FIRST RESULTS FROM THE USE OF THE AQUA SOUNDING SYSTEM IN THE CPTEC GLOBAL DATA ASSIMILATION/FORECAST SYSTEM

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Introduction

During the last decade the gain in quality in the initial conditions of the state of the atmosphere or the analysis for the numerical weather models has become a critical aspect for the improvement for weather forecast. Observations of atmospheric parameters are obviously the main ingredients for a good analysis. Satellite observations those were the principal contributors over southern hemisphere for some time, have recently been become the primary source of the information to global analysis and forecasts. This great importance has been documented in a series of studies where satellite data have been withheld in data assimilation experiments (Zapotocny et al., 2005; Kelly et al., 2004).

Nowadays, remote sensing data have become the predominant source of information at Center for Weather Forecasting and Climate Studies of the National Institute for Space Research (CPTEC/INPE). This center is responsible for producing weather forecast in Brazil. The CPTEC uses operationally information from ATOVS/NOAA sounding system to supply the lack of vertical atmospheric profiles. For these reasons, constant efforts are made towards incorporating more observations into operational analysis. This paper presents preliminary results from the use of AQUA sounding system (AIRS/AMSU retrievals) in the CPTEC global data assimilation/forecast system. Experiments have been conducted by using these datas to evaluate its impact on weather analysis and forecasting. In these experiments, AIRS/AMSU retrievals were assimilated by using the Physical-space Statistical Analysis System (PSAS) data assimilation system. The spectral Atmospheric Global Circulation Model CPTEC/COLA was used to generate the first guess forecast up to 5 days. The experiments performed as well as the verifications methodologies are described in the next section. The results are presented in section 3 where as the conclusions are discussed in the last section.

Experimental design and verification methodology

Assimilation and forecast experiments have been realized in CPTEC by using the Global Physical-space Statistical Analysis System (GPSAS), which represents a combination of the Spectral Atmospheric Global Circulation Model (CPTEC/COLA) with the Physical-space Statistical Analysis System (PSAS). The system runs with the model CPTEC/COLA with T126L28 resolution, which corresponds to 100 km in the horizontal with 28 levels in the vertical sigma coordinate. The details of this model and of assimilation scheme can be found in Cavalcanti et al. (2002) and Cohn et al. (1998), respectively.

Three experiments were done to investigate the impact of the AIRS/AMSU retrievals on weather analysis and forecasting. In the first experiment, denominated control (CTRL), conventional data 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 Precipitation Water (TPW), are used in the assimilation system. In the other experiments, AIRS/AMSU retrievals (version v4 of the algorithm retrieval, SussKind et al. 2003) have been included in the assimilation process. These vertical profiles were selected according to quality control flags which provides qualitative information on the accuracy of the retrievals (Fetzer et al, 2004). Thus, only the highest quality retrievals simultaneously in the bottom, in the middle and on the top of the troposphere were used.

The PSAS analysis requires temperature profiles observations to be converted into geopotential height profiles by using the hydrostatic relation and "anchoring" the profile with the background surface pressure. Thus, the first experiment (EXP1) use the hydrostatic relation to convert temperature profile into thickness and considers the first guess height field for the anchoring of the AIRS/MSU height profile, therefore, the lowest height value, which would be exactly the first guess is not included in the observation vector. The second experiment (EXP2) used directly the geopotential height profile generated by algorithm retrieval. Here the height of surface is included in the observation vector. These experiments provide an evaluate of the impact of the anchoring process in the analysis and forecasts. In order to evaluate the possible differences between height AIRS/AMSU profiles assimilated in the EXP1 and EXP2, the AIRS/AMSU profiles had been compared with radiosondes data (320 radiosondes for the 12 UTC). It is noted in Figure 1 that highest differences in the RMS error occur at 300 hPa for 30 hPa. In addition to it, it is also noted the negative Bias (~ -20 m) above 300 hPa for the height profiles in the EXP1, indicating the underestimated of the geopotential height in the tropopause level. For the height profile in the EXP2 the Bias is positive. These results indicate that little errors in the first guess can generate these differences associated to anchoring process.

