Climate sensitivity of the Brazilian Earth System Model, version 2.5

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Introduction

The Brazilian Earth System Model, coupled ocean-atmosphere (BESM-OA2.5) is the coupling of the CPTEC/INPE Atmospheric General Circulation Model (AGCM) and the GFDL/NOAA ocean model (MOM4p1) (Nobre *et al.*, 2013).

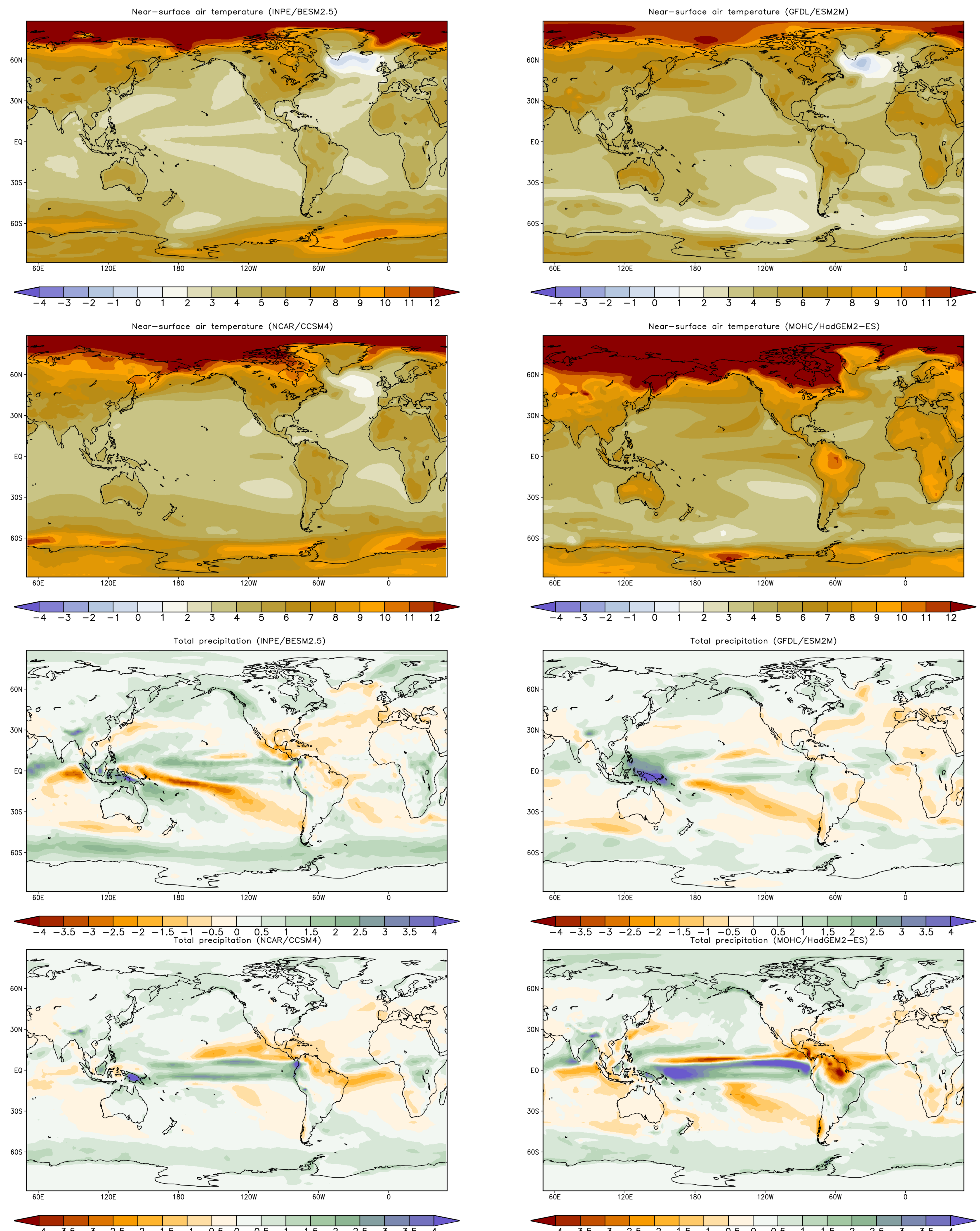
Methodology

The piControl and Abrupt4xCO2 simulations were used in this study. Comparisons were made between the results of BESM-OA2.5 and other CMIP5 models, chosen arbitrarily as representative of the state of the art models in global climate modeling: NCAR's CCMS4, GFDL's ESM2M and the Hadley Centre's HadGEM-ES. Moreover, Gregory *et al.* (2004) and Andrews *et al.* (2012) were used to estimate the Equilibrium Climate Sensitivity (ECS) and the Cloud Radiative Effect (CRE) of the BESM-AO2.5. In this approach the difference in net radiation at the top of atmosphere (N) is considered linearly related to the near-surface temperature change (ΔT) as follow:

$$N = F - \alpha \Delta T$$

Results

The BESM-OA2.5 has ECS of 2.95 K and CRE of $-0.11\ Wm^{-2}K^{-1}$. This model simulates the warming in the Arctic, a feature observed in CMIP5 models, but absent in the previous version of the model (BESM-OA2.4). This result was the consequence of several improvements in BESM, namely the physical representation of the AGCM, especially in the parameterization of cloud microphysics and the formulation of wind, humidity and temperature near the surface. The warming in the Arctic region exceeds 12ºC for all models evaluated in this study in a scenario of quadrupling the concentration of carbon dioxide (CO_2). The BESM-OA2.5 and ESM2M models present a cooling region around 60ºN in the Atlantic Ocean, this is probably due to a same oceanic feature associated with the fact that both use the same ocean model. In addition, the BESM-OA2.5 shows agreement with other models on the location of maximum heating in different parts