Study of Northeast Monsoon over India using a coupled land-atmosphere model RegCM4-CLM4.5

EGU2020-7772

Praveen Rai, Pyarimohan Maharana, Dhirendra Kumar, Ashok Priyadarshan Dimri, and Heiko Paeth

Introduction

- North East Monsoon-
  - Important for South peninsular India during October to December (Dhar and Rakhecha, 1983).
  - Contributes around 17 - 49% in most of the sub-divisions (Sreekala et al., 2018), and 11% of the total annual rainfall of the country (Rajeevan et al., 2012).
  - One of the responsible system for NEM is the southward shift of the trough of the low pressure along with the formation of cyclonic storm and disturbances (Kripalani and Kumar, 2004).
  - Received much less attention in comparison to Indian Summer Monsoon (Acharya et al., 2011).
  - Onset date variability is found to be much larger as compared to the demise date (Misra and Bharadhwaj, 2019).
  - The global teleconnections have a great influence on the variability of NEM (Zubair and Ropelewski 2006).
  - Limited modelling studies.
- Mean and variability of NEMR have poorly been captured by the climate models and their ensembles (Rodwell, 2005; Parvathi et al., 2017).
- The present study highlights the better scheme for reproducing the land-surface processes associated with the NEM.

Data and Methodology

- RegCM (vn4.7)-
  - Coupled with different land-surface schemes (BATS, CLM and SUBGRID) for a period of 1970 to 2005 (36 years).

- Observation Data-
  - Daily mean Precipitation from India Meteorological Department (0.25° horizontal resolution).
  - Monthly mean near surface air temperature gridded dataset from Climatic Research Unit (0.5° horizontal resolution).
  - ERA-Interim U and V wind Fields; Specific humidity (at different pressure levels).

Table 1. Model configuration for the downscaling experiments.

Dynamics	**Hydrostatics**
Regional Climate Model Model Domain	RegCM-4.7 CORDEX-SA, 10°E-130°E and 22°S-50°N
Resolution	50 Km horizontal and 18 vertical sigma levels
Initial and boundary conditions	MIROC5 from CMIP5 programme Prognostic Variables (u, v, t, q, ps)
SST	MIROC5
Land surface treatment	A) Control B) SUB-BATS C) CLM4.5
Radiation Parameterization	Modified CCM3
PBL parameterization	Modified Holtslag
Convective Parameterization	Grell over land and ocean for Control and SUB-BATS Emanuel over land and ocean for CLM4.5
Period	1970-2005 (5 year spin up)

Table 2. List of the observed and simulated wet (excess), Dry (deficit) and normal years

	Wet Years	**Dry Years**	**Normal Years**
IMD	1975, 1977, 1987, 1990, 1993, 1998	1988, 1989, 2000, 2002	1976, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1991, 1992, 1994, 1995, 1996, 1997, 1999, 2001, 2003, 2004, 2005
CONTROL	1976, 1980, 1984, 1986, 1996	1978, 1989, 1991, 1999, 2004	1975, 1977, 1979, 1981, 1982, 1983, 1985, 1987, 1988, 1990, 1992, 1993, 1994, 1995, 1997, 1998, 2000, 2001, 2002, 2003, 2005
SUB	1975, 1976, 1977, 1978, 1983, 1994	1991, 1995, 1998, 1999, 2001, 2003	1979, 1980, 1981, 1982, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1992, 1993, 1996, 1997, 2000, 2002, 2004, 2005
CLM	1976, 1977, 1986, 1994, 1995, 2003, 2004	1979, 1983, 1989, 1990, 1993, 1996, 1997	1975, 1978, 1980, 1981, 1982, 1984, 1985, 1987, 1988, 1991, 1992, 1998, 1999, 2000, 2001, 2002, 2005