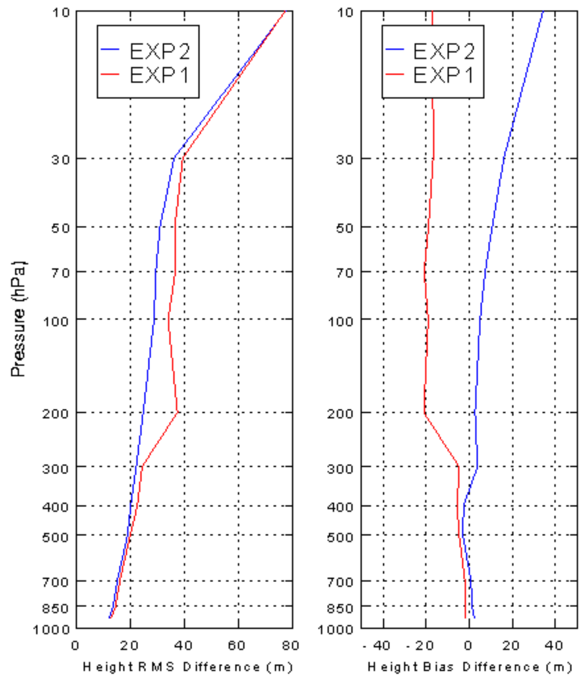

Fig. 1: Geopotential height RMS (left) and BIAS (right) differences for the selected profiles: RAOB versus geopotential height profile anchored in the first-guess (EXP1); RAOB versus geopotential height profile generated by algorithm retrieval (EXP2).

This study was realized for march 2004. The anomaly correlation (AC) score and root mean square (RMS), are used in verification statistics. The AC is the correlation between verifying analysis and predicted deviations from climatological conditions. The verifying analysis field used is the EXP2 analysis. The RMS is evaluated against observations data (radiosonde). For this, the models field were interpolated to the same point of the observed data and the differences between the interpolated values and observations were used. The set of 1525, and 959 (6568, 6983) geopotential height observations at 850 hPa, and 500 hPa levels, respectively, on South Hemisphere (North Hemisphere), have been selected to provide preliminary forecast verification. For the zonal wind component at 850 hPa, and 250 hPa levels, the quantity of the observations are 1397 and 1106, respectively, on South Hemisphere, and are 6663 and 6348 observations, respectively, on North Hemisphere. The analyses are realized for the 12 UTC analyses and forecasts.

In addition, impact statistics are calculated as in Zapotocny et al. (2005). In particular, the forecast impact statistic is the difference in RMS error between the EXP2 and CTRL experiment normalized by the RMS error of the EXP2 and multiplied by 100 to normalize the result. The verification is performed against EXP2 analyses. It provides a percentage improvement with respect to the control forecast. A positive result means that the forecast quality is improved when the retrievals AIRS/AMSU are included. Additionally, spatial fields of statistics such as RMS error were generated by replacing the averaging over horizontal grid points (equation 2, Zapotocny et al., 2005), with averaging over all runs in the month concerned. These verifications exclude the five first days of period, and reduces the analysis period to 26 days. Finally, it is important to note that the period used in this study was run with the GPSAS operating in cycling mode.

Results

The Figure 2 shows Anomaly Correlation (AC) for the GPSAS over the Northern Hemisphere (NH), the Southern Hemisphere (SH), and the South America (SA) regions in March 2004 at one to five days, with and without AIRS/AMSU retrievals. Figures 2a, 2b and 2c, shows the impact at 850hPa and the Figures 2d, 2e, and 2f shows the impact at 500 hPa. There is a significant positive impact for the SH (Figures 2b e 2d) and the AS (Figures 2c e 2f) from days 2 to 5 when AIRS/AMSU retrievals are assimilated during this period. The improvement in forecast skill at four days in (SH), with the EXP2, is equivalent to gaining an extension of forecast capability of six hours. Specifically over AS, this improvement is of twelve hours. In the NH the impact is smaller.

