NORTHERN SOUTH AMERICA PRECIPITATION BIAS IN CCSM4 MODEL

Fernanda C. VASCONCELLOS[1], Yi DENG[2], J. Guilherme M. dos SANTOS[3]
fernandavasconcellos@igeo.ufrj.br

[1]Federal University of Rio de Janeiro (UFRJ - Brazil)
[2] Georgia Institute of Technology (GaTech – USA)
[3] National Institute of Space Research (INPE – Brazil)

RESUMO

Neste trabalho avaliou-se a rodada histórica (1980-2005) do *Community Climate System Model version 4* (CCSM4). Os resultados obtidos apresentaram um bias negativo de precipitação no norte da América do Sul. A ocorrência deste bias está relacionada a uma divergência anômala do fluxo de umidade em baixos níveis, sugerindo que menos umidade está disponível para convecção no modelo. A causa dessa divergência anômala está no Atlântico tropical. A presença de um bias negativo de TSM no Atlântico Norte tropical gerou alísios de nordeste mais intensos, o que levou a um fluxo de umidade mais forte em direção ao interior do continente e, consequentemente, a uma divergência do fluxo de umidade perto da costa.

ABSTRACT

We have examined the historical (1980-2005) austral summer precipitation at tropical South America (SA) with the Community Climate System Model version 4 (CCSM4). Our results presented a negative precipitation bias at northern parts of SA. This bias occurs because an anomalous divergence of moisture flux at low level, indicating that there is less moisture available for convection. The cause of this anomalous moisture flux divergence is in Tropical Atlantic Ocean. Negative SST bias over northern tropical Atlantic produced stronger northeasterly trade wind, leading to a more intense moisture flux to inner continent and, consequently, an anomalous divergence of moisture flux near coast.

Key-words: Northern South America, precipitation bias, CCSM4

1) INTRODUCTION

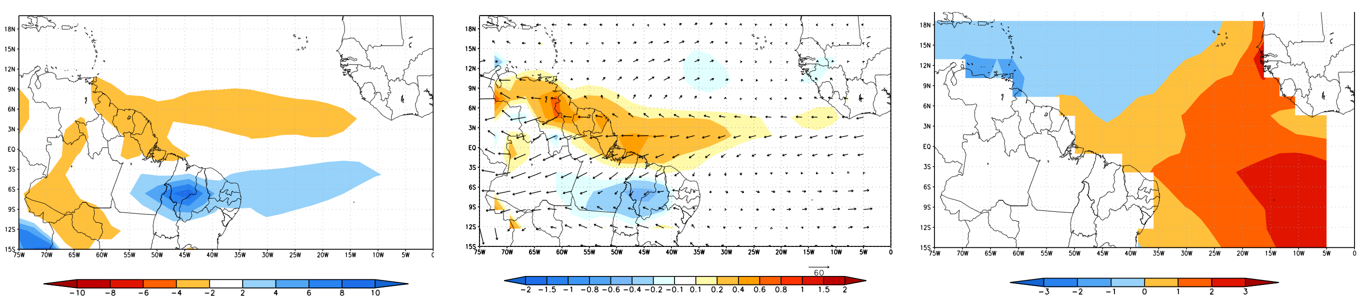
The northern tropical South America (SA) encompasses one of the major continental regions with intense convective activity in the globe. Thus, it constitutes an important heat source for the atmosphere and contributes to the atmospheric general circulation (Andreoli et al., 2012). State-of-the-art Earth System Models (ESMs) in Coupled Model Intercomparison Project phase 5 (CMIP5) suffer from large errors when simulating tropical climate, imposing some limitations over their utility in climate prediction and projection. Identify theses ESM tropical errors and evaluate possible causes is an important step toward improve accuracy in future model development efforts. This study evaluates the Community Climate System Model version 4 (CCSM4), an ESM available in CMIP5, specifically focusing on precipitation over northern tropical SA. The following questions are investigated: 1) Are austral summer rainfall climatology over tropical SA and their controlling processes realistically represented in CCSM4? 2) If not, what are the main causes of such model bias?

