LOW FREQUENCY VARIABILITIES IN THE SOUTH ATLANTIC OCEAN

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1. INTRODUCTION

In the last few years, several studies have been devoted to understand the importance of the South Atlantic Ocean in the global climate. Because the South Atlantic plays a unique role in transporting energy across the equator, establishing an important link in the Global Conveyor Belt, a comprehension of the relative importance of the ocean and the atmosphere and the effect of their interaction is required.

In this study we investigate the existence of patterns of oceanic and atmospheric climate variability on decadal timescales using a coupled global climate model (GCM). Results from a 130-year simulation where the ocean is coupled to the atmosphere are compared to an uncoupled simulation, in order to better understand the underlying dynamical causes of variability in the South Atlantic.

The most significant difference of the coupled model used in this study from others lies in its ocean component, the Miami Isopycnic Coordinate Ocean Model (MICOM). Because decadal scale mixing in the ocean interior mainly takes place along isopycnal surfaces, isopycnic coordinate ocean models benefit from the explicit control they have over diapycnal mixing.

2. MODEL DESCRIPTION

The atmospheric component of the coupled model used in this study is the NCAR Community Climate Model (CCM3), a state-of-the-art global spectrum GCM. The horizontal resolution of the model is T42, with 18 vertical levels which extend from the surface to 3 mb, following the terrain near the bottom, pressure surfaces near the top, and a mixture of the two in the middle.

The oceanic component of our study consists of MICOM, covering the global ocean on a Mercator projection from 66° N to 69° S. The model has a $2^\circ \times 2^\circ \cos(\phi)$ horizontal resolution, with 15 interior layers and a mixed layer. The bottom topography and coastline are realistic given the horizontal resolution.

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3. EXPERIMENTS

The data for this work were obtained from a study of the North Atlantic Ocean climate variabilities by Cheng (2000). In order to identify and understand patterns of variability which may arise from the coupled interaction between the ocean and the atmosphere, we compare two different experiments: a coupled run using both CCM3 and MICOM, and an uncoupled run using a CCM3 climatology forced with observational monthly sea surface temperatures (SST).

3.1 *Coupled Run*

The first experiment consists of a 130-year simulation conducted using a coupled implementation between MICOM and CCM3. Because the atmospheric and oceanic grid points were not coincident, SST from MICOM was interpolated onto atmospheric grid points, in which the air-sea fluxes of heat, fresh water and momentum were calculated by CCM3; finally, these fluxes were interpolated back onto the oceanic grid points as a surface forcing for the ocean. Outside of the domain covered by MICOM, SST was provided by a monthly climatology.

In this experiment, MICOM was initialized with a quasi-Levitus state, which is the Levitus annual mean conditions driven by COADS monthly climatology for one year to establish reasonable mixed layer depths. CCM3 was started from as instantaneous state representing January 15th.

3.2 *Uncoupled Run*

Besides the MICOM-CCM3 coupled mode, we also analyzed an ocean-alone experiment, in which the surface forcing for the ocean was taken from the CCM3 climatology, a 10-year average for each month of a CCM3 simulation forced with observational monthly SST distributed by NCAR. Because the ocean state in this uncoupled integration is compared with the coupled run, it is important that the differences between the experiments exist mainly due to the coupling effect between the models.

4. RESULTS

The results from a 55-year period, starting with year 25 of the simulations, were analyzed in the South Atlantic using empirical orthogonal function (EOF) and singular value decomposition (SVD). The patterns of the first

EOFs of the SST anomalies fields for both the coupled and uncoupled simulations are shown in figure 1. The coupled run EOF bears a strong resemblance with the pattern observed in NCEP/NCAR reanalysis data (Sterl and Hazeleger, 2002, hereafter SH). EOF analysis performed on an extended domain including the northern hemisphere resulted in the same pattern for the first SST EOF.

On the other hand, the results of the stand-alone ocean experiment differ from observational data. Most of the variability when the ocean is forced by a climatological atmosphere is contained in the region of the Brazil-Malvinas confluence. This pattern also appears on the second and third EOFs (not shown).