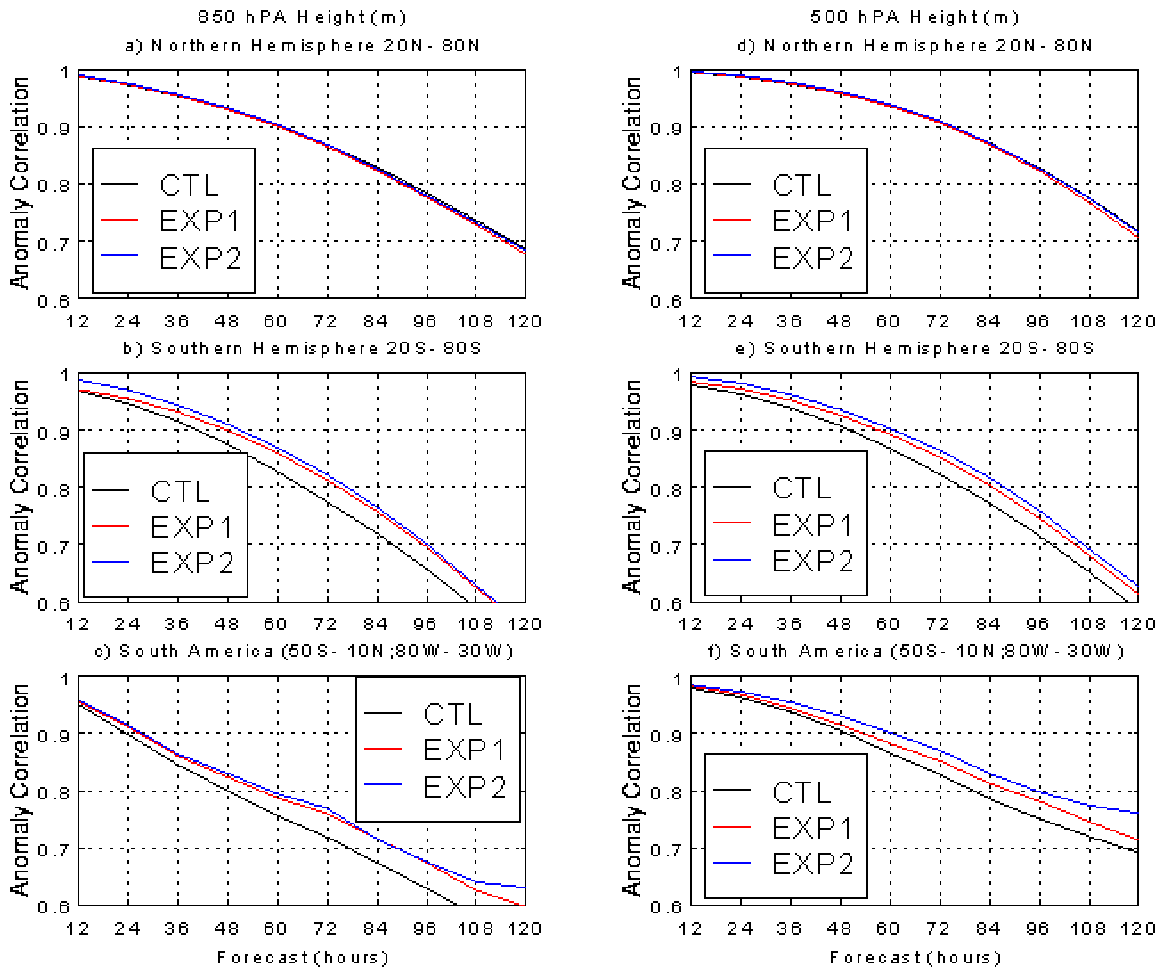

Fig. 2: Geopotential anomaly correlation scores at 850 hPa and 500 hPa, over Northern Hemisphere (1a and 1d), Southern Hemisphere (1b and 1e) and South America (1c and 1f).