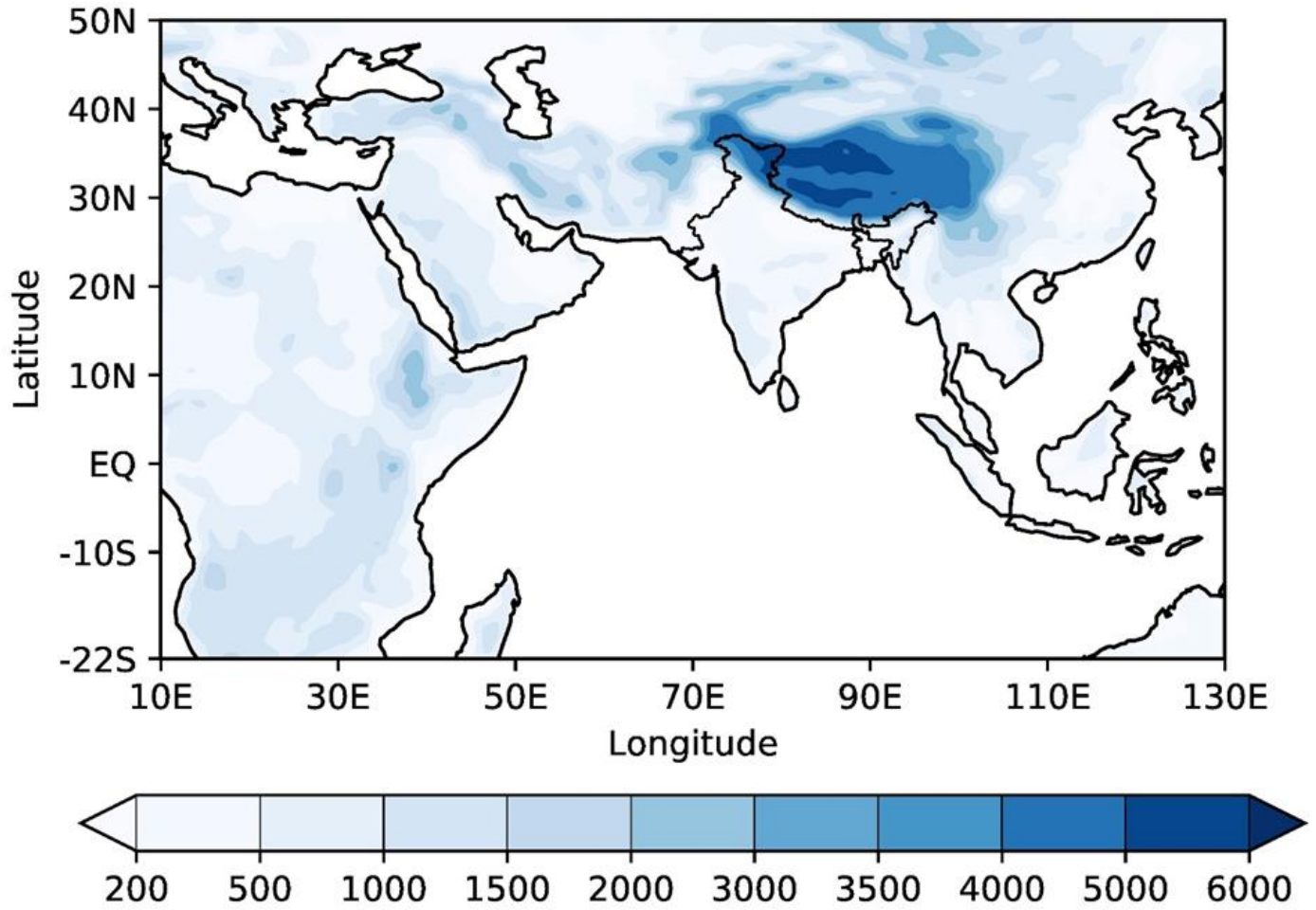


Fig. 1 Model domain with topography (shaded; m) (The NEM region for the present study spread over a geographical region 6°N - 20°N to 65°E - 90°E).

