Data Assimiliation Study using SALLJEX Data

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Introduction

A data assimilation study is being performed to assess the impact of observations on analyses over a usually data sparse region. The study uses radiosonde data taken during the South America Low-Level Jet Experiment (SALLJEX) (November 2002-February 2003), which focused on the region east of the Andes Mountains from western Brazil southward to central Argentina. This region has a high frequency of occurrence of a northwesterly Low-Level Jet (LLJ) and Mesoscale Convective Systems (MCS). A better understanding of the vertical and spatial atmospheric structures associated with these features is necessary in order to validate existing global and regional models, and ultimately to improve forecasts and simulations on a variety of time scales.

The additional SALLJEX soundings are included in the data assimilation system of CPTEC to prepare the initial conditions used to integrate the Atmospheric Global Circulation Model. One of the purposes of assimilating these data is to assess their impact on the initial conditions and on the forecasts for specific cases. Another objective is to provide a reanalysis set for the period of the experiment. The additional soundings were taken in areas where there is lack of conventional data; Rio Branco (Brazil), Dourados (Brazil), Santa Cruz (Bolivia), Resistência (Argentina), Santiago del Estero (Argentina) and Mariscal Estigarribia (Paraguay). These stations are indicated in Fig. 1, along with the locations of operational radiosonde stations in South America. The additional sites were chosen considering the entrance and exit regions of the LLJ. The assimilation of these data is expected to improve the LLJ analysis and forecasts.

The Data Assimilation System

The data assimilation scheme blends observations with a short term (6-hour) forecast, which is a first guess of the state of the atmosphere. The scheme implemented at CPTEC is the Physical-space Statistical Analysis System (PSAS), developed at the Global Model Assimilation Office (GMAO/ NASA) (Da Silva and Guo, 1996; Cohn et al., 1998). PSAS is a global analysis system with characteristics of 3D-Var and Optimal Interpolation, in which the minimization is performed in the physical space of the observations, rather than in a model space. PSAS solves the analysis equation globally rather than locally, similar to the global spectral variational analysis system (3D-Var) and it is fundamentally independent of the forecast model formulation. Therefore, it is a portable algorithm suitable for global and regional models.

The scheme runs with the spectral Atmospheric Global Circulation Model CPTEC/COLA, with T126 L28 resolution, which corresponds to 100 km in the horizontal with 28 levels in the vertical sigma coordinate. Details of this model can be found in Cavalcanti et al. 2002. The assimilation scheme has a regional version (RPSAS), which runs with the Regional Eta Model with a horizontal resolution of 40 km and 38 vertical layers (Seluchi et al, 2003).

The Global dataset used in the assimilation system is obtained from the Global Telecommunication System - GTS (T, P, u, v, q), ATOVS (temperature and humidity), QuikScat data (u and v over the ocean surface) and Total Precipitable Water (TPW). In addition, this study uses the radiosonde data taken from the SALLJEX (see SALLJEX stations shown in Fig. 1).

GTS sites - SALLJEX sites

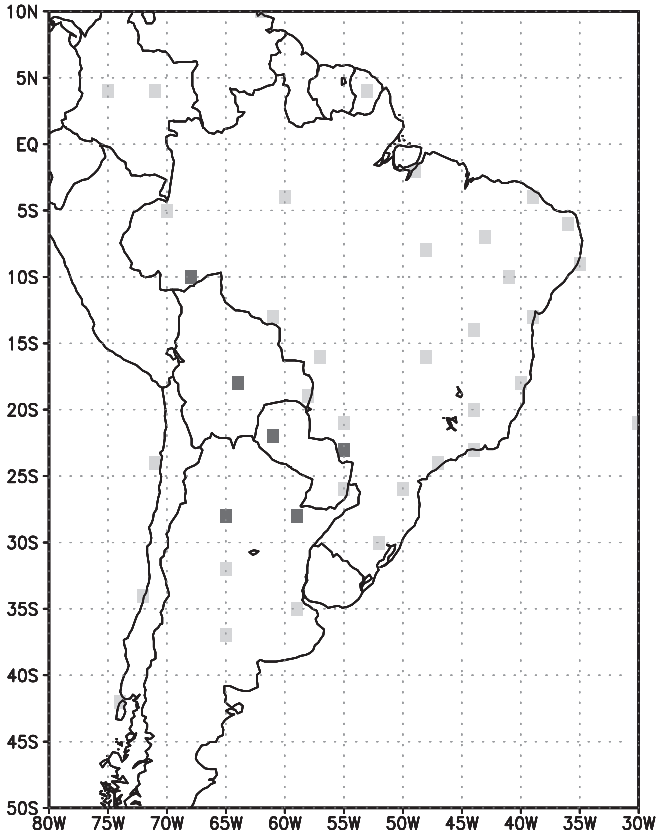

Fig. 1- Location of GTS data (light grey squares) and SALLJEX data (dark grey squares).

