IMPACT OF OGCM RESOLUTION ON THE TROPICAL ATLANTIC DYNAMICS AND SEA SURFACE TEMPERATURE

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RESUMO

Dois experimentos utilizando um modelo oceânico de circulação geral com resoluções de1/4 e 1/8 de grau na região tropical do Atlântico foram comparados com observações para avaliar o impacto do aumento de resolução de grade na dinâmica e termodinâmica oceânica tropical. O experimento com 1/4 de grau mostrou campos de velocidade muito suaves e não foi capaz de reproduzir adequadamente o sistema zonal de correntes equatoriais do Atlântico. A termoclina se mostrou muito horizontal ao longo de 38W como consequência da auxência de processos dinâmicos. O experimento com 1/8 de grau, por outro lado, foi capaz de reproduzir o sistema zonal de correntes assim como as inflexões na termoclina presentes nas observações. Uma baixa resolução de grade prejudica a reprodução da distribuição horizontal de TSM. A correta simulação da dinâmica oceânica realizada pelo experimento com 1/8 de grau gerou manchas de valores mais altos no campo de TSM. Essas manchas provavelmente são capazes de disparar processos de convecção profunda na atmosfera. Portanto, uma resolução de 1/8 de garu em modelos acoplados irá fornecer melhores previsões do tempo.

ABSTRACT

Two Ocean General Circulation Model experiments were built with 1/4 and 1/8 degrees resolution and compared with observations on the Tropical Atlantic to evaluate the impact of grid resolution on the ocean dynamics and thermodynamics. 1/4-degree resolution resulted in a too smoothed velocity field and was not able to reproduce correctly the equatorial zonal current system. Its thermocline was too flat as a consequence of the lack of dynamical processes imposed by the low resolution. Otherwise, the 1/8-degree resolution outputs were very similar to the observations. The high-resolution experiment was able to reproduce correctly both the velocity field and the thermocline slopes. The lack of resolution affected the SST horizontal distribution. The correct representation of the ocean dynamics on the 1/8-degree resolution experiment was related with

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patches of high SST. These patches might trigger deep convective processes on the atmosphere. Therefore, a resolution of 1/8-degree on coupled models may improve the weather forecast skills.

Palavras-chave: OGCM; Atlântico Tropical; TSM.

INTRODUCTION

In the Tropical Atlantic Ocean complex dynamical processes highly influence the atmosphere and therefore the climate over South America and Africa, its continental barriers. Better understanding the ocean dynamics and thermodynamics will improve the knowledge about air-sea fluxes and therefore the weather forecast skill.

Ocean General Circulation Model (OGCM) is a useful tool since the appropriated configuration and grid resolution are applied. Improvements on modeling must be constantly done and new resolutions and configuration need to be verified and compared. In this work two Modular Ocean Model (MOM) experiments were built to evaluate the impact of grid resolution on the Tropical Atlantic dynamics and thermodynamics.

Observations alone cannot explain the processes over the tropical Atlantic basin and are important to point to the correct direction of the model evolution. Here, direct upper ocean velocity and temperature data were compared with outputs from different model configuration.

MODEL CONFIGURATION AND DATA

The OGCM used was the Modular Ocean Model version 3 (MOM3). Two different configurations were applied: (a) G4-1010 with grid resolution of 1/4 degree between 10S-10N and 60W-12E; and (b) R8-515 with grid resolution of 1/8 degree between 5S-15N and 60W-12E, both changing linearly to 3 degrees out of these regions.

For both experiments there were 20 levels in the vertical with 18 levels within the first 500-m depth and 7 in the first 100 m. The model used the NCEP wind stress as monthly and diary momentum forcing and Levitus climatology as initial condition. The solar radiation and heat flux were parameterized. The integration ran from January 1971 to December 2005, with 24 years of spin-up under monthly wind stress and the last10 years under diary wind stress forcing.

Data were from the Pilot Research Moored Array in the Tropical Atlantic (PIRATA)(Servain et al., 1998). The velocity distribution in the upper ocean was measured with a

75-kHz vessel-mounted Acoustic Doppler Current Profiler (ADCP) from RD Instruments. Conductivity-Temperature-Depth (CTD) stations were one degree apart and up to 500-m depth. The velocity data were collected using a vertical bin length of 8 m. The first reliable bin represents a velocity mean from 16 to 24 m depths. The depth range was about 400 m but it is dependent on sea state; the range was <250 m if the ship headed into heavier weather. ADCP absolute current was determined by using standard shipboard gyro heading and navigation from the global positioning system (GPS).

Here, three ADCP sections were used as summarized on Table 1. These ADCP velocity maps are novel direct observations in the western tropical Atlantic, reaching 15N along 38W. German and French observational programs have collected VM-ADCP data around the same longitude but no data were obtained northward 7.5N (Wilson et al., 1994; Stramma and Schott, 1999; Schott et al., 1998; Bourlès et al., 1999b; Bourlès et al., 1999a; Urbano et al., 2006).