The RMS errors for geopotential at 850 hPa and 500 hPa, wind components at 850 hPA and 250 hPa, in both hemispheres, for march 2004 at one to five days, with and without AIRS/AMSU retrievals, are shown in the Figure 3. The results consider all the forecasts of 12 UTC, and indicate improvements in forecasts when enclosed soundings AIRS/AMSU in the assimilation/forecast system, compared to those without the inclusion of these data. Consistent with the correlation analyses, the RMS errors present a positive impact of the inclusion of AIRS/AMSU retrievals in the global system of assimilation/forecast at CPTEC.

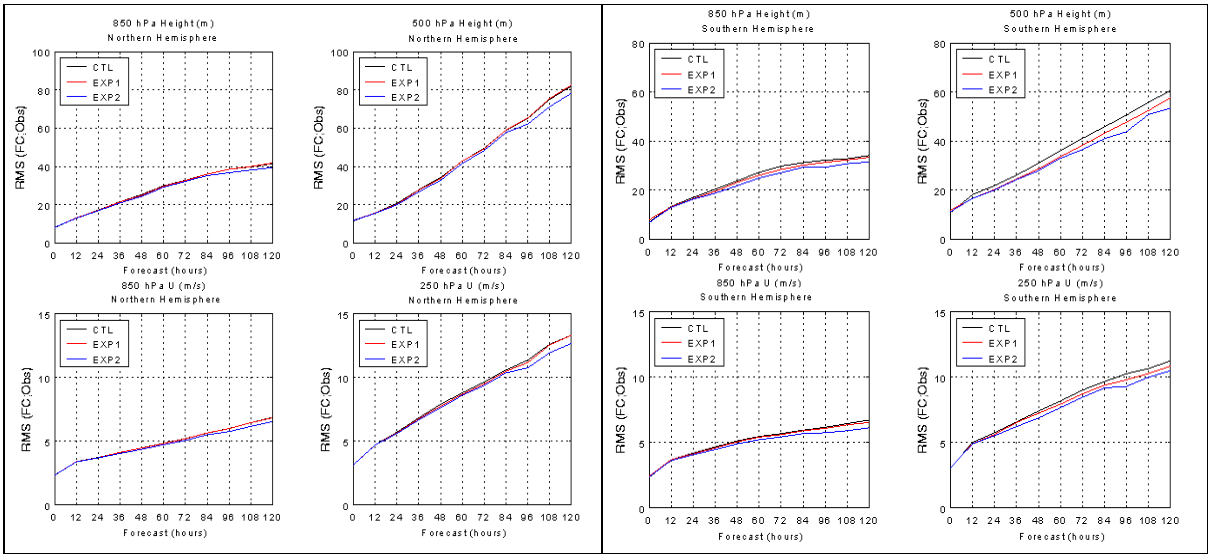

Fig. 3: Geopotential at 850 hPa, and 500 hPa, and zonal wind components at 850 hPa, and 250 hPa, forecasts errors as verified against radiosondes, over the northern (right) hemisphere and southern hemisphere (left).

The results of the time-averaged forecast impact (FI) on the domain of South America, for the 24, 48, 72, and 96 hours forecasts periods, are shown in the Figure 4. The results are presented for the zonal wind component, the geopotential height, the temperature and relative humidity at 1000 hPa, 850 hPa, 500 hPa, 300 hPa, 200 hPa levels. For all the analyzed variable, in general, the inclusion of the AIRS/AMSU soundings had a positive impact in the first 96 hours of forecast, except for the 300 hPa temperature, the zonal wind component in low levels, and the relative humidity, when negative impacts appear from 96 hours of forecast. For the zonal wind component, in the first 72 hours, the largest forecast impact occurs at 500 hPa level. In addition, a small decrease in the FI value as function of forecast time, was noticed. For the relative humidity the decrease in the FI value as function of forecast time is observed for all analyzed levels. The largest impact are found for the geopotential height, with maximums values (~15%) for the 72 hours of forecast. A characteristic notable in the temperature forecast is the increase of the index FI as function of the time forecast at 850 hPa level.

