J1.2 REGIONAL SPECTRAL MODEL SIMULATION FOR BRAZIL WITH SOIL MOISTURE CORRECTION

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1. INTRODUCTION

A dynamical downscaling methodology for use over Brazil has been developed using the regional spectral model (RSM). Here the regional spectral model (RSM) originally developed at NCEP (Juang and Kanamitsu 1994) is utilized. This regional model was used for many of our previous regional modeling efforts (e.g. Chen et. al 1999; Roads and Chen 2000; Chen 2001). The RSM has the same vertical structure (sigma coordinates) and physical parameterizations as NCEP's global spectral model (GSM) used for the NCEP/NCAR reanalysis I (NCEPRI) as well as most of the modifications made to the GSM for the NCEP-DOE reanalysis (Kanamitsu et al. 1998). Our current effort has focused on the simulation of regional climate features over Brazil, when these simulations are forced by the NCEP/NCAR reanalysis I. It was found that there is a drying trend in the model soil moisture after the initial 3 months of continuous integration. The drying trend is a response to the positive feedback from the dry bias of precipitation, due to the imperfect model parameterization. By utilizing the available observed precipitation (Xie and Arkin 1997), we will show that a soil moisture correction scheme can improve this regional simulation.

2. FORCING REANALYSIS AND EXPERIMENT DESIGN

The 4 times daily NCEP/NCAR reanalysis I (Kalnay ***et al***. 1996), 28 vertical levels of virtual temperature, horizontal wind components, and specific humidity and surface pressure are used to force the regional model. In addition, reanalysis skin temperature, volumetric soil moisture, snow depth, soil temperature, albedo, sea-land-ice mask, and topography were also required to initialize the model.

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The simulation covers an area from 85W-20W and 40S-10N with Mercator projection centered at (15N 55W) and with 50 km grid space. Two continuous simulations for each model for the periods of March 1, 1997 through March 31, 1999, and January 1 through May 31, 1985 have been done. All model variables are nudged at the lateral boundary with updated reanalysis 4 times daily data. Following an initialization at the beginning of the two periods, the simulations were then run continuously during the chosen time periods.

3. PRELIMINARY RESULTS

Initial results showed that our version of the RSM developed a severe surface moisture-drying trend, which affected the precipitation and other model variables. In the NCEPR1, this drying was corrected by forcing the analyses back to a climatology (Roads et al. 1999). There were a number of problems with this type of approach and a different approach was developed for the NCEPRII (Kanamitsu et al. 2000), from which we adopted the idea but modified the methodology. In particular, we used observed precipitation to correct the drying trend in the soil moisture. However, unlike the NCEPRII, we mainly corrected the lower level soil (lower 190 cm) moisture and allowed the upper level soil moisture (upper 10 cm) to come to equilibrium with the model precipitation.

The detailed procedure was to adjust the deep layer soil moisture every 5 days using the differences of accumulated model precipitation during the period with those of Xie-Arkin. We first ran the model precipitation through a 25-point smoother to match the spatial resolution of both fields. Then we injected the required (when observation is more than model rain) water into the 2nd layer if the soil moisture content was dryer than the first layer, and the opposite water extraction was performed if the model rain was in excess of observation. The spatial smoothing was important since (unlike the NCEPRII) our regional high-resolution precipitation and land surface were

