircraft winds: u and v
Cloud track winds: u and v
Satellite: h,u,v

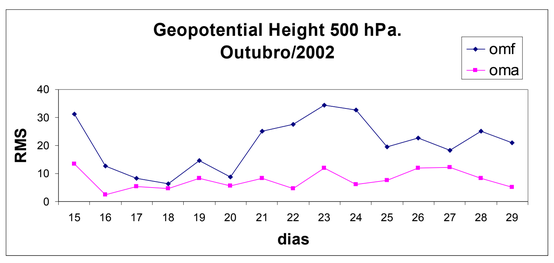
Soundings for LBA

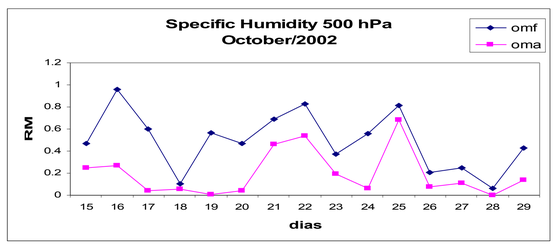
Abracos: (10°76'S-62°36'W)
Guajará Mirin: (10°75'S-65°30'W)
Porto Velho: (8°71'S-63°89'W)
Rebio Jaru: (10°14'S-61°91'W)

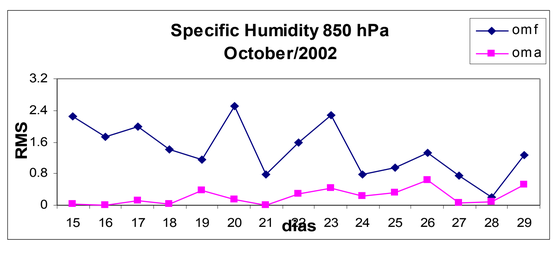
Results
OMF x OMA











REFERENCES

Cohn, S. E., A. da Silva, J. Guo, M. Sienkiewicz, D. Lamich, 1998: Assessing the Effects of the Data Selection with the DAO Physical-space Statistical Analysis System. Mon. Wea. Rev., 126, 2913-2926.

da Da Silva, Arlindo , M. Tippet, J. Guo, 1998: *PSAS User's Manual.* DAO Offoce Note 96-02, NASA/ Goddard Space Flight Center,25pp

Cintra, R., Tota, Julio, Herdies,D.,Aravequia, J.,Bonatti,J.P., 2002:Statistical Evaluation of the Wet Season Atmospheric Mesoscale Campaign – LBA and GTS Observations used in RPSAS with CPTEC Eta model**.** II Conferencia Científica LBA. Manaus.AM.

Cintra, R. e Aravéquia, J. A.: *Apresentação do Método de Geração de Dados para Assimilação do Modelo ETA/CPTEC*. Anais do X Congresso Brasileiro de Meteorologia. Brasília – DF, 1998.

Cintra, R., Bottino, M., Aravéquia, J. A., Bonatti, J. P.: *Avaliação dos Campos de Pressão Ao Nível do Mar e Altura Geopotencial gerado pela Assimilação de Dados em Modelo Regional de Previsão Numérica de Tempo usando um Sistema Estatístico em Espaço Físico de Análise Objetiva*. Anais do IX Congresso Latino Americano e Ibérico de Meteorologia. Buenos Aires, Argentina. 2001.

Daley, R. *Atmospherics Data Analysis*, New York: Cambridge University Press, 1991