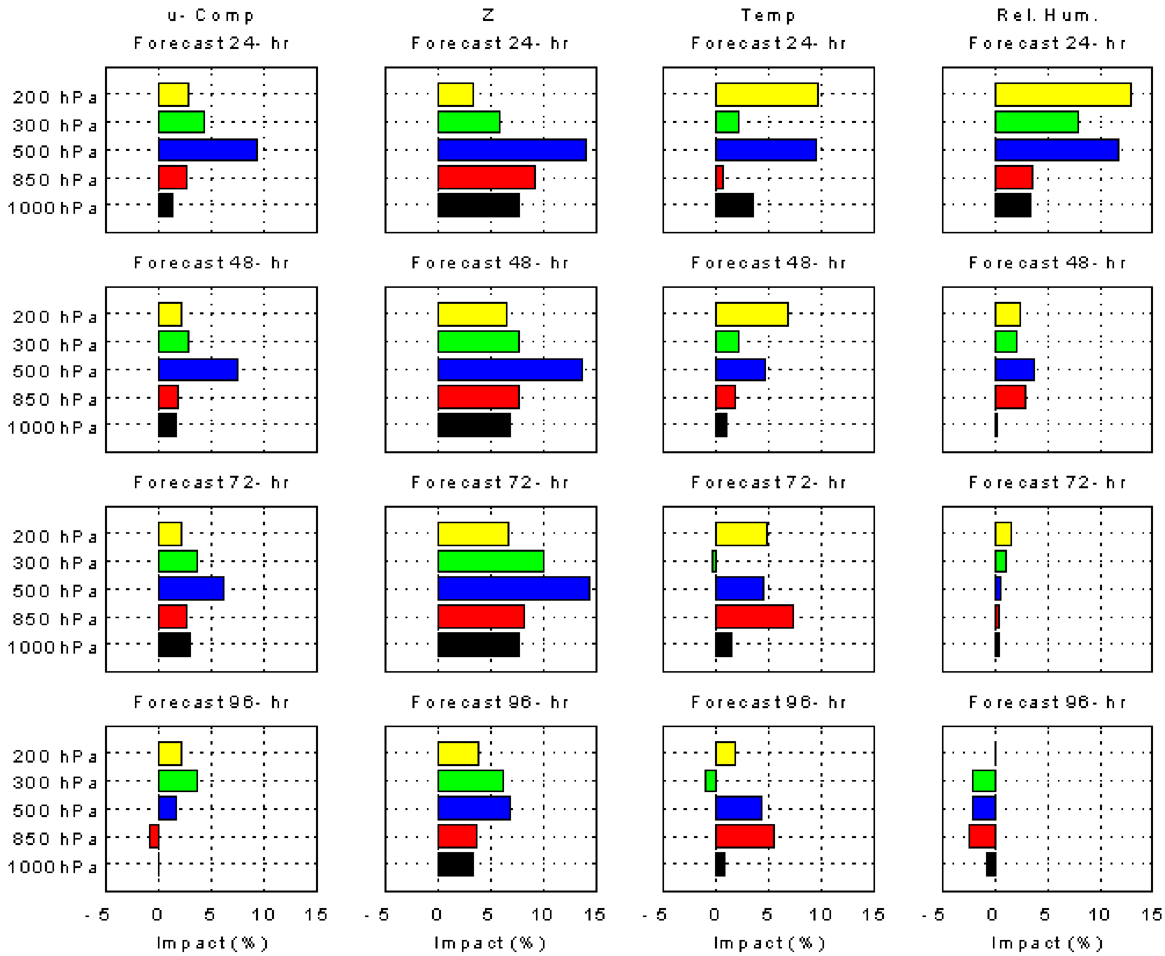

Fig. 4: Forecast impact (%) for the zonal wind component, the geopotential height, the temperature and the relative humidity at 1000 hPa, 850 hPa, 500 hPa, 300 hPa, 200 hPa levels. Forecast periods are 24,48,72, and 96 hours.

The Figure 5 represents the 24-hr 850 hPa relative humidity, 500 hPa temperature, 300 hPa zonal wind component, and 500 hPa geopotential, spatial distribution of forecast impact for the AQUA sounding assimilation. For the relative humidity, the largest impacts are realized over tropical regions (South America and Africa), while for others variables the largest impacts are in the Southern Hemisphere. The Figure 6 shows the 48-hr forecast impact. A direct comparison between the Figures 5 and 6 reveals the drop in forecast impact from 24 to 48 hours. However, even with the general decrease in forecast impact, the sign of the forecast impact changed from positive to negative in only a few cases.

