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THE IMPACT OF CUMULUS AND RADIATION PARAMETERIZATION SCHEMES ON SOUTHERN HEMISPHERE SUMMER CLIMATE SIMULATED BY CPTEC ATMOSPHERIC GENERAL CIRCULATION MODEL

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1. Introduction

The Southern Hemisphere (SH) summer climate is primarily influenced by the Indonesian, African and Amazon intense convection; the South Pacific Convergence Zone (SPCZ) and South Atlantic Convergence Zone (SACZ); the low pressures over western Australia, southern South America (Gran Chaco) and southern Africa. The SPCZ and SACZ are significant low level convergence zones in the SH characterized by strong moisture convergence and poleward flows along the western peripheries of the subtropical highs. They are linked to the tropical monsoon convection over the Indonesian and Amazonian regions respectively.

The South American summer climate is influenced by the Indonesian and African monsoon convection and the SPCZ through remote teleconecctions and regionally by the Amazon convection, Gran Chaco low pressure and SACZ. Therefore, a successful seasonal climate prediction over South America in part depends on the ability of the Atmosphere General Circulation Model (AGCM) coupled or not to the ocean model to simulate the main features of summer climate over the SH. So far, most of GCMs (including the CPTEC-COLA AGCM) have deficiencies to simulate the summer climate over the SH and mainly over South America. The objective of this study is to show that it is possible to improve the climate summer simulation over the SH through the improvement and adjustment of deep and shallow cumulus and solar radiation parameterization schemes in the new CPTEC dynamic global model.

2. Model description

The spectral dynamic model has been developed at CPTEC (here after CPTEC-AGCM). The Eulerian part of this code is similar to the CPTEC-COLA described in Cavalcanti et al. (2002), but computationally more efficient. The mass conservation is done with ln(P_s) constant, where P_s is the surface pressure. The CPTEC-AGCM is similar to the CPTEC-COLA-AGCM except for the new dynamic code. However, there are other differences: the new model contains three cumulus schemes: KUO (Kuo, 1974), Relaxed Arakawa-Schubert and Grell-ensemble (Grell and Devenyi, 2002) called here Grell2, two shallow convection schemes Tied (Tiedtke, 1989) and Souz (Souza, 1999) and two solar radiation schemes (of Lacis and Hansen (1974) called here Rad1 and Clirad-SW of Chou and Suarez (1999) called here Rad2. Rad 2 was modified by Tarasova and Fomin (2000). Grell2 and Souz schemes were modified and adjusted by Figueroa et al. (2006) for the LBA experiment. All remaining physical processes are similar to CPTEC-COLA AGCM described by Cavalcanti et al. (2002).

The horizontal resolution of the model is triangular T62, and vertical resolution is 28 levels (L28). The sea surface temperature is prescribed, which is updated daily by linear interpolation between monthly climatological blended data sets. The initial conditions were obtained from NCEP analysis.

3. Simulation design

The climate simulation was performed by integrating the model for 7 years, for each experiment, from the initial condition of 15 September 1995. The results are analyzed for the last 6 summers. The experiments were carried out with different cumulus and solar radiation parameterization schemes, such as showed in Table 1.

Exp.	Deep conv.	Shallow conv.	Solar rad.
Exp1	KUO	Tied	Rad1
Exp2	KUO	Tied	Rad2
Exp3	KUO	Souz	Rad1
Exp4	Grell2	Tied	Rad1
Exp5	Grell2	Tied	Rad2
Exp6	Grell2	Souz	Rad1
Exp7	Grell2	Souz	Rad2

Table 1. The experiments with different cumulus convection and solar radiation schemes.

4. Results

The precipitation field from Exp1 shows the similar systematic errors found by Cavalcanti et al (2002). Like Exp1, Exp2 also shows intense precipitation over the Andes, weak precipitation over the Amazon, strong SCPZ and SACZ (compare Fig.1 and Fig. 2). The comparison of Exp2 and Exp1 shows reduction of downward solar radiation at the surface and precipitaton over oceans (figures not showed). More details about the impact of Rad2 into CPTEC-GCM can be found in (Tarasova et al. 2006) and (Barbosa and Tarasova 2006).

The precipitation in the Exp3 shows an increasing of the systematic errors over South America found in Exp1. The Exp4 and Exp5 improve the precipitation over the Amazon but the SACZ is weak in comparison with observations. The results from Exp6 (Fig.3) and Exp7 (Fig.4) show enlargement of precipitation over the Amazon and the SACZ. However the Amazon precipitation is more intense than observation. The interesting result from the last experiment is observed over oceanic areas. The SPCZ and low subtropical pressures are well simulated.

