PROCEDURES FOR THE CHOICE OF SUB-ENSEMBLE WITH BETTER USE FOR THE CLIMATE FORECAST

Gilvan Sampaio de Oliveira e Prakki Satyamurty
Centro de Previsão de Tempo e Estudos Climáticos (CPTEC)
Instituto Nacional de Pesquisas Espaciais (INPE) - Brasil
Tel.: +55 12 560-8545, Fax: +55 12 561-2835, e-mail: sampaio@cptec.inpe.br

ABSTRACT

This paper addresses important questions about ensemble climate forecasting system. Given an atmospheric general circulation model (AGCM) ensemble run with a large number of independent integrations, is there a subensemble whose mean, in principle, improves the forecast performance? Is there a way to identify a priori (before running the forecast integrations) a subensemble whose mean can possibly give a performance better or equal to the performance of the whole ensemble? The model is essentially run in forecast mode with fixed SST anomalies and predicted SST anomalies using 25 members. To answer these questions, a subgroup of members with the anomaly correlation coefficient (CCA) equal to or greater than CCA of the complete ensemble during the spin up period are chosen. The mean of the forecasts based on this subset is found to have a spatial correlation with the observed precipitation of the same order of the complete ensemble. The size of this subset is found to be around 9 members. This method can be employed as a useful tool for economizing the computer time and to obtain early seasonal forecasts. The methods employed in this study can be extended to other regions of the globe, because the best subset and its size can differ from region to region, from season to season and from year to year.

1 - INTRODUCTION

Climatic forecasts or seasonal forecasts base on the premise that slow variations in the boundary conditions can have significant impacts in the atmospheric development (Brankovic et al., 1994). According to Shukla (1998), the circulation of large scale and the precipitation in the tropical area are completely determined by the conditions of boundary of the sea surface temperature (SST). It is known that each simulation done with observed SST and different initial conditions exhibit different results. Though, Brankovic and Palmer (1997) they evidence that in years of strong intensity ENSO, the climatic previsibility in the tropics increases.

Numerical climate prediction have been performed at CPTEC/INPE since 1995 using the spectral numerical global circulation model, CPTEC/COLA AGCM with T62L28 resolution. They are used 25 initial conditions that are analyses of NCEP of 12 GMT, with interval of 24 hours among them. Each initial condition represents a member of the forecast for group. The initializations of the 25 members are made about two and a half months before the beginning of the period to be forecast. To follow the average of the 25 members of the ensemble it is calculated and it is made the difference between this average and the control, like this supplying forecasts of anomalies for the variables post-processed by the model. For the development of the present work they were made forecasts of CPTEC/COLA AGCM, among December of 1995 and May of 1999, with SST in two ways: persisted SST anomalies and predicted SST anomalies.

The objective is to test a method of choice of a subset of the ensemble of forecasts that could increase the skill of the forecasts. This method considers the two months " spin-up " of the model and it verifies the correlation anomalies of the precipitation in the South American area with the observed fields. Starting from then they are chosen the members of the ensemble with larger correlation and a subset of members is built.

2 - DATA

For the verification of the forecasts were used monthly data of precipitation of "Climate Prediction Center Merged Analysis Precipitation (CMAP)" (Xie and Arkin, 1997, 1998), since January of 1979 to December of 1999, with resolution of 2,50 of latitude and of longitude they are used to calculate the climatology of the precipitation. In the present study was used the period of December of 1995 to May of 1999.

The initial conditions are analyses from NCEP of 12 UTC, with interval of 24 hours among them. Each forecast is composed by 25 initial conditions. As control, the results of a simulation done in 1999 by CPTEC/INPE were used, with the average of 9 initial conditions, applying as boundary condition monthly SST observed by 10 years - January of 1982 to December of 1991 (Cavalcanti et al., 2001). This average was used for the calculation of anomalies of the fields of forecasts.

The several forecasts of anomalies of precipitation of the model were obtained with anomalies of persisted SST of the last month of simulation of the model in all the Oceans and SST foreseen at the Pacific and Atlantic Ocean by the coupled of NCEP models and SIMOC/CPTEC, respectively, and persisted in other Oceans.

3 - METHODOLOGY

The method used for the choice of the elements of the ensemble that produce better forecasts bases on the hypothesis that, if a certain member got to simulate the pattern well in the simulation period (or " spin up ") of the forecast on South America, that is to say, with observed SST, he theoretically could produce better forecasts than a member that doesn't get to simulate satisfactorily.