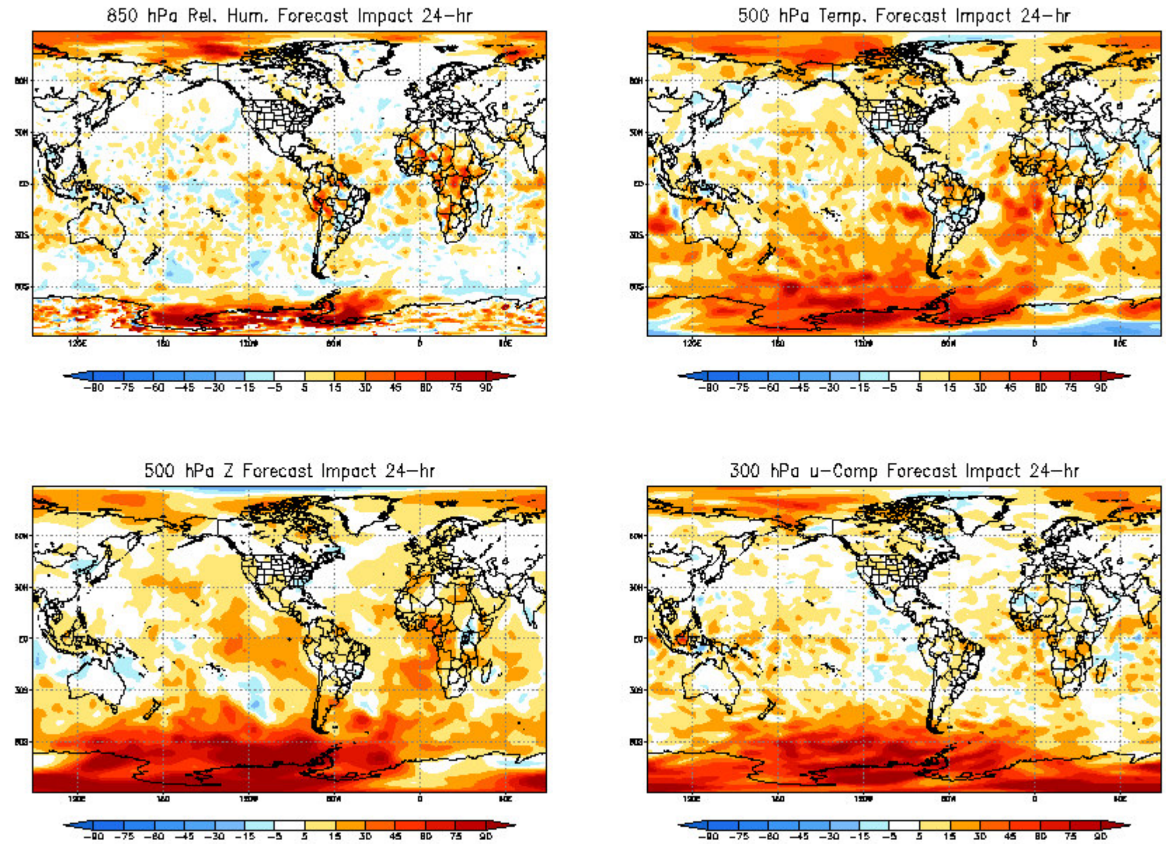

Fig. 5: Spatial distribution of the forecast impact (%) for the 850 hPa relative humidity, 500 hPa temperature, 300 hPa zonal wind component, and 500 hPa geopotential. Forecast period is 24 hours.