Table 1. Summary of the ADCP PIRATA cruises, with the respective dates and tracks.

Cruises	Dates	Boreal Seasons
PBR02	01-05 February 1999	Winter
PBR04	09-14 April 2001	Spring
PBR06	17-25 July 2003	Summer

RESULTS

Figure 1 presents the comparison between 1/4-degree output (G4-1010), 1/8-degree output (R8-515) and observations (ADCP+CTD). The G4-1010 experiment shows smoothed contours of velocity. In the G4-1010 results, the Equatorial Undercurrent (EUC) was very idealized and weak (~60cm/s) while in the R8-515 results the current multiple core structure could be reproduced as it is shown by the observations (~90 cm/s). During February 1999, the North Equatorial Countercurrent (NECC) was almost absent on the G4-1010 simulation while a flux of 50 cm/s around 7N was present in both R8-515 and ADCP velocities. The same occurred for April 2001. The NECC second core (Urbano et al., 2006) was not reproduced by the G4-1010 while it was well placed at 11N during February 1999 and at 9N during July 2003. Also almost absent in the G4-1010 experiment was the North Equatorial Undercurrent (NEUC), the eastward flow at 5N and 150-m deep. Otherwise, it was well reproduced by the R8-515 results as measured by the ADCP.

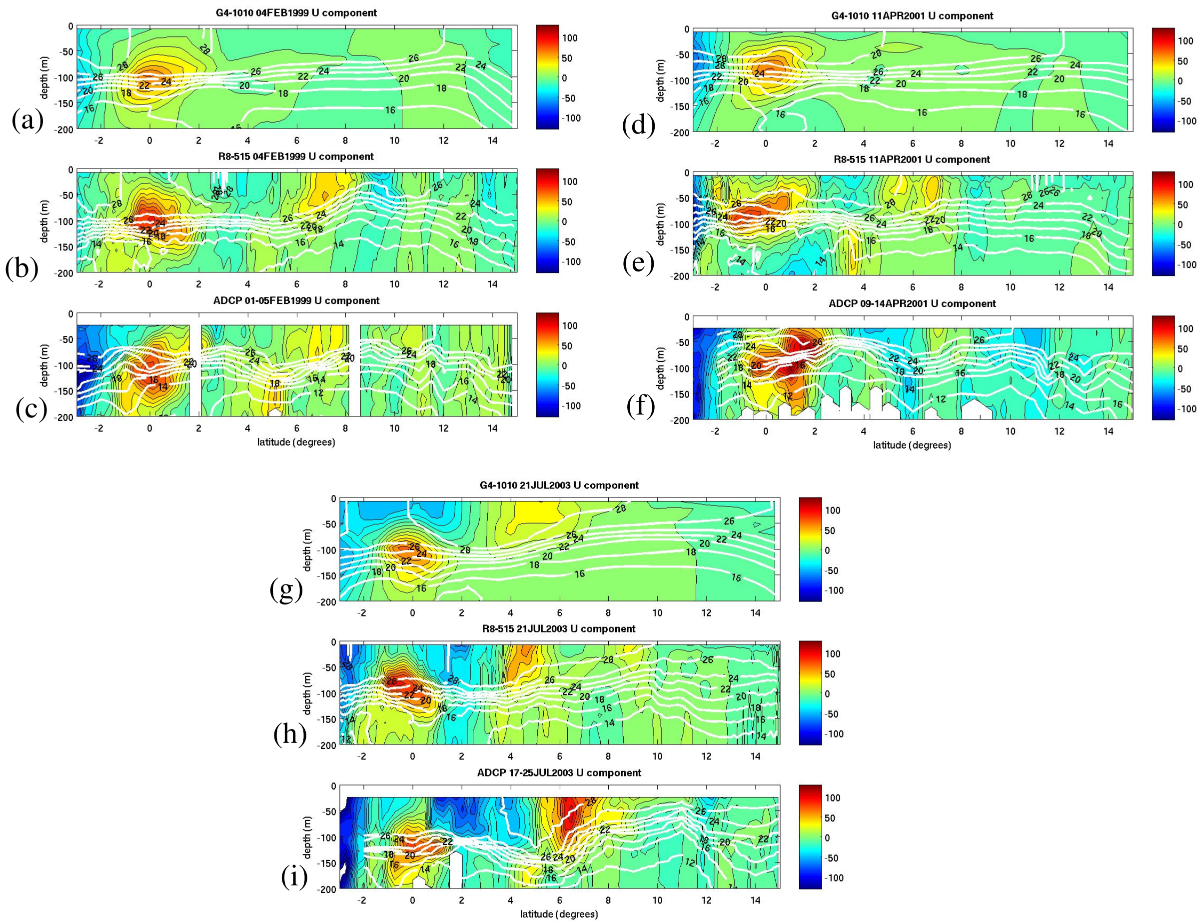

Figure 1: Meridional sections along 38W from 3S to 15N. (a, b, c) correspond to winter 1999, (d, e, f) spring 2001, and (g, h, i) summer 2003. Top panels (a, d and g) are the ¼ degree model outputs G4-1010. (b, e, and h) 1/8 degree model outputs R8-515. (c, f, and i) are ADCP velocities. Filled contours show zonal velocity (U) positive eastward and negative westward. Contour interval is 10 cm/s. White contours are temperature each two degrees Celsius.