The SVD analysis of the SST and sea level pressure (SLP) fields in the coupled simulation, shown on figure 2, reveal the same pattern observed for the South Atlantic by Venegas et al. (1997) in COADS data. This pattern can be described as an intensification/weakening of the subtropical anticyclone, producing a north-south dipole structure in the SST. It is also similar to the first SVD found by SH, suggesting that the model can successfully reproduce the physics of the region.

5. CONCLUSIONS

The initial results obtained from the analysis of model data for the South Atlantic show that the coupling between MICOM and CCM3 can successfully reproduce the SST patterns observed in COADS and NCEP/NCAR reanalysis data. This fact confirms the advantages of using a isopycnic ocean model in the study of decadal timescale variabilities in climate.

The results of the ocean-alone experiment suggests that the SST variabilities in the South Atlantic can not be explained only as a passive response of the ocean to climate variations generated by the atmosphere. Instead, it seems that the ocean circulation in the South Atlantic plays an active role in setting the spatial and temporal patterns of SST anomalies.

In order to identify and better understand which physical mechanisms are responsible for the simulated patterns of variabilities in the SST field, our next step is to perform a regression analysis based on the temperature tendency equation for the mixed layer. Similar to the analysis done by SH, this will give us insight in the nature of the coupling between ocean and atmosphere.

References

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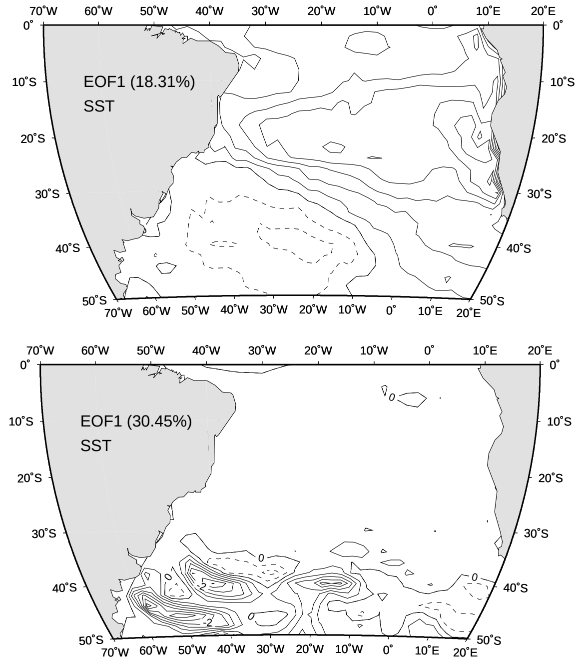

FIGURE 1: Patterns of the first EOFs of SST anomalies for the coupled and uncoupled run, respectively. Explained variance is displayed on top of each panel.

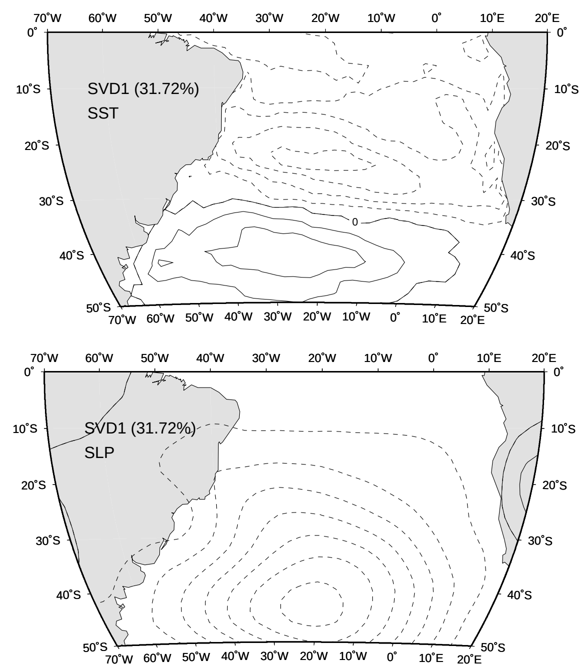

FIGURE 2: First leading mode of a combined SVD analysis of SST and SLP anomalies fields, respectively, from the coupled experiment. Explained variance is displayed on top of the panels.