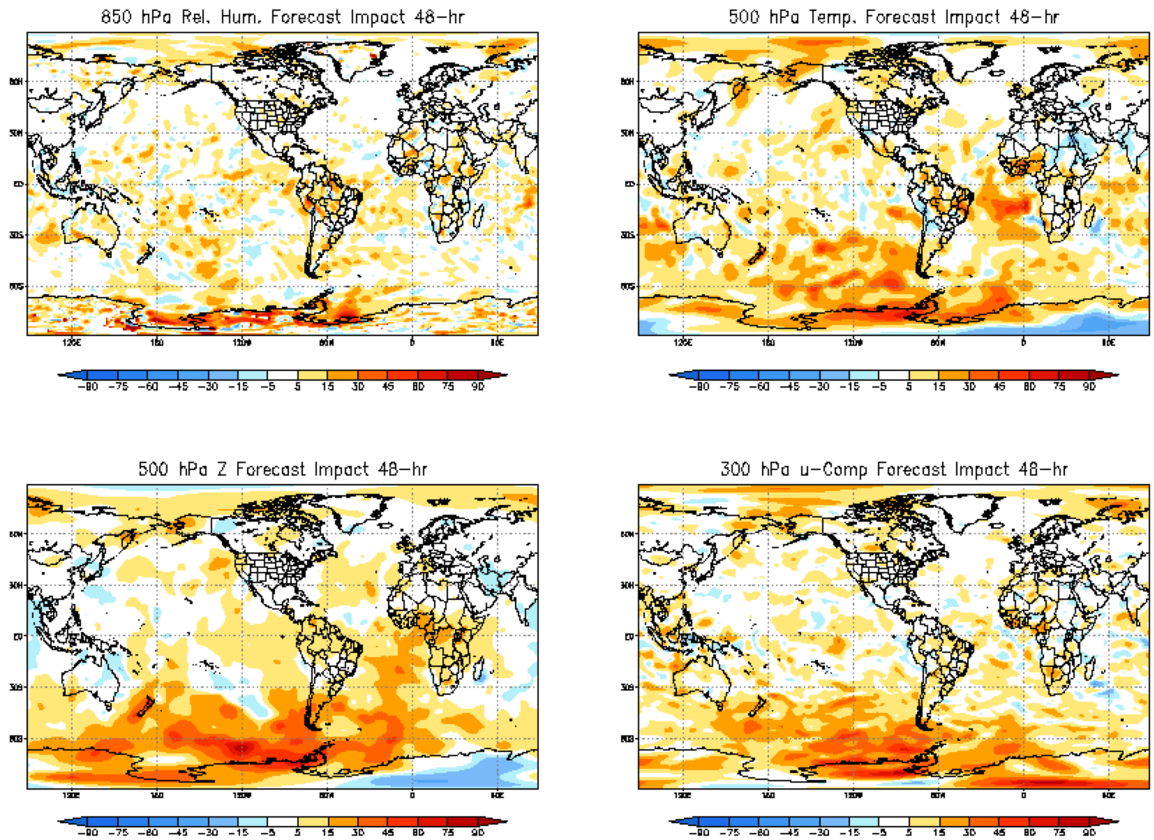

Fig. 6: As in Figure 5, except for forecast period of the 48 hours.

Conclusion

The impact of the AIRS/AMSU sounding in the CPTEC global data assimilation/forecast system have been evaluated for the month of March 2004. In these experiments, AIRS/AMSU retrievals were assimilated using the Physical-space Statistical Analysis System (PSAS) data assimilation system. The spectral Atmospheric Global Circulation Model CPTEC/COLA was used to generate the first guess and forecast up to 5 days. The results from the initial experiments with AQUA data indicate significant improvements in forecast skill over the Southern Hemisphere and South America, compared with the experiment without AIRS/AMSU sounding data. The improvement in the forecast skills at four days in Southern Hemisphere is equivalent to gaining an extension of forecast capability of six hours. Besides, the impact analysis clearly indicates an improvement in the quality of the forecasts, mainly in the South Hemisphere, when soundings AIRS/AMSU are enclosed in the assimilation/forecast system. This results indicate the potential of AQUA sounding system to improve operational forecast skill at CPTEC/INPE. Others studies are being carried through in order to evaluate the relative impact of various types of observations in the CPTEC global data assimilation/forecast system.

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