Improvement of simulated monsoon precipitation over South-Asia with a regionally coupled model ROM

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1. Motivation

A regional coupled atmosphere–ocean model is developed to study the monsoon climate over South Asia. Most of the climate models (both GCM and RCM) underestimate precipitation over South Asia, but overestimate precipitation over the Bay of Bengal and the equatorial Indian Ocean. These systematic differences between the models may be related to a fundamental problem of atmospheric models: the inability to simulate intraseasonal variability. The intraseasonal oscillations of the South Asian monsoon play a major role in influencing the seasonal mean monsoon characteristics and their interannual variability (Goswami and Mohan, 2001). Several GCM studies with focus on the South Asian monsoonal region have concluded that GCMs have difficulties in simulating the mean monsoon climate (Turner and Annamalai, 2012). RCMs do simulate better orographic induced precipitation, but also show limited ability to simulate the land precipitation (Lucas-Picher et al., 2011; Kumar et al., 2013). For this study, differences in coupled and uncoupled simulations are analyzed to investigate the effect of coupling on the simulated climate, especially precipitation spatial patterns.

2. Model Setup

The REgional atmosphere MOdel REMO (Jacob, 2001) with 50km horizontal resolution is coupled to the global ocean – sea ice model MPIOM with increased resolution over the Indian Ocean (up to 20 km). Hereafter this coupled system will be called as ROM. The CORDEX south Asia domain is taken as atmospheric model domain (Fig.1). The models are coupled via the OASIS coupler. The global Hydrological Discharge model HD, which calculates river runoff (0.5^{o} horizontal grid resolution), is coupled to both the atmosphere and ocean components. Exchange of fields between ocean and atmosphere takes place every three hours. Exchange between REMO/MPIOM and HD model is done once per day. Lateral atmospheric and upper oceanic boundary conditions outside the REMO domain were prescribed using ERA40 reanalysis for the two hindcast simulations and using MPI-ESM-LR for two historical runs. The total simulation period is 1958-2005. Results are presented for the period 1988-1997.

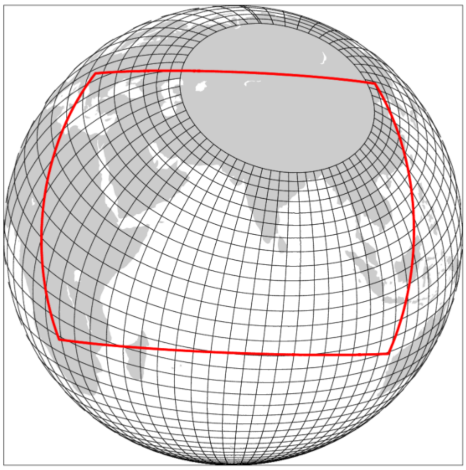

Figure 1. Grid configuration: the red “rectangle” indicates the coupled domain (REMO model) black lines indicate the grid of the MPIOM/HAMOCC. For the ocean/sea ice grid only every 15th line is shown.

3. Hindcast simulations

Fig-2 shows the annual mean SST difference between the two model simulations ROM and REMO [forced with historical simulation of MPI-ESM-LR for the period 1988-1997] with observation (ORSA4) SST. ROM is able to reproduce the SST well over the region of interest. The forcing GCM has a large cold bias (right panel), which the coupled model has reduced (middle panel) despite some enhanced cold biases over the south Indian Ocean.

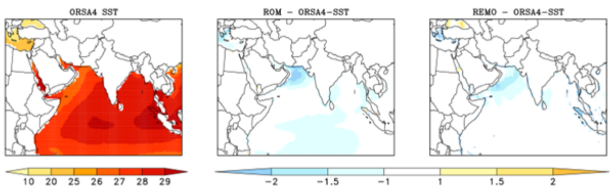

Fig. 2: Left panel, spatial pattern of annual mean observed (ORSA4) SST over the Indian ocean. Middle (ROM) and right (REMO) panels show the SST difference with ORSA4. Period 1988-1997, unit is (°C).

Fig-3 shows the precipitation difference (%) for ROM and REMO with respect to CRU (land)-HOAPS (ocean). Standalone model simulated results (forced with ERA40 and MPI-ESM-LR) show large precipitation biases both over land and ocean.

Over land it is highly underestimating rainfall over plains of South Asia (Bangladesh, India, also over the west coast of Myanmar and India). Keeping in mind that these are key precipitation zones of the monsoon climate (top panel) receiving large annual mean rainfall (6 to 20 mm/d). There is a large overestimation of precipitation over the south Indian Ocean.

However, feedback of ocean SST has a positive influence on the simulated precipitation of ROM both over land and ocean. As evident, compared to REMO, ROM simulations show significant improvement in the annual mean spatial pattern of precipitation both over land and ocean. ROM showed an increase over Bangladesh (~75%), over the plains of northern India (~50%) and decrease over the southern Indian Ocean (~100%) with respect to the uncoupled model. The western part of the domain receives very less amount of rainfall, so small change (< 0.5 mm/d) in magnitude lead to large relative differences (%). The possible mechanisms responsible for such an improvement is still under investigation, results of this analysis may be presented at the conference.

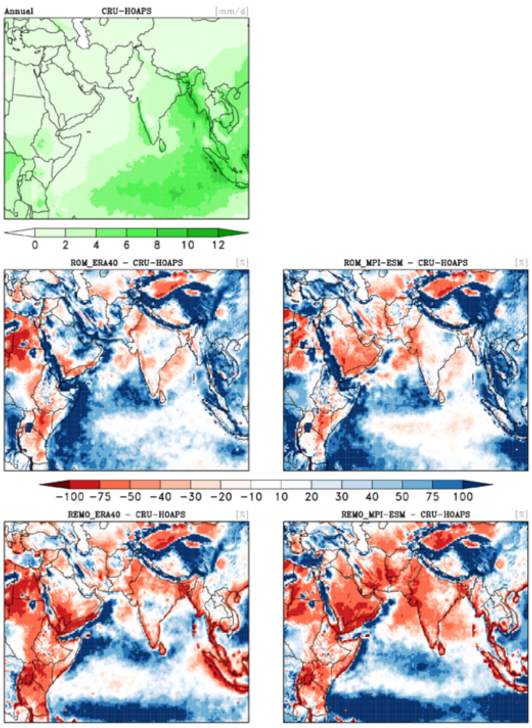

Fig.3: Top panel, annual mean precipitation over south Asia (mm/d). Middle panel shows the ROM (forced with ERA40 and MPI-ESM-LR) precipitation difference (%) with observations CRU-HOAPS. Lower panels is same as middle but for REMO. Period is 1989-2008.

4. Conclusion

REMO coupled with MPIOM (ROM) shows good skill with respect to the REMO standalone model results. ROM shows ability to reproduce SST as well as spatial pattern of monsoon precipitation. The coupling has positive impacts on the simulated precipitation not only over land but also over ocean. However, a more robust conclusion will be made after the assessment of a long term climate simulation.

Reference

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