Indian rainfall and Eurasian snow climatology in CMIP5 historical simulations

Amita Prabhu[1,*] and Sujata K. Mandke[1]
[1]Indian Institute of Tropical Meteorology, Dr. Homi Bhabha Road, Pashan, Pune-411008, INDIA
*amitaprabhu@tropmet.res.in , amin@tropmet.res.in

1. Introduction

The interannual variations (IAV) of the Indian summer monsoon rainfall (ISMR) have a very large impact on the agriculture and economy of the country. The understanding and prediction of ISMR is thus extremely important and have been a subject of considerable urgency. The IAV of ISMR are significantly correlated with the tropical sea surface temperature and snow cover anomalies. An inverse relation between Eurasian/Himalayan snow extent/depth in the preceding season and ISMR has been extensively documented (Hahn and Shukla, 1976; Kripalani and Kulkarni, 1999 and many others). As the continental snow cover is one of the few potential sources of seasonal persistence in the Asian region, the snow-monsoon connection is especially compelling. Of late, many international climate research groups made an extensive set of climate runs as a part of Coupled Model Intercomparison Project phase 5 (CMIP5) explorations (Taylor et al., 2012). CMIP5 provides a promising opportunity to examine snow-monsoon links simulated by several state-of-the-art global atmosphere-ocean coupled models. The simulation of better rainfall climatology has proven to be a test of model's ability to simulate IAV (Sperber and Palmer, 1996). Therefore, as an initial step towards the goal of studying snow-monsoon relation, we assess fidelity of five CMIP5 models to simulate climatology of precipitation averaged over Indian land (INDP) and snow averaged over Eurasian (EURS) region (20-140°E, 50-70°N) in historical runs of five CMIP5 models (Table 1).

Table 1: CMIP5 models used in the present study (horizontal resolution (in °E X °N))

No.	Model name	Atmospheric horizontal resolution
1.	CCSM4	1.2x0.9
2.	CNRM-CM5	1.4x1.4
3.	GFDL-ESM2G	2.5x2.0
4.	MIROC4h	T213L56
5.	NorESM1-M	2.5x1.9

2. Data

The model data from CMIP5 historical simulations (http://pcmdi3.llnl.gov/esgcet/home.htm) is used. The information on individual models is available (http://cmip-pcmdi.llnl.gov/cmip5/). The model simulations are validated using the corresponding observations - (i) High resolution (0.25° x 0.25°) spatially gridded rainfall data developed by India Meteorological Department (Pai et al., 2014) (ii) Snow water equivalent (SWE) data obtained from the Nimbus-7 Scanning Multi-Channel Microwave Radiometer and Defense Meteorological Satellite Program’s Special Sensor Microwave Imager and archived at the National Snow and Ice Data Center (*ftp.sidads.colorado.edu)*. SWE is hereinafter referred to simply as snow in this study. Model and observed climatologies are based on the period 1979-2006, which is a consistent available data record across all data sets used.

3. Results

The annual cycles of INDP (Figure 1a) and EURS (Figure 1b) for five selected CMIP5 models along with the corresponding observations are depicted. There is a general consensus among model simulations and observations in regard to representing annual cycle of INDP except MIROC4h model that overestimates precipitation and also exhibits much earlier monsoon onset as compared to the observed data. All models simulate excessive (deficient) EURS during January-March (September-October) (Figure 1b). Next, summer averaged INDP and winter averaged EURS climatologies of five CMIP5 models are compared with observations (Figure 2). The summer season is considered from June to September and the winter season is from December of the previous year to January- March of the next year. All five models underestimate winter EURS climatology. Further, the summer INDP climatology simulated by three models exceeds observations, being less than observations for CNRM-CM5 model and in good agreement with observations for GFDL-ESM2G model.