These results show the importance of convection scheme for the Amazon convection and the SACZ and of solar radiation scheme for subtropical low pressures and SPCZ. The main impact of Rad2 in comparison with Rad1 is the reduction of downward solar radiation at the surface by approximately 50 W/m^2 in the subtropical region. The more realistic absorption of solar radiation in the new scheme was demonstrated in the off line comparison of both schemes with benchmark line-by-line calculations (Barbosa and Tarasova, 2006).

5. Summary and conclusions

Numerical experiments with different cumulus and solar radiation parameterization schemes were performed using the CPTEC-AGCM to study the impact of different physical processes on Southern Hemisphere summer climate simulation. Our results show the importance of convection scheme (deep and shallow) and radiation schemes for tropical convection and subtropical convergence zones. The main impact of Rad2 in comparison with Rad1 is the reduction of downward solar radiation at the surface by approximately 50 W/m2 in the subtropical region. The reduced solar radiative fluxes are in a better agreement with those observed at the surface. Our conclusion is that the best simulations of the Southern Hemisphere summer climate with the CPTEC-AGCM are obtained by the combination of the Grell2 parameterization for the deep convection, Souz for shallow convection and Rad2 for solar radiation.

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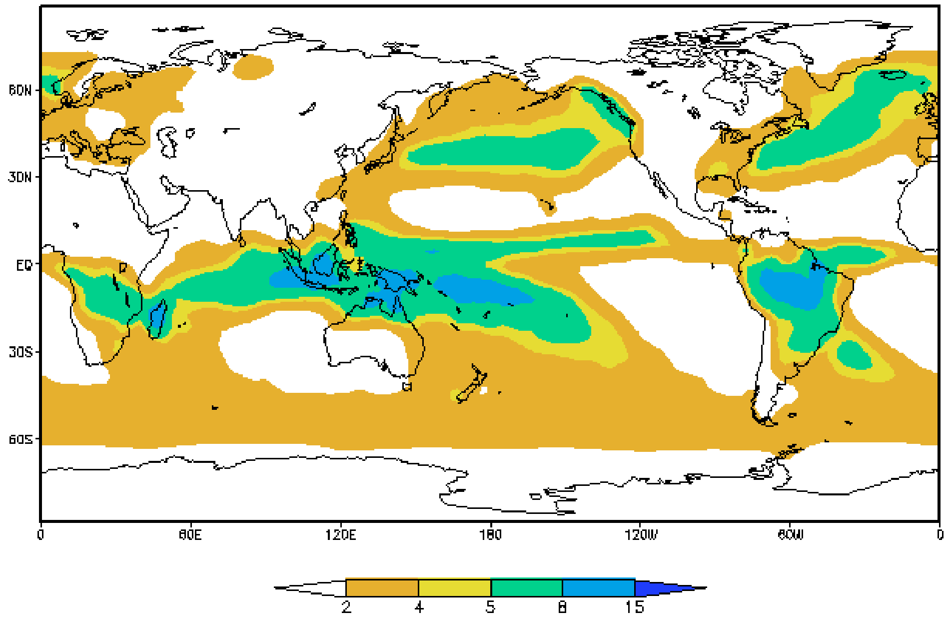

Fig1. Average summer precipitation (mm/day) derived from satellite observations (GPCP).

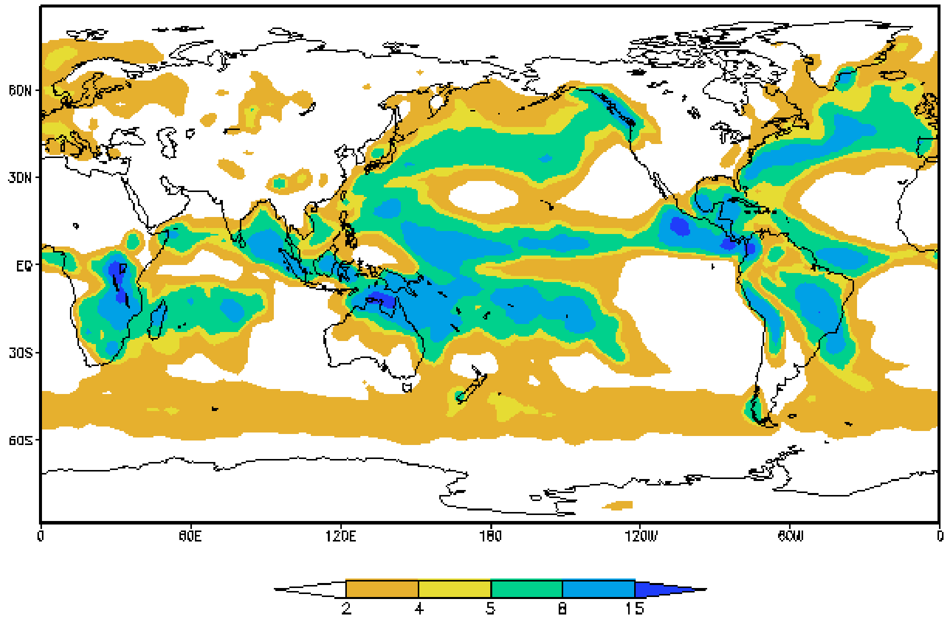

Fig.2- Precipitation (mm/day) from second summer is shown for model simulation using **KUO** and **Rad2**.