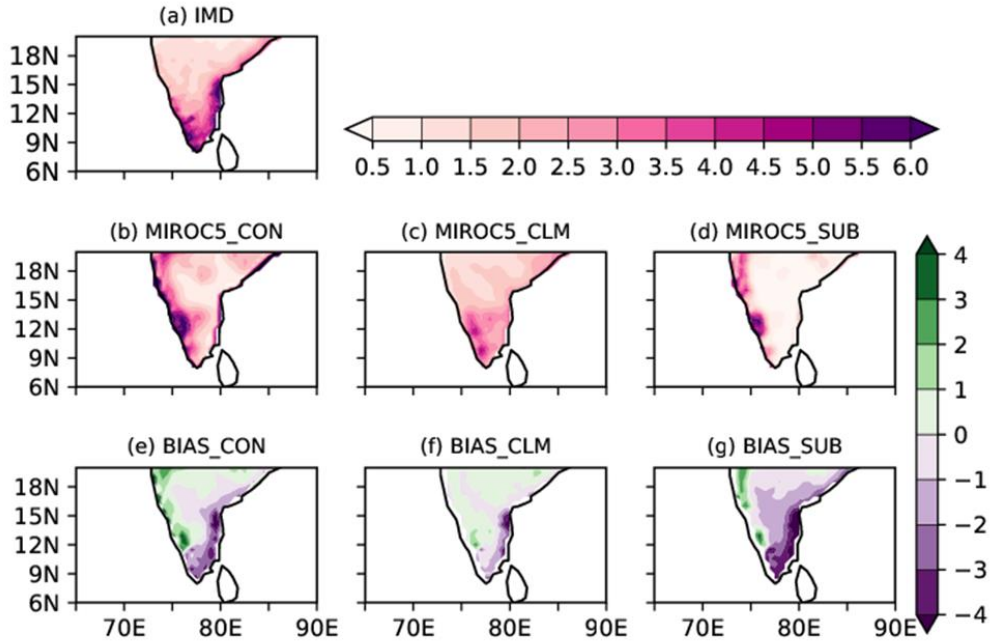
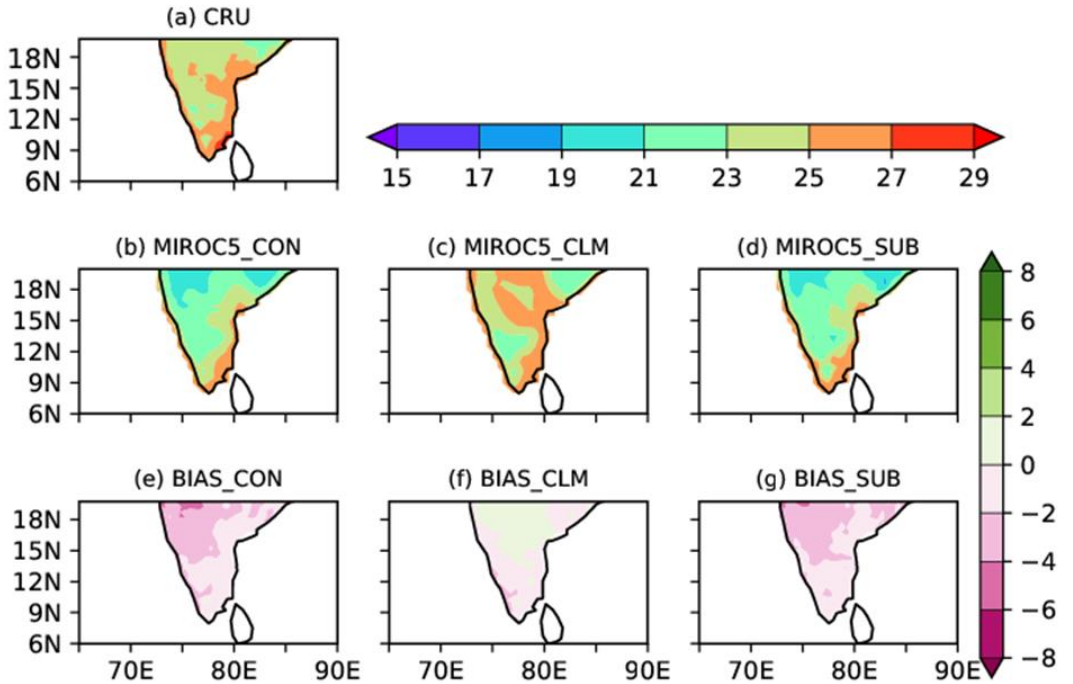


Fig. 2. Climatology of rainfall (mm/d) for the OND (October, November and December) season for the period 1975-2005 for (a) IMD observation, (b – d) model experiments and (e –g) their bias.