Preliminary results

As a pilot study, we selected the period 15-24 January 2003. On 21 January 2003 an intense MCS developed over northern Argentina and then propagated north-northeastward into Paraguay. Two experiments were performed, one without SALLJEX data (control), and another including the additional SALLJEX soundings.

The objective was to verify the impact of assimilating the additional data on the analyses and model forecasts. A time series of the vertical structure of meridional moisture flux, from the daily analysis taken at a grid point (18^0 S, 62^0 W) to the north of the MCS development shows a gradual increase in the intensity of northerly moisture flux reaching a maximum on 21 January. The moisture flux in the model results changed direction to southerly on 24 January. These results are consistent with the MCS development on 21 January and with the synoptic conditions observed in satellite images. Both experiments revealed similar features, but the intensity of the northerly moisture flux was larger in the experiment using the additional SALLJEX data (Fig. 2).

Another difference was found in the position of the maximum moisture flux on 21 January. In the experiment with the additional SALLJEX data, the maximum was slightly shifted to the west of the region of the LLJ. This shift and greater intensity occurred only within the longitude band of the LLJ, where additional SALLJEX soundings were taken. No difference was found at longitudes farther to the east, where there was another maximum of northerly moisture flux associated with the convergence and presence of a frontal system. The forecasts showed an increase in the intensity of the northerly flow and in the humidity over Bolivia when the additional SALLJEX data are included. Furthermore, the vertical structure of the meridional wind and humidity in the forecasts using the SALLJEX data are much closer to the observed radiosonde profiles than those produced in the control experiment (Fig. 3).

Ongoing and future activities

The data assimilation system at CPTEC is being used to reanalyze the entire period of the SALLJEX. This data set will be made available on the JOSS web site. During January 2003 several synoptic and mesoscale systems developed over South America, and there was considerable variability of the meridional wind in the LLJ region. The reanalysis dataset from the data assimilation system will be used to investigate this variability and to explore the details of atmospheric conditions in a region where there is generally a lack of meteorological observations. A detailed study of the synoptic and mesoscale conditions, mainly related to the moisture flux, LLJ and the South American monsoon variability, will be possible using the reanalysis data. The impact of assimilating the SALLJEX data will be assessed through these analyses and comparisons with control analyses, and also by studying the forecasts based on the two sets of initial conditions. Other investigations will include: sensitivity experiments using data from one station at each time, verification of the remote sensing data impact compared to the extra SALLJEX data impact and use of PSAS with the Regional Eta Model, considering the boundary conditions from the CPTEC AGCM reanalysis (including SALLJEX dataset).

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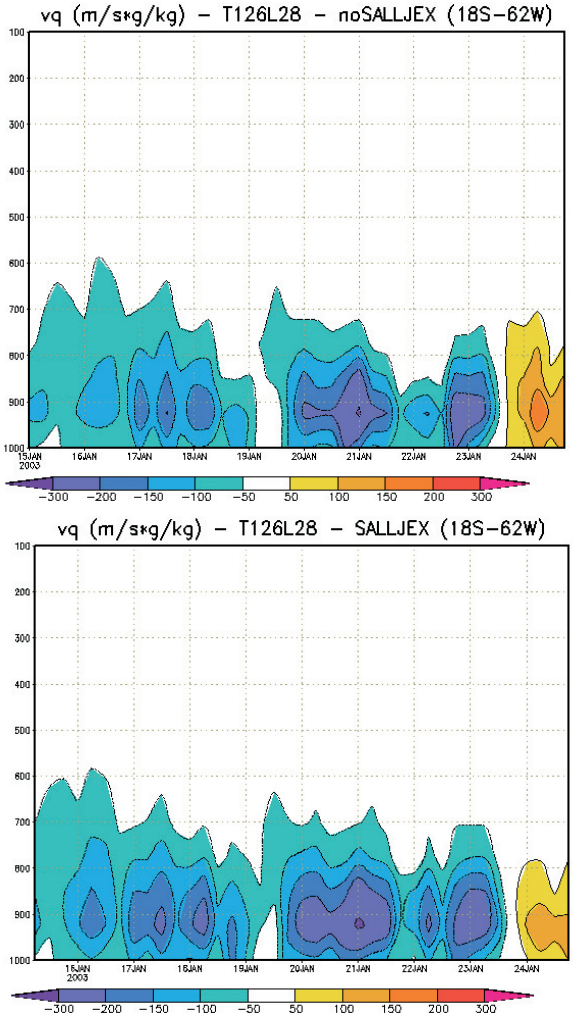