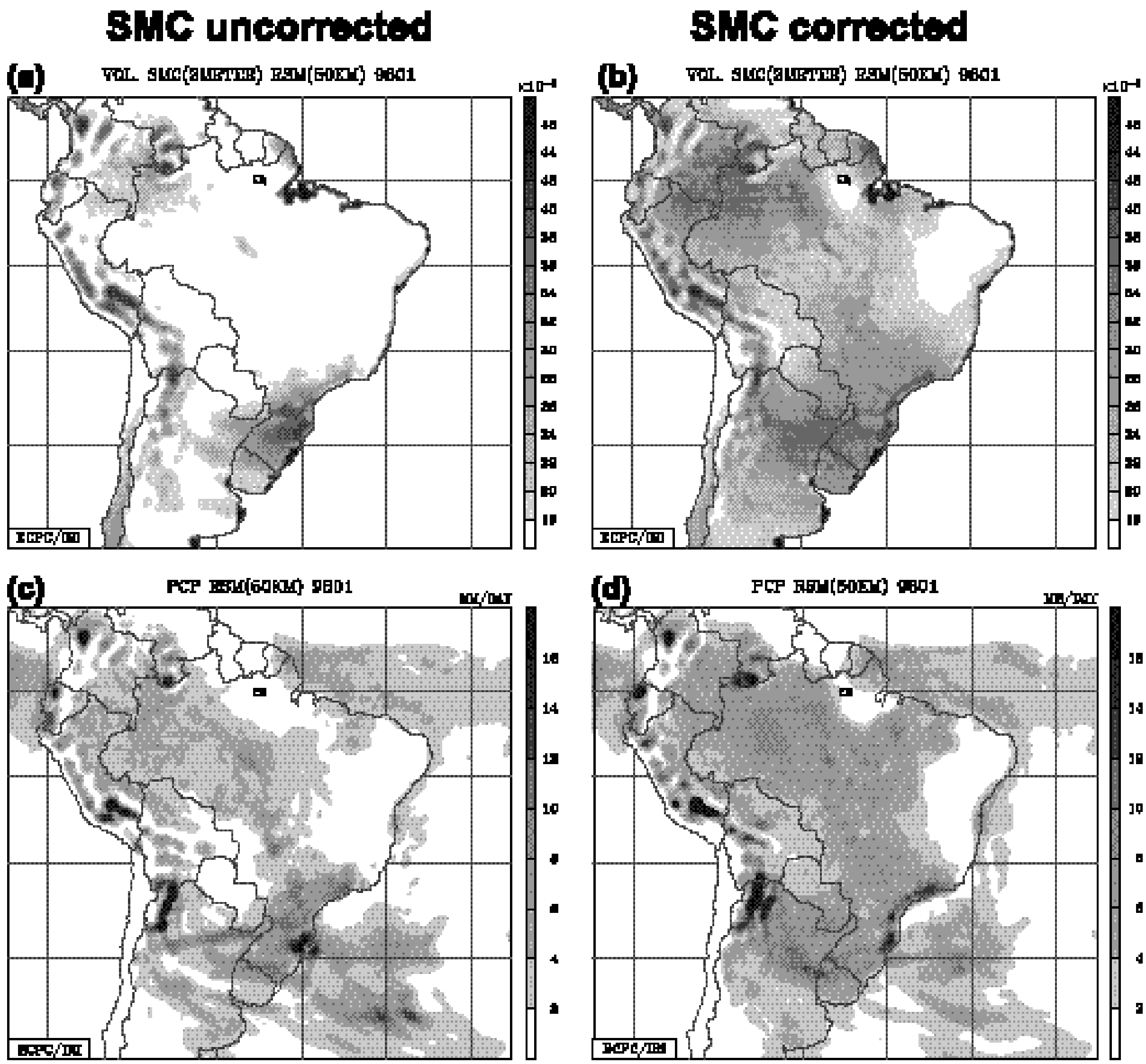

Figure 1. The monthly-mean soil moisture content (SMC) (volumetric, top panels) and precipitation (mm day^{-1}, lower panels) during RSM run during January 1998. Results from the SMC uncorrected run are shown on the left panels, the SMC corrected run is on the right.

not well matched to the coarser global scale observations. Any supersaturated water from the 2nd layer would be temporarily moved into the 1st layer, then run off at the next time-step by the model surface hydrologic process.

