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NEW DEVELOPMENTS IN SEASONAL PREDICTION AT CPTEC/INPE BRAZIL

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1. INTRODUCTION

The Brazilian Center for Weather Forecasting and Climate Studies (CPTEC) of the National Institute for Space Research (INPE) is a center that has been developing, producing and disseminating real time weather forecasts, as well as seasonal climate forecasts during the last 10 years. The current numerical model is the spectral CPTEC/COLA AGCM, with resolution of T62 L28 (Cavalcanti et al, 2002a, Marengo et al. 2003). The initial conditions for the numerical model are taken from global NCEP analysis of 15 consecutive days. The model is run with persisted SST as well as predicted SST anomalies for the same 15 initial conditions. Pacific SST predictions are provided by NCEP, and Atlantic SST predictions are obtained from the SIMOC model, which produces forecasts of SST anomalies over the tropical Atlantic (Pezzi et al, 1998). These predicted SST anomalies are input to the CPTEC AGCM as lower boundary conditions. Several results of seasonal climate prediction were published in the ELF Bulletin (Cavalcanti et al, 1999, 2000, 2001). The model interannual variability associated with ENSO is discussed in Cavalcanti and Marengo (2005).

One of the changes in the Long Range Forecasting (LRF) system was related to the climatology period. The climatology of 10 years (1982-1991) was changed to 50 years climatology (1951-2001). The probabilistic forecast is now issued considering 33 years (1965 to 1997) of this 50 years period. The seasonal forecast is issued one month before the beginning of the validity period and results are presented for each three-month combination during the 6-months forecasts.

The LRF results are expressed in probabilistic as well as in deterministic form. Deterministic Long-Range Forecasts are presented in maps of anomalies, considering the ensemble mean of all members obtained from the CPTEC/INPE AGCM Ensemble Prediction System (EPS). Precipitation, temperature and geopotential anomaly maps are available at CPTEC homepage (www.cptec.inpe.br) for the globe and also for several regions of the world. The probabilistic categorical forecasts are prepared as terciles, for South America, considering the period of 1965 to 1997, for precipitation and temperature.

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2. NEW DEVELOPMENTS

New parameterizations of convection and radiation schemes have been implemented in the CPTEC/COLA AGCM, in order to improve the model performance. Systematic errors and low predictability in some regions of South America were reported in Cavalcanti et al (2002a). Therefore, the resolution increase, the implementation of new parameterizations schemes, a new version of the model and new techniques of model results analysis have been applied aiming a better forecasting in weather and climate. The original version, with Kuo convection scheme was replaced by Grell ensemble convection scheme. A climate simulation of 10 years for the same period of the climate simulation documented in Cavalcanti et al (2002a) and Marengo et al (2003) was performed with this new version and validation and statistical analysis are under way (Figueroa et al, 2006).

For radiation parameterization, two schemes were implemented: CLIRAD, developed by Chou and Suarez (1999) and modified by Tarasova and Fomin (2000) and the U.K. Met Office scheme (Edwards and Slingo, 1996). The improvements in the model with CLIRAD scheme is reported in Barbosa and Tarasova (2006). One of the problems with the original version (Lacis and Hansen, 1974) was the excess of incoming short wave radiation at the surface (Cavalcanti et al. 2002a; Tarasova and Cavalcanti, 2002). The new versions improved this feature.

A new AGCM that has been developed at CPTEC, based on CPTEC/COLA AGCM, but with a different structure of integration, has been tested for climate simulations using resolution of T062L42 and T126L42. The efficiency of this model is much higher than the operational one, and allows the higher resolution runs. Several analyses have been conducted to verify the model behaviour (Sampaio et al, 2006).

The introduction of an updated vegetation set and an estimated soil humidity field obtained from a hydrological model, in the AGCM, are also in development. At present, the model considers the monthly climatological soil humidity and a vegetation set from Dorman and Sellers (1989). The coupled atmosphere-ocean global circulation model (CPTEC/COLA and MOM) that allows the interaction between the ocean and the atmosphere was tested in several experiments and it is now applied in the seasonal forecasts at CPTEC/INPE. Results of this model are discussed in Nobre et al, 2006. Studies using the Eta regional model in seasonal prediction are also in development at CPTEC to depict, in a higher resolution, the regional features over South America. An ensemble of five integrations of this regional model has been analyzed in the monthly seasonal prediction.

New maps of anomaly precipitation correlation were prepared for South America considering the 1965-1997 period from the 50 years long-run simulation and CRU dataset. As in the previous 10 years analysis (Cavalcanti et al, 2002a; Marengo et al. 2003), the correlations are high in the Northeast Brazil region, Northern Amazonia and Southern Brazil. However, in some areas, of central and southeastern Brazil, where the correlations were very low or even negative, the values were higher in the new simulation, due to the increase of the period simulation. Even though, large spread among the members is noticed in these regions, in contrast with the higher members' convergence in Northeast Brazil.