Fig 3. Same as Fig. 2 but for near surface air temperature (°C)



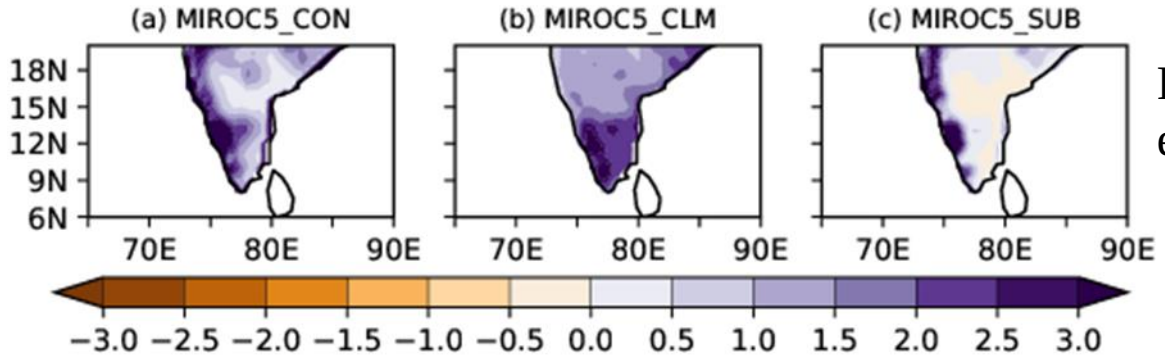


Fig. 4. P-E climatology (mm/d) for OND season for model experiments.