For so much, be considered a forecast for ensembles with anomalies of SST persisted for the quarter of months 3, 4 and 5. The integrations of the numeric model begin with initial conditions of about two and a half months before the forecast period, and it uses boundary conditions observed during this period (period of " spin up "). This period of each one of the forecasts will be considered as the simulation period. After the simulation period, the anomalies of SST are persisted or foreseen during next three months that compose the forecast period. We will designate S(m,k), m=1,2,... ,M and k=1,2 as the simulation of the precipitation of the m-ésimo member of the ensemble for the k-ésimo month. In the same way, we will designate P(m,k), m=1,2... ,M and k=3,4,5 as the forecast of the m-ésimo member of the ensemble for the months k=3,4 and 5, respectively. Be and the averages of the ensemble. O(k is designated), k=1 and 2 as the precipitation observed for the months of simulation 1 and 2.

The method of choice of a subset that can improve the dexterity of the forecast bases on the performance of the members during the simulation period. Like this being, the method follows the steps below:
1) the anomaly of medium precipitation is calculated for the two months k=1 and 2, of the simulation period for each member of the " ensemble ": S(m,K), and for the observed precipitation: , where K represents the two months of simulation;

$$S(m,K) = \frac{S(m,1) + S(m,2)}{2}$$
$$O(K) = \frac{O(1) + O(2)}{2} \qquad (3.1.1)$$

2) space CCA is calculated on South America (350S-100N, 800W-300W) among and: CCA (,), that is to say, space CCA among the average of the members of the ensemble-average for the simulation period and the observed data.

$$\overline{\overline{S}}(K) = \frac{1}{M}\sum_{m=1}^{M} S(m,K) \qquad (3.1.2)$$

3) space CCA is calculated on South America (350S-100N, 800W-300W) among S(m,K) and: CCA(S(m,K),), for each member of the ensemble, m=1,2,... ,M., during the simulation period.
4) they are S(m,K), m=1,2,... ,L, where (L M), the members that present CCA(S(m,K),) CCA (,).
5) then, a new average of members is built, starting from this new subset: .

In beginning, it is waited that the average of this subset has the same or larger dexterity than the average of the whole ensemble on the South American area. Still plus, the sum of the precipitation quarterly should be foreseen better by this subset. To test this possibility, it is enough to obtain CCAs among and.

This method is tested for the forecasts with anomalies of persisted SST and foreseen for all the quarters of the studied period. It is waited that this method can answer important subjects about the existence or not of objective means of finding a subset, before processing the forecasts, that it presents a better forecast than of the complete ensemble.

4 - RESULTS

For each wheeled one, they were applied the calculations described in the Methodology (3.1) to choose the members of the ensemble with better correlations of precipitation anomalies during the simulation period (" spin up "). starting from this choice, the averages of the subsets chosen during the forecast period were calculated and the correlations of anomalies were calculated between the average of the whole ensemble and the observations and the average of the new subset and the observations. These results are shown in the Illustration 4.1.1.

Analyzing the Illustration 4.1.1, it is noticed that the correlation of precipitation anomalies between the average of 25 members and the observed data and the new subset and the observed data is plenty similar, that is to say, it is ended that the new subset has dexterity the same to the average of the whole ensemble on the South American area. Other areas of the globe, such like Pacific-America of South-Atlantic, Pacific-America of the South, Tropics were also tested (not shown in this work), even so they were not obtained results as satisfactory as on the South American area. The new subsets have numbers of members that vary among 3 (MAM 1996) and 16 (JJA 1997), and the medium number of members of the new subsets is 9. Though, to the we analyze the Illustration 4.1.1, we also noticed that the correlation of anomalies of the members of the ensemble that you/they were discarded is quite coincident with the correlation of anomalies of the average of the ensemble and of the whole subset. With that, the method doesn't get to identify " the members of the ensemble that can produce better forecasts a priori ".