Fig. 2- Timeseries (15-24 January 2003) of moisture flux vertical section at 18^0S , 62^0W for (top) without SALLJEX data, (bottom) including SALLJEX data

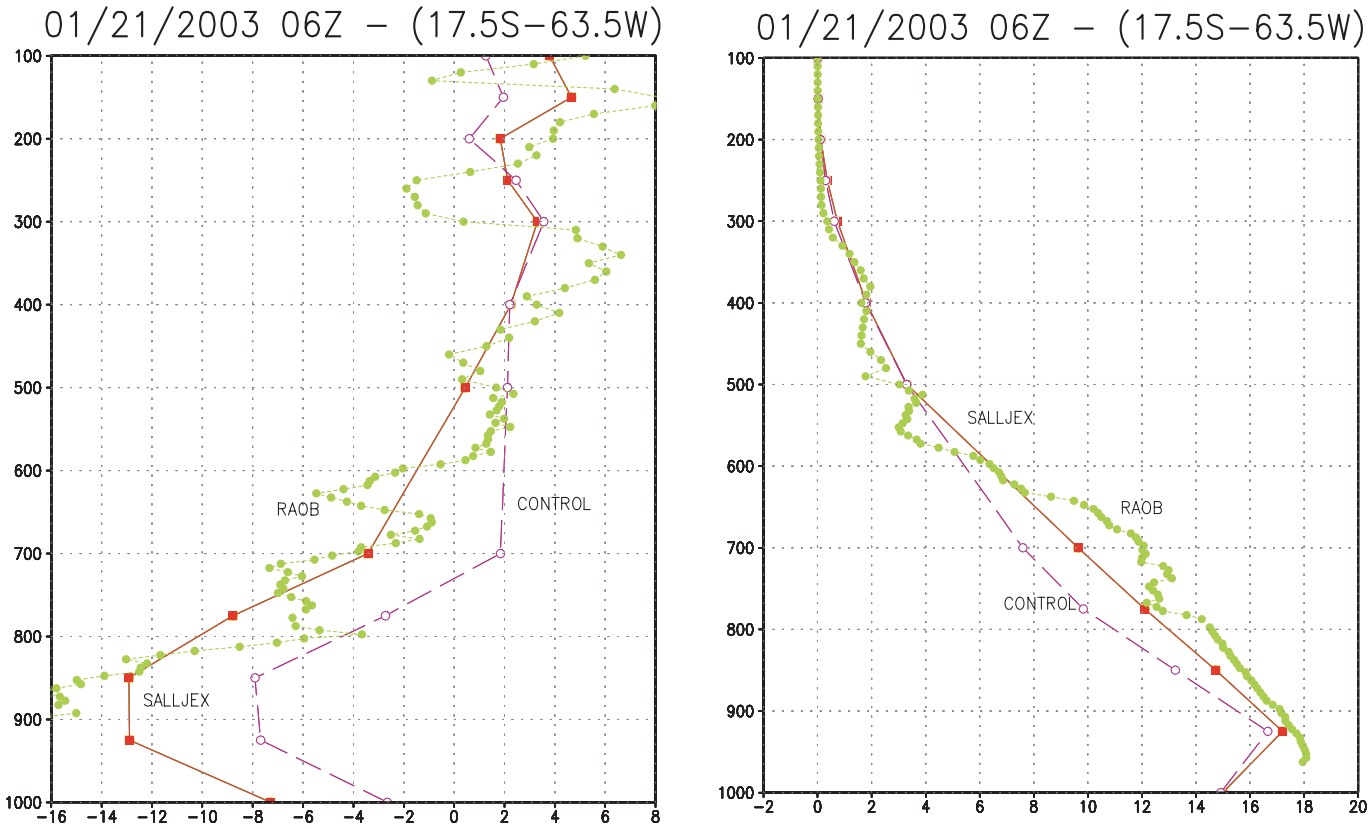

Fig.3- Vertical structure of (left) meridional wind, (right) humidity, on January, 21, from radiosonde data at Santa Cruz (17.50S, 63.50W) (RAOB), and forecast results using SALLJEX data and from the Control

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