Session: C34 Poster: W255B

Systematic underestimation of precipitation over southeastern South America in the WCRP-CMIP3 multi-model dataset simulations: an evaluation of possible causes

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Global Climate Model (GCM) simulations included in the WCRP-CMIP3 multi model dataset display a surprisingly consistent pattern of underestimated precipitation over much of southeastern South America for the present climate. This problem is particularly noticeable in some GCMs and is somewhat less distinct in others, but is nevertheless present in all of them. In this work, the atmospheric-only CAM3.1 global model is used to explore the role of different horizontal resolutions, physical parameterization schemes, sea surface temperature (SST) distributions and its ability to represent the main teleconnection patterns. A control run spanning a 10-yr period and using observed monthly SST fields as boundary conditions is performed to determine the skill of the CAM3.1 to represent the present climate. Validation results show the same underestimation pattern as in the WCRP-CMIP3 GCMs. Since CAM3.1 is an atmospheric-only climate model, this result suggests that the representation of the oceanic component and its impact on the atmosphere is probably not forcing the errors in the estimation of precipitation but that the source of the underestimation should be looked for in the atmosphere itself. Consequently, a series of simulations were performed to explore the role of the size of the grid mesh varying it from T42 to T85. Additionally, a simulation was carried out removing the Andes Cordillera (which runs almost parallel to the coast, along the western edge of South America) to study to what extent the representation of this topographic barrier determines the horizontal moisture flux fields and their impacts on precipitation genesis. SST representation and influence on the Southern Hemisphere circulation were assessed by performing two different simulations. In the first one, the SST gradient over the South Pacific was modified in order to increase the atmospheric baroclinicity and upper tropospheric winds by enhancing the thermal wind. In the second one, the SST distribution along the South Pacific Convergence Zone (SPCZ) was altered to enhance Rossby wave genesis in that region to analyze the teleconnection representation between the SPCZ and southeastern South America. The impact of the convective parameterization selection was assessed changing the original Zhang-McFarlane scheme used by CAM3.1 to modify the possibilities of convection development. In one case, by increasing the convective available potential energy threshold necessary for convective triggering in the model, less convection was allowed to develop. In the second case and by lowering this threshold, more convection was admitted. Finally, a simulation was carried out with a new version of CAM in which the representation of convection is improved by adding a treatment of convective momentum transports. Comparisons among the different simulations indicate that both horizontal resolution and topography have an important role in the representation of the atmospheric circulation of the Southern Hemisphere and also on precipitation over the region, although their influence in the simulations particularly over southeastern South America is less distinct. It is also found that errors in precipitation fields can be largely solved by improving the convective scheme considered. Consequently, the results of the different simulations performed suggest that the misrepresentation of rainfall over southeastern South America is a thermodynamic- rather than a dynamic-related issue.