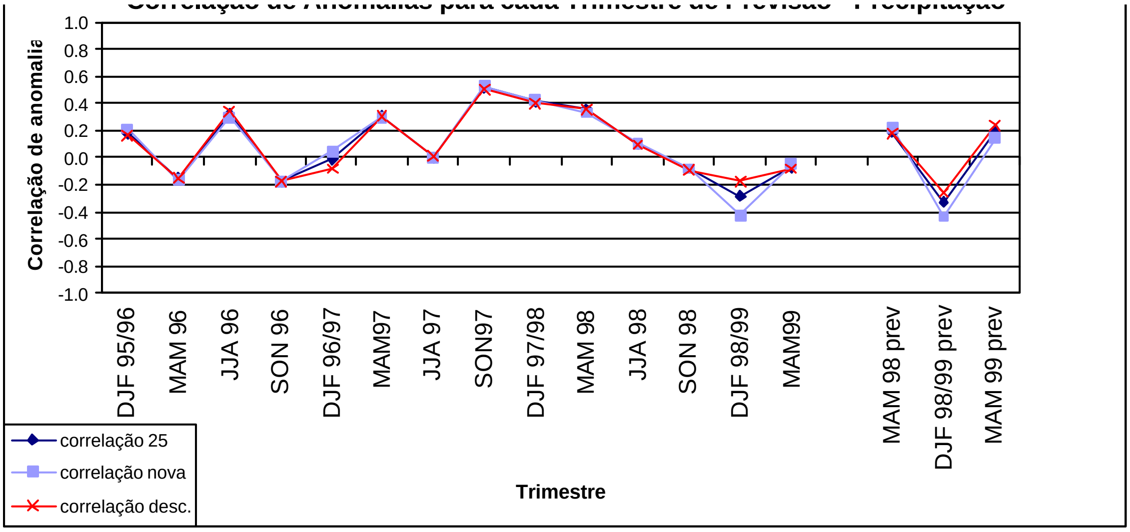

Fig. 4.1.1 - correlation of precipitation anomalies for each forecast quarter with: - forecast - average of 25 members of the ensemble (correlation 25); - forecast - average of the new subset (new correlation); - subset of the discarded members (correlation desc.). Forecast with anomalies of foreseen SST (prev) and persisted.

Though, the great usefulness of this result is to choose the members of a ensemble of simulations that will have dexterity similar to the average of the whole ensemble on the South American area. This position, it can be rationalized the use of the supercomputadores, what is extremely interesting due to the long time that each climatic forecast takes to be ended. For example, in the case of a forecast with 25 initial conditions, it cannot him first " to rotate " the simulation period and then to apply the method to choose the members that will go first be submitted for the calculation of the forecasts, and only after having concluded the wheeled of these chosen members he/she submits the other members of the ensemble. Other great advantage is that can be supplied the boundary conditions for regional models with larger antecedence and using an objective method of choice of members.

The fact of it have been choose " the subset a priori " significantly with dexterity superior to the dexterity of the average of the ensemble is in the fact that the best of the initial conditions during the simulation period is not enough due to the little dependence of the initial conditions about the climatic forecasts, as emphasized by Shukla (1998). THE circulation of great scale and the precipitation in the tropical area are completely determined by the conditions of boundary of SST (Shukla, 1998). being like this, it would be difficult to establish " the members of the ensemble that will produce the best forecasts a priori ".

5 -DISCUSSION IS CONCLUSIONS

Basing on the hypothesis that if a member gets to simulate the pattern of anomalies well in the simulation period (or " spin up "), on an area sufficiently big, he can produce better forecasts. A method is developed to choose a subset " a priori " (before rotating the forecasts). Para each member of the ensemble during the simulation period, the correlations of anomalies were calculated and chosen the members of the ensemble with better correlations of precipitation anomalies during the simulation period. The correlations of anomalies were calculated between the average of the whole ensemble and the observations and the average of the new subset and the observations.

The results indicated that, for each forecast, the new subset has dexterity of the same order that the average of the original ensemble on the South American area and the medium number of members is around 9. Though, the analysis of the correlation of anomalies of the members of the ensemble that were discarded it is quite coincident with the correlation of anomalies of the average of the ensemble and therefore of the subset. With that, once again it can be said that the evolution of the members is chaotic and the forecasts don't depend a lot on the initial conditions, conclusion similar to obtained her for Brankovic et al. (1997).

As stood out, the circulation of great scale and the precipitation in the tropical area are certain for the conditions of boundary of SST (Shukla, 1998). being like this, difficultly it would be possible to establish " the members of the ensemble that will produce the best forecasts a priori ".

For future studies, he/she suggests himself to verify the methods discussed a priori " for the choice of subsets " it is applied to other areas of the globe.

6 - REFERENCES

Brankovic, C., et al., 1994: Predictability of seasonal atmospheric variations. **Journal of Climate**, **7**, 217-237.

Brankovic, C., et al., 1997: Atmospheric seasonal predictability and estimates of ensemble size. **Monthly Weather Review**, **125,** 859-874.

Cavalcanti, I. F. A., et al., 2001: **Climate Characteristics in an Ensemble Simulation Using the CPTEC/COLA Atmospheric Global Circulation Model**, São José dos Campos, INPE, 2001, 71 p. (INPE-8150-RPQ/717).

Shukla, J., 1998: Predictability in the Midst of Chaos: A Scientific Basis for Climate Forecasting. **Science**, **282**, 728-731.

Xie P, Arkin P., 1997 - Global precipitation: a 17-yr monthly analysis based on gauged observations, satellite estimates and numerical model outputs. **Bull. Amer. Met. Soc.** 78:2539-2558

Xie P, Arkin P., 1998 - Global monthly precipitation estimates from satellite-observed outgoing longwave radiation. **J. Climate** 11:137-164