Another interesting result is that the thermocline was flat on the G4-1010 experiment while the R8-515, as a consequence of the improved dynamic field, displays slopes similarly to the observations.

Important note that most of the differences between the R8-515 results and the observations is due to the fact that the model supplies a snapshot while the measured field took several days to be done by the ship. On top of the ADCP the periods the ship took to measure the 38W sections were displayed.

Figure 2 compares the SST horizontal distribution computed by the G4-1010 and R8-515 experiments. During February 1999 and on the R8-515 experiment (Figure 2a bottom), around

38W, 2N and 44W, 8N there are patches of high temperature that is almost invisible in the G4-1010 simulation (Figure 2a top).

On Figure 2b, westward 50W and northward 4N there is a huge difference on the SST pattern due to lack of dynamics from the 1/4-degree resolution. There, the western boundary currents both flowing northward (North Brazil Current) and southward (Guiana Current) were not well reproduced. The same occurs during July 2003 (Figure 2c), but under a different seasonal phase of surface currents.

In the whole tropical Atlantic region these patches looks like details but small changes in SST can be able to trigger a deep convective process in the atmosphere, mainly at the tropics. In a future work the impact of these patches will be quantified.

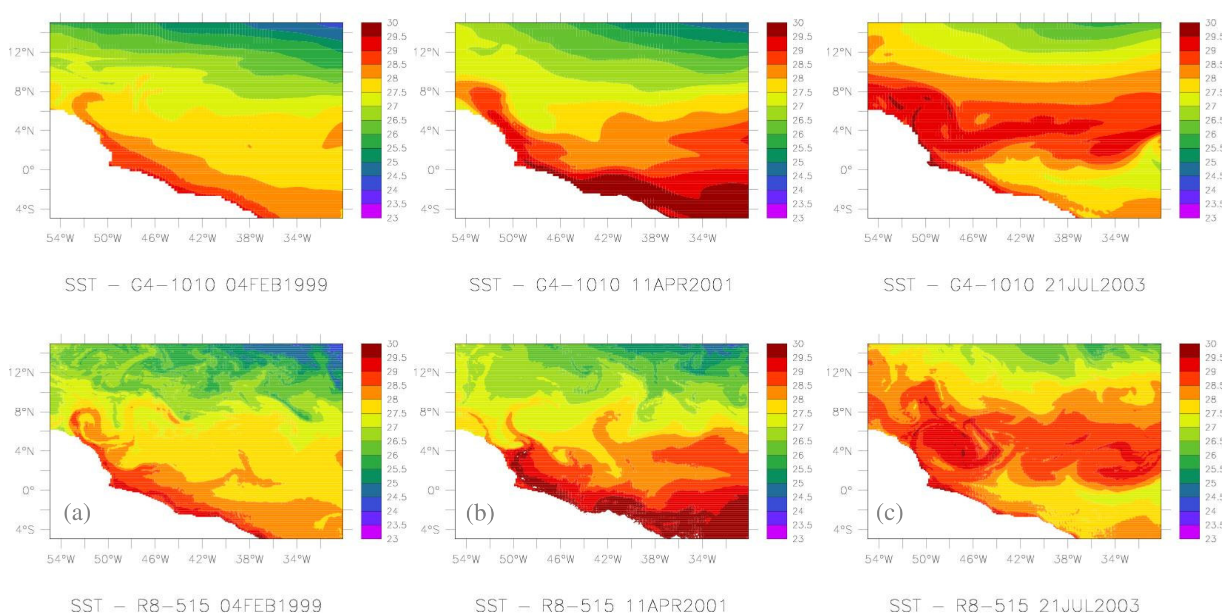

Figure 2: Comparison of Sea Surface Temperature (SST) distribution between G4-1010 and R8-515 experiments for (a) winter 1999, (b) spring 2001, and (c) summer 2003.

CONCLUSION

In this work two different OGCM grid resolutions on the Tropical Atlantic Ocean were used: 1/4-degree and 1/8-degree resolution, named G4-1010 and R8-515, respectively. The model outputs were compared with *in situ* upper ocean velocity measurements.

The G4-1010 experiment showed a very smoothed velocity field and was not able to reproduce correctly the equatorial zonal current system. The thermocline along 38W was too flat as a consequence of the lack of dynamical processes of 1/4-degree resolution.

The R8-515 experiment was able to reproduce correctly both the velocity field and the thermocline slopes along 38W.

The lack of resolution affects the SST horizontal distribution. The correct representation of dynamics on the 1/8-degree resolution experiment generated patches of high SST over the Tropical Atlantic. These patches might trigger deep convective processes on the atmosphere. Therefore, a resolution of 1/8-degree on the tropics may improve the weather forecast skills.

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