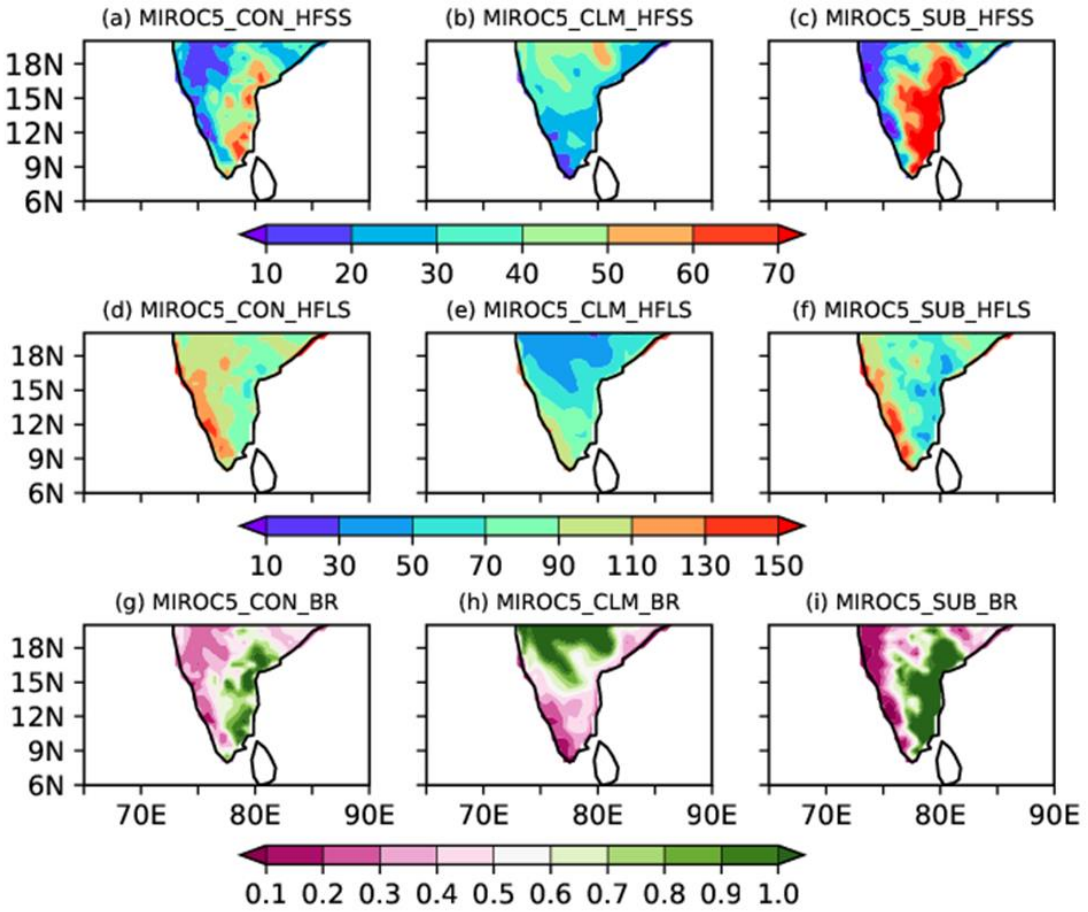


Fig. 5. Climatology of (a-c) Sensible heat flux (HFSS; W/m^{-2}), (d –f) Latent heat flux (HFLS; W/m^{-2}), and (g-i) Bowen's ratio which is expressed as sensible heat flux divided by latent heat flux for model experiments.

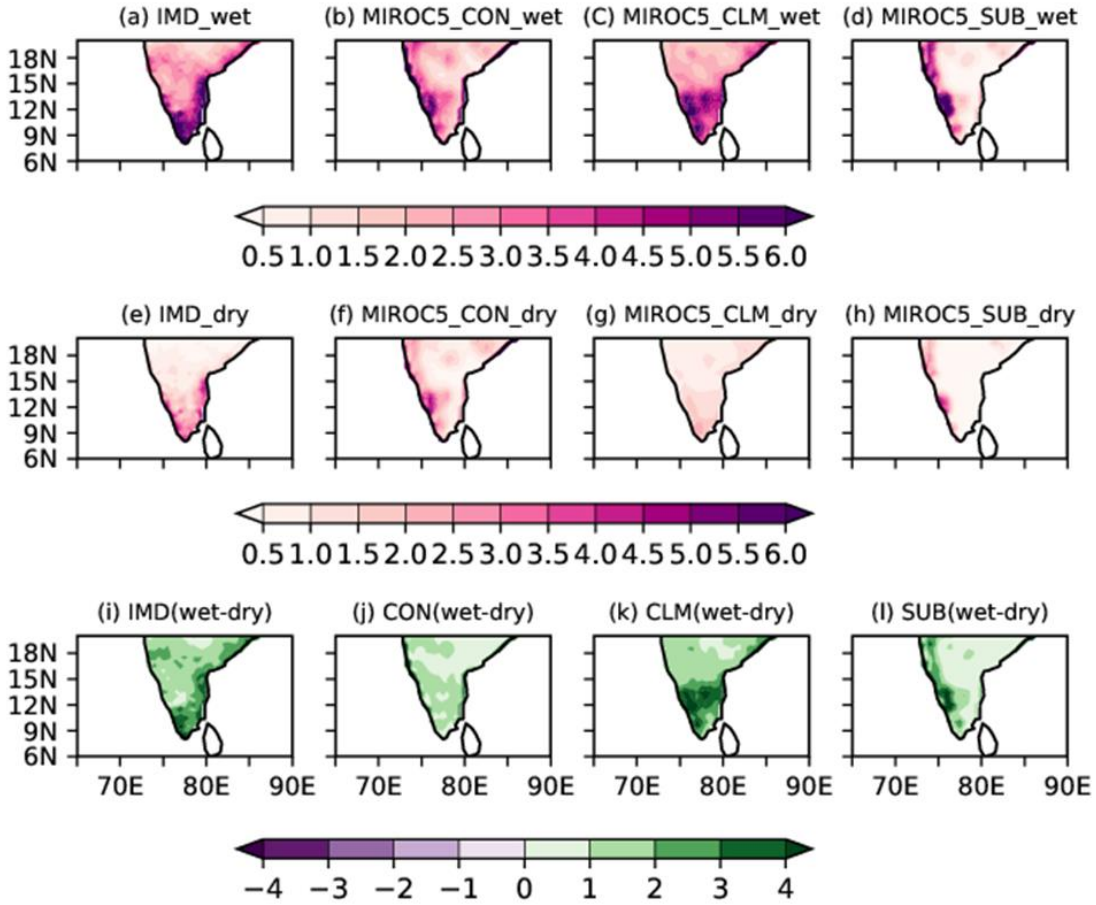
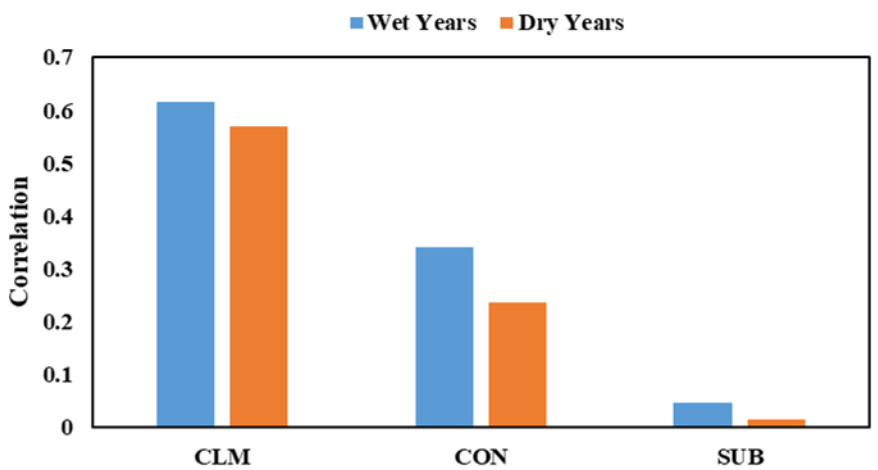