2) DATA AND METHODOLOGY

The analysis of the historical experiment in this paper includes daily outputs CCSM4 (one run only). For comparison and evaluation of model results, following datasets were utilized: monthly output of Global Precipitation Climatology Project (GPCP) (Adler et al., 2003); daily output of National Oceanic & Atmospheric Administration (NOAA) Sea Surface Temperature (SST) (Reynolds et al., 2007); daily output of ECMWF Era-interim Reanalysis (Dee et al., 2011). We evaluated austral summer (DJF) for 1980-2005 period, except for SST analysis (1982-2005), because NOAA SST period available. Maps of summer difference between model and observation were built for tropical precipitation and SST. Moisture flux and divergence moisture flux at 850 hPa was calculated for model and Era-interim outputs. Then difference between model result and Era-interim for these variables was calculated. DFJ means of this difference was built. We also repeat methodology above, but calculating moisture flux and divergence moisture flux using wind from models and moisture from Era-Interim and vice versa, subtracting then from Era-interim only.

3) RESULTS

Historical austral summer precipitation at tropical SA in CCSM4 showed a negative bias at northern parts of SA, including Guianas, Suriname and northern Brazil (Figure 1 a). This bias is also present in other CMIP5 models, as showed in Jones and Carvalho (2013). Low level anomalous moisture flux divergence is seen at northern coast of SA (Figure 1a), explaining negative precipitation bias. We also calculated the divergence of low level moisture flux, using wind from models and moisture from Era-Interim and vice versa. The results suggest the wind is mainly responsible for anomalous moisture flux divergence at northern SA (not shown). These results indicate the northeasterly trade winds over tropical North Atlantic are more intense at models comparing to Era-Interim, causing a more intense moisture flux to inner continent and, consequently, an anomalous divergence of moisture flux near coast. CCSM4 presents a negative SST biases over northern tropical Atlantic (Figure 1 c), explaining stronger northeastly trade winds and stronger moisture flux to inner continent at CCSM4.



(a) (b) (c)

Figure 1: DJF mean (a) CCSM4 precipitation minus GPCP (mm.dia-1), (b) CCSM4 minus Era-Interim divergence of moisture flux at 850 hPa (10-4 g.kg-1.s-1 - colour) and moisture flux (g.kg-1.m.s-1 - vector), (c) CCSM4 minus NOAA SST (°C).

4) CONCLUSION

CCSM4 model shows a negative precipitation bias over northern SA. This bias is caused by anomalous divergence of moisture flux at low levels, indicating less moisture avaliable for convection. Cause of this anomalous moisture flux divergence is in Tropical Atlantic Ocean. Negative SST bias over northern tropical Atlantic produce stronger northeasterly trade wind, leading to a more intense moisture flux to inner continent and, consequently, an anomalous divergence of moisture flux near coast.

REFERENCES

Adler, R.F. et al., 2003: The Version 2 Global Precipitation Climatology Project (GPCP) monthly precipitation analysis (1979-Present). Journal of Hydrometeorology, 4, 1147-1167.

Andreoli, R.V. et al., 2012: Seasonal anomalous rainfall in the central and eastern Amazon and associated anomalous oceanic and atmospheric patterns. International Journal of Climatology, 32, 1193–1205.

Dee, D.P. et al., 2011: The ERA-Interim reanalysis: configuration and performance of the data assimilation system. Quarterly Journal of the Royal Meteorological Society, 137, 553–597.

Jones, C. and Carvalho, L.M.V., 2013: Climate Change in the South American Monsoon System: Present Climate and CMIP5 Projections. Journal of Climate, 26, 6660-6678.

Reynolds, R.W. et al., 2007: Daily High-Resolution-Blended Analyses for Sea Surface Temperature. Journal of Climate, 20, 5473-5496.