Figure 1 shows the impact of the soil moisture correction. The soil moisture in Figure 1a in the uncorrected run demonstrates a drying up in the entire 2-meter column of soil 10 months into the integration. The corrected run however, maintains the moisture level closer to the reanalysis (not shown) but with more spatial details. The impact to the precipitation is also noticeable between two runs. In particular, the precipitation over central Brazil has been enhanced to a more reasonable value.

The correction amount of this soil water is relatively small at each pentad interval (less than 5% in general) in comparison to the model rainfall. However the impact is quite substantial.

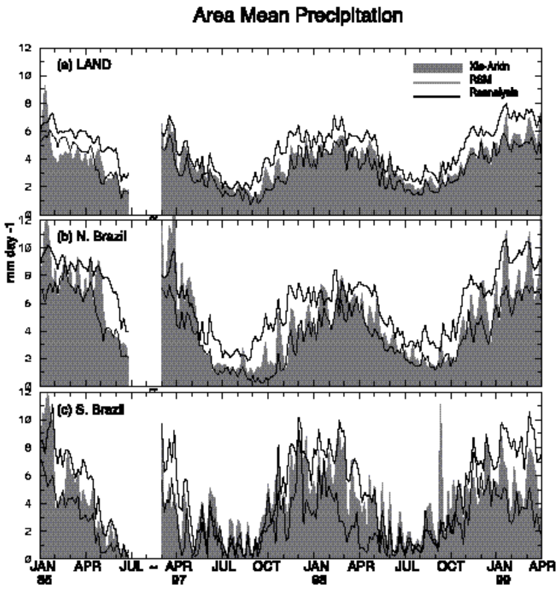

Figure 2. Area mean precipitation over (a) total land of entire simulation domain, (b) Northern Brazil, and (c) Southern Brazil. Xie-Arkin's observations are shaded; reanalyses are represented by thick solid lines; RSM simulations are represented by thin lines.

Figure 2 shows the simulated area average precipitation for the entire land region of South America, as well as the Northern (north of 15S) and Southern (south of 15S) regions. Although the strong annual cycle is present in both the NCEPRI and Xie and Arkin observations, it is encouraging that the wet bias of NEZPRI has been improved in this soil-moisture corrected RSM simulation. However there are still some simulation defects. The RSM precipitation may still be too dry, particularly in Southern Brazil during the 97/98 summer. Further research is needed.

The March-April-May (MAM) precipitation for 1998 and its contrast with the other years are also examined. For 1998, RSM modifies the precipitation details of that in the reanalysis, although there is still a dry bias in central Brazil, compared to the Xie and Arkin precipitation. Still, the inter-annual differences are simulated well, especially in the extra-tropical region. The dipole wet-dry structure over Brazil in both 1997 and 1999 is well captured, in comparison to reanalysis, especially the dry region over the southern-most tip of Brazil. We will also be comparing these simulations to station observations in order to examine statistical characteristics, such as rain day probability, distribution frequencies, detailed geographical distribution; and extend these diagnostics to other variables.

4. SUMMARY AND DISCUSSION

Although the improvement of the well-known precipitation dry bias in the NCEP model and its direct impact to the soil moisture are under development, here we demonstrated an empirical method that can retain the soil moisture at its reasonable level and distribution. The correction is rather small in comparison to the total precipitation, however the effect is significant. This experiment also underlines the importance of the soil moisture in influencing the precipitation of this region.

Work is underway to further validate these simulations with available observation data. A limited set of station precipitation data has been made available to us through collaboration with the International Research Center (IRI). The downscale skill can only be confirmed through a rigorous comparison with station data. However we also felt that the different regional model physics and modeling strategy were almost as important as the change in resolution (Chen 2001) and it was therefore important for us to better understand this by running low resolution regional model runs in addition to the higher resolution runs. The low-resolution runs should be of comparable resolution to the driving reanalysis. It was felt these lower resolution runs could be performed fairly quickly and would provide another useful intercomparison.

5. ACKNOWLEDGEMENTS

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