Fig. 6. Time averaged composite of (a-d) wet years, (e-h) dry years, and (i-l) difference of wet minus dry years of rainfall for IMD observation and model experiments.

Fig. 7. Spatial correlation of rainfall various experiments with IMD observation during wet and dry years with IMD data over NEM region.



Conclusion

- The better representation of moisture convergence and transport over NEM region in CLM experiment, resulted in the better spatial distribution of rainfall as compared to CON and SUB experiments.
- Based on the rainfall distribution, the sensible (latent) heat is high (low) over eastern coast and central Tamilnadu (Kerala) for CON and SUB experiments, while the opposite spatial structure is observed for CLM experiment.
- RegCM4 coupled with CLM land-surface scheme is better in representing the NEMR over southern Indian region as compared to the other schemes incorporated in the study.

- Acharya, N., Kar, S. C., Kulkarni, M. A., Mohanty, U. C., & Sahoo, L. N. (2011). Multi-model ensemble schemes for predicting northeast monsoon rainfall over peninsular India. Journal of earth system science, 120(5), 795-805.
- Dhar, O. N., & Rakhecha, P. R. (1983). Foreshadowing northeast monsoon rainfall over Tamil Nadu, India. Monthly Weather Review, 111(1), 109-112.
- Kripalani, R. H., & Kumar, P. (2004). Northeast monsoon rainfall variability over south peninsular India vis-à-vis the Indian Ocean dipole mode. International Journal of Climatology: A Journal of the Royal Meteorological Society, 24(10), 1267-1282.
- Misra, V., & Bhardwaj, A. (2019). Defining the Northeast Monsoon of India. Monthly Weather Review, 147(3), 791-807.
- Parvathi, V., Suresh, I., Lengaigne, M., Izumo, T., & Vialard, J. (2017). Robust projected weakening of winter monsoon winds over the Arabian Sea under climate change. Geophysical Research Letters, 44(19), 9833-9843.
- Rajeevan, M., Unnikrishnan, C. K., Bhate, J., Niranjan Kumar, K., & Sreekala, P. P. (2012). Northeast monsoon over India: variability and prediction. Meteorological Applications, 19(2), 226-236.
- Rodwell, M. J. (2005). Monsoon internal dynamics. The Global Monsoon System: Research and Forecast, 326-341.
- Sreekala, P. P., Rao, S. V. B., Rajeevan, K., & Arunachalam, M. S. (2018). Combined effect of MJO, ENSO and IOD on the intraseasonal variability of northeast monsoon rainfall over south peninsular India. Climate dynamics, 51(9-10), 3865-3882.
- Zubair, L., & Ropelewski, C. F. (2006). The strengthening relationship between ENSO and northeast monsoon rainfall over Sri Lanka and southern India. Journal of Climate, 19(8), 1567-1575.