INTERDECADAL VARIATIONS IN AGCM SIMULATION SKILLS

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1. INTRODUCTION

Assessing the reliability of dynamical atmospheric general circulation models (AGCM) in reproducing the observed atmospheric circulation given the lower boundary conditions, and thus its ability to predict climate, has been a recurrent concern in seasonal-to-interannual climate prediction. The assessments have been carried out in several ways, including the comparison between the leading modes of variability from the observations and the models' outputs and comparison of the AGCM's skill with the skill of statistical models (e.g., Peng et al. 2000). In those studies there was frequently concern about the influence of seasonal variation on the models' skill, but no analysis has been carried out about the possible variation of the models' performance throughout the years. Thus, this important question has not been answered yet: is the long-term variability of the atmosphere and the oceans prone to influence the performance of models, as is the seasonal variability?

2. DATA AND METHODOLOGY

In the present study, the seasonal responses of two AGCMs (ECHAM3, from Max Planck Institute, and NCEP, from National Centers for Environmental Prediction) to prescribed observed SST are compared to the observed seasonal anomalies (from the Reanalysis NCEP/NCAR) to verify whether the performance is affected by long-term variations.

The analysis is based on the simultaneous correlation between series of three-month mean model responses and reanalysis data, averaged over 20º latitude × 40º longitude regions all over the globe, for the period 1950-1994.

The possible influence of the interdecadal variability on the models' performance is assessed through the computation of the global fields of simultaneous correlation coefficients (CC) between 11-year running series of the reanalysis data and of the models' output.

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The value considered for each year is a three-month mean of the analyzed parameter. Thus, the seasonal influence on the interdecadal variations can be detected.

The variation of the CC is an indication of the interdecadal variation of the models' skill all over the globe. Also to see whether the models reproduce the interdecadal modulation of the ENSO impacts on the atmospheric circulation, global fields of simultaneous correlation are computed between 11-year running series of the SST in the Niño 3 region and streamfunction, zonal and meridional components of the wind at 200 hPa.

A possible connection between interdecadal modes of SST variability and the decadal/ interdecadal variations of the models' skill was sought. The Empirical Ortogonal Functions (EOFs) of the global field of running correlations for streamfunction at 200 hPa were computed, and the two first principal components were correlated with the 11-year running mean of SST. This gives an indication about the relationship between the interdecadal variability of the models' skill and the interdecadal variability of SST. The statistical significance of this correlation was assessed by using a Monte Carlo procedure.

3. RESULTS AND DISCUSSION

There are significant differences between the skill of the ECHAM3 model and the NCEP model. Most frequently the ECHAM3 performs better than the NCEP model, but the comparative skill depends on the region, the season and the parameter being analized. For streamfunction at 200 hPa in December-January-February (DJF) the overall performance of ECHAM3 is better in the equatorial belt, but in the extratropics the NCEP model output presents higher correlation with the observed data. In June-July-August (JJA) the skill of the ECHAM3 model is better almost all over the globe. The running CCs also point out the significant interdecadal variability of the model skill, which is even larger for other parameters (like the zonal and meridional components of the wind).

In order to see whether the models reproduce the interdecadal variability of the ENSO impacts, the CC between the sea surface temperature

(SST) in the Niño3 region and the observed streamfunction at 200 hPa (reanalysis), and the CC with the models´ output were also calculated. The NCEP model does not reproduce almost any of the ENSO interdecadal variability, keeping an almost constant relationship between the streamfunction and the Niño events, except for the equatorial region. Even there, the variability is not well reproduced. Some of the features of the interdecadal modulation of the ENSO impacts are reproduced by ECHAM3 model, but not most of them. Also much of the variation shown by ECHAM3 model does not coincide with the observed one. This shows the temporal variability of the models ability to respond to ENSO, and thus is additional evidence that the models´ skill undergoes interdecadal variability.

As the models did not undergo any change in their formulation during the period under focus, the variation in the skill must be due to other reasons. One might think that the increasing reliability of the reanalysis, which is our reference, is responsible for apparent changes in the skill, but this hypothesis does not fit in the oscillation of the CCs. They would, in this case, show trends.

Another hypothesis is that the basic state of the general atmospheric circulation varies slowly in interdecadal time scales and the model does not reproduce these variations. Therefore, the basic state in which the perturbations propagate may turn less realistic in certain periods and the errors in the models may grow. To test this hypothesis an EOF analysis was performed on the fields of the running correlations. Only the results for the ECHAM3 model are commented. The factor loadings of the 1st EOF indicate that the highest loadings are in the extratropics, while the 2nd EOF indicates stronger variations in the subtropics. The 1st and 2nd principal component (PC) series show interdecadal oscillations, fairly coherent for the ECHAM3 and the NCEP models.

The field of the CC between the principal components and the SST discloses patterns that have similarities with the spatial patterns of EOFs of the global non-ENSO SST variability from Enfield and Mestas Nuñez (1999). The correlation patterns with the 1st PC has features similar to those of the 3rd EOF of Enfield and Mestas Nuñez, representing the Atlantic multidecadal variability, but including as well interdecadal variability in the Pacific and the Indian Oceans. The correlation patterns with the 2nd PC show similarities with the 1st EOF of Enfield and Mestas Nuñez, representing mainly the variability in the subtropical eastern Pacific.

Therefore, the results show a clear interdecadal modulation of the models´ skill and its relationship with known interdecadal SST modes of variability like those with maximal realization in North Atlantic and North Pacific, as well as in the East Pacific.

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