The benefits of increased resolution in simulating precipitation over Sub-Saharan Africa. A comparison of AMIP integrations of GEM at 1° and 2° model resolution.

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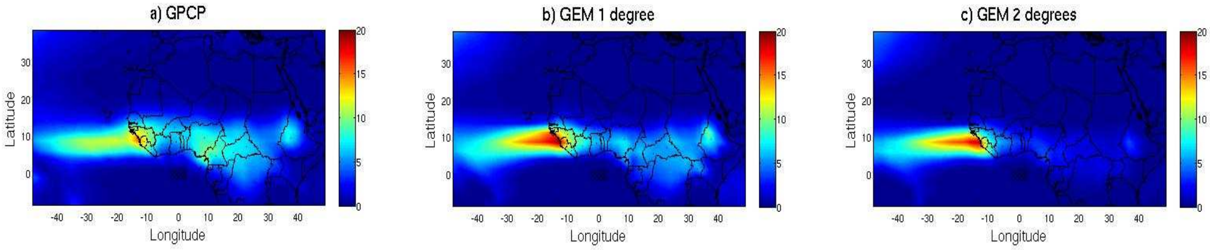
Introduction

The Sub-Saharan tropical climate is mainly driven by the seasonal migration of the ITCZ (Inter Tropical Convergence Zone). Within the ITCZ strong scale interaction supports the development of African Easterly Waves (AEWs), with Mesoscale Convective Systems (MCS) embedded within these synoptic scale waves. The latter MCS are responsible for much of the precipitation in the sub-Saharan region (Lebel et al., 2003). Substantial differences have been documented in the meridional migration and intensity of the ITCZ between wet and dry years (Grist and Nicholson 2001), with large impacts on local populations. The aim of this study is to investigate the ability of 2 versions of the Global Environmental Model (GEM) to simulate precipitation variability over Sub-Saharan Africa, both in terms of the climatological annual cycle and interannual variability.

Model and Observations

Simulated data is obtained from an AMIP-style integration of the Global version of GEM, forced by observed Sea Surface Temperatures (SST) for the period 1978-2003. Two versions of GEM are compared, at resolutions of 1° and 2° respectively. GEM uses the Kain-Fristch convection scheme (Kain and Fritsch 1990) which amongst other features includes a resolution dependent convective trigger function. In this study we wish to compare the impact of increased resolution on simulated precipitation over sub-Saharan Africa. Model results are compared to observations from the Global Precipitation Climatology Project (GPCP) pentad precipitation data set at 2.5° resolution for the period 1979-2003. All results have been interpolated to a common 2.5° grid.

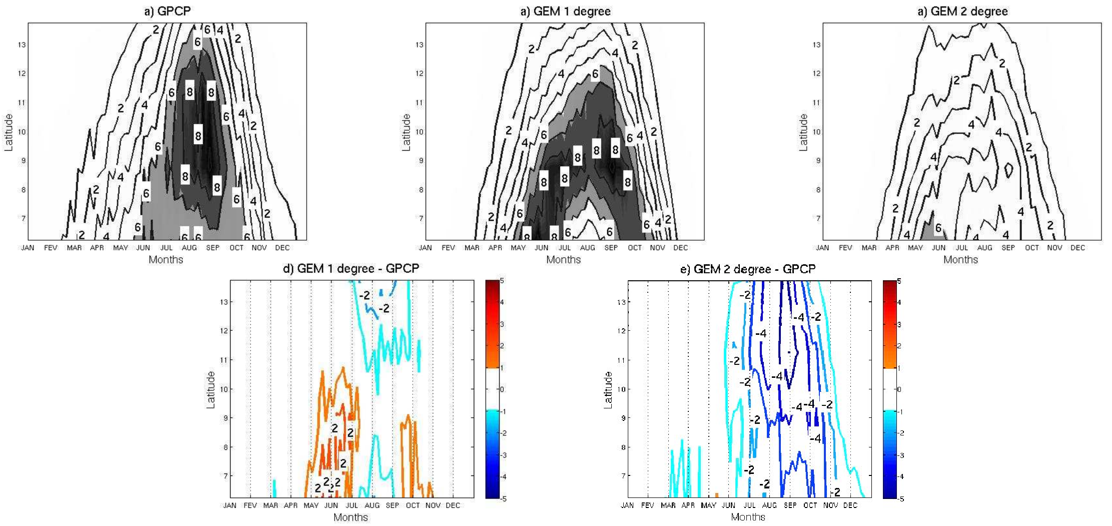


Figures 1 *Climatological seasonal mean (JAS, July, August, and September) precipitation (mm/day) for: a) GPCP, b) GEM 1° and c) GEM2°, for 1979-2003.*

Results

Figure 1 shows the 1979-2003 averaged seasonal mean precipitation for the months June-August (JJA). The GEM 2° integration significantly underestimates precipitation across the African ITCZ region, while the GEM 1° results are clearly improved, although still underestimated by ~20% compared to GPCP values. Local maxima in precipitation are well captured around the Ethiopian highlands (35-40°W, 10°N) and at the Atlantic coast. The latter maxima appears somewhat overestimated in both GEM integrations, although TRMM climatology (1998-2003) suggests more like 16-18 mm/day in this region and GPCP values around 14-16 mm/day.

To better evaluate the seasonal migration of the ITCZ, figure 2 presents a latitude versus time analysis of precipitation, averaged over the longitude belt 20°W-40°E (i.e. the continental Africa ITCZ) and for the years 1979-2003. Differences between the 2 GEM integrations and the GPCP values are shown in figure 2c and 2d. Both the ITCZ intensity and northward propagation are significantly improved in the 1° version of GEM. The onset and decay of the rainy season are also relatively well captured, with the main error being excess precipitation in the early part of the wet season (May-June).



Figures 2 *Cross section of mean rainfall (mm.day^{-1}) as a function of month and latitude, averaged for 20^{o}W to 40^{o}E from 1979 to 2003 for: a) GPCP, b) GEM of 1 degree resolution, c) for GEM with a resolution of 2 degrees, d) GEM 1 degree minus GPCP observations and e) GEM 2 degrees minus GPCP observations.*

Conclusions

This work clearly shows the benefits of increased resolution in the GEM global atmospheric model in terms of simulating the climatology of precipitation over sub-Saharan Africa. Both the location, intensity and seasonal migration are significantly improved when the resolution of GEM, is increased from 2° to 1°. Further work will look at the benefits ensuing with respect to simulated inter-annual variability of precipitation in this region and higher time frequency precipitation intensities.

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