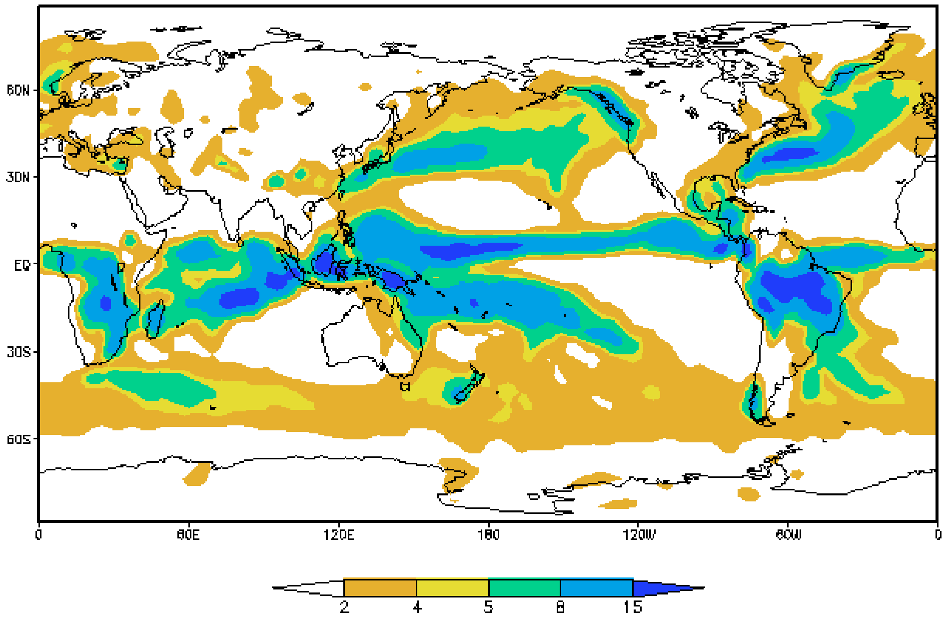

Fig.3- Precipitation (mm/day) from second summer is shown for model simulation using **Grell2** and **Rad1**.

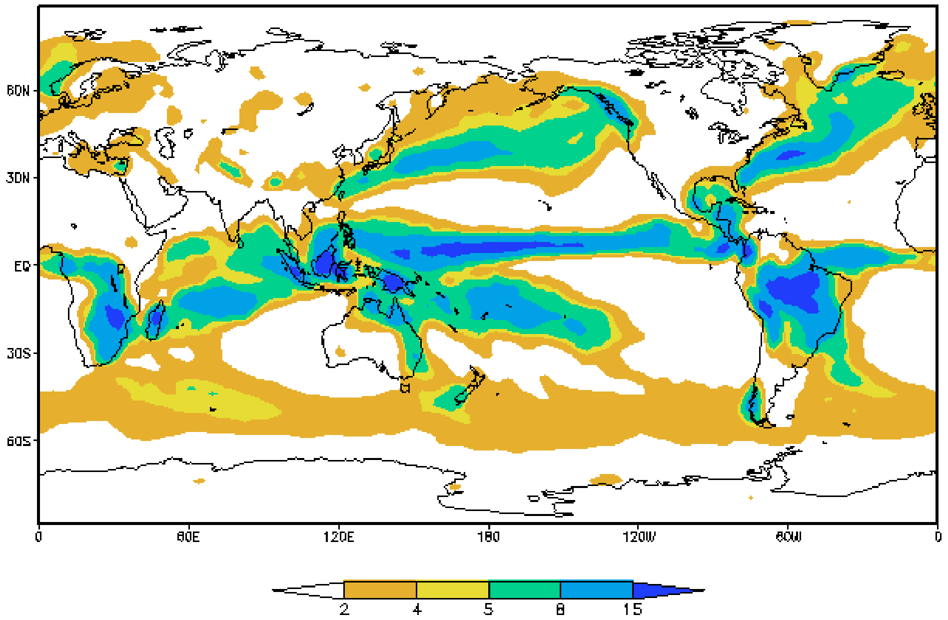

Fig.4- Precipitation (mm/day) from second summer is shown for model simulation using **Grell2** and **Rad2**.