3. NEW TECHNIQUES

In order to improve the final prediction, new techniques have been applied to analyze the model results. A new product, removing the average bias of previous forecasts has been prepared and has shown improvement in the results. Another new product is the time-series of precipitation anomalies for each member, the ensemble mean, the ensemble standard deviation and the observed anomaly, in a specific region for each 3-months model simulation results from 1951 to 2000. Then, the results of three-month forecast are compared, considering the ensemble mean and members anomalies. This shows how the forecasting for that specific 3-months compares to the past period simulation. Maps of ranking probability skill score (RPSS) for each three-month were also introduced as a new product for verification.

Another technique that is being applied to the daily results of seasonal prediction and simulation is the Madden-Julian Oscillation analysis. It is already known that intraseasonal oscillations have influence on South America convection (Kayano and Kousky, 1994; Nogues-Paegle et al, 2000; Carvalho et al. 2004; Cunningham and Cavalcanti, 2006). Therefore it is important to analyse this kind of variability in the model results to find ways of increasing the predictability in the regions that are strongly affected. The model dominant intraseasonal patterns of OLR and meridional wind are very similar to observations (Cavalcanti and Castro, 2003). The north-south OLR dipole over South America in the summer associated with the SACZ was well represented in model simulations. The PSA pattern, a typical feature that affects South America was also obtained in EOF analysis of model result. However, the SACZ region displays the lowest skill in anomaly predictions. Thus, model results of seasonal prediction and climate simulations have been analysed considering the intraseasonal variability. The component waves of OLR at intraseasonal time scales are applied using the space-time spectral analysis projected on a dispersion diagram, useful to separate modes (Ramirez Gutierrez and Cavalcanti, 2006). The signal of MJO is very weak in the prediction results, but some of the integrations show features of convective propagation over Pacific Ocean.

The monthly or seasonal model results, in climate simulations or predictions, indicate an average of the daily conditions during the period. It is well known that the southeastern region of Brazil is affected by frontal systems during the whole year (Cavalcanti and Kousky, 2003; Andrade, 2005). Intense precipitation over South/Southeastern South America occurs sometimes in association with the displacement and intensification of MCS that occur over Northern Argentina. These MCS are related to the Low Level Jet (LLJ) to the east of Andes, discussed in several studies, such as Zipser et al. (2004) and Marengo et al. (2004). Thus, it is necessary to know if the models (global and regional) have the ability to simulate the behaviour and the influence of synoptic systems, such as frontal systems, and features associated with the LLJ over the region, in long-range integrations.

These features were analyzed for all seasons in a climate simulation of 10 years using the CPTEC/COLA AGCM (Cavalcanti and Coura Silva, 2003; Cavalcanti et al, 2002b). The frontal system results showed that the ensemble mean does not represent well the typical atmospheric characteristics of a frontal system. Each result of each initial condition shows the system in a different position, and the ensemble average removes the atmospheric characteristics of a frontal system. However, if each condition is analyzed separately, the typical features of a frontal system are well identified in the model simulation. The LLJ was identified in the long-range simulation in the four seasons, but with less occurrences in the summer, compared to the reanalysis (Cavalcanti et al, 2002b).The identification of frontal systems and LLJ in results of seasonal predictions are experimental tasks.

A cluster analysis has been applied to the ensemble members to identify different groups that show different behaviour with respect to anomaly precipitation in specific regions. In this technique we do clustering of members with similar behaviour, resulting in several different clusters. Thus, in regions with large dispersion, the cluster analysis can be an useful tool to replace the ensemble average. Improvements in the technique are under way, mainly to be used in Southeast Brazil where there is large spread among members and where there is low predictability considering the ensemble mean. Preliminary results indicate that the number of integrations (15) is not enough to have an improvement in the prediction, and an increase of members is necessary in the near future.

4. CONCLUSION

Several activities to improve the seasonal prediction at CPTEC/INPE are in development. The use of new versions of the CPTEC/COLA AGCM with different convection and radiation parameterizations, the implementation of updated vegetation and a more realistic soil moisture field are envisaged in a near future to improve the forecasting. The application of the coupled ocean-atmospheric model to overcome the problem of SST boundary condition, and the use of the regional Eta model are important tools to the seasonal prediction improvements. New techniques besides the ensemble deterministic and probabilistic, as identification of transient and intraseasonal features, cluster analysis and removal of bias have been applied to results of seasonal prediction. Future developments are statistical and stochastic analysis considering the model behaviour in climate simulations to correct the model results.

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