of the globe, such as: northern and southern Africa; center part of Australia; northeastern North America; northern and central South America; in the south of the Middle East; northern and central Asia; over the ocean near Antarctica. In the case of precipitation, there is greater variability in the spatial patterns of increase/decrease in comparison to the temperature. The largest deviations are presented by HadGEM2-ES model, while BESM-OA2.5, CCSM4 and ESM2M present variations of the same order of magnitude among them. The analyzed models feature a westward shifted South Pacific convergence zone (SPCZ) in a climate with $4xCO_2$, which means an increase (a decrease) of precipitation over the western (central and eastern) part of the South Pacific. The models show an increase in the precipitation over the Equatorial Pacific region. Furthermore, a dipole structure over South America is presented by the BESM-OA2.5, CCSM4 and HadGEM2-ES models.



Conclusion

The BESM-OA2.5 has ECS of 2.95 K and CRE of $-0.11\ Wm^{-2}K^{-1}$, which are comparable to other CMIP5 models. The BESM-OA2.5 shows agreement with other models on the location of maximum heating in different parts of the globe. Moreover, the analyzed models feature a westward shifted SPCZ and increased precipitation over the Equatorial Pacific region.

Acknowledgements

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Reference

[1] Andrews, T., Gregory, J. M., Webb, M. J., Taylor, K. E. **Forcing, feedbacks and climate sensitivity in CMIP5 coupled atmosphere-ocean climate models** *Geophys. Res. Lett.*, vol. 39, no. 9, pp. 1944–8007, 2012.

[2] Gregory, J. M. , W. J. Ingram, M. A. Palmer, G. S. Jones, P. A. Stott, R. B. Thorpe, J. A. Lowe, T. C. Johns, and K. D. Williams **A new method for diagnosing radiative forcing and climate sensitivity** *Geophys. Res. Lett.*, vol. 31, doi:10.1029/2003GL0187477, 2012.

[3] Nobre, P. *et al.*. **Climate simulation and change in the Brazilian climate model**. *J Clim*, vol. 26(17):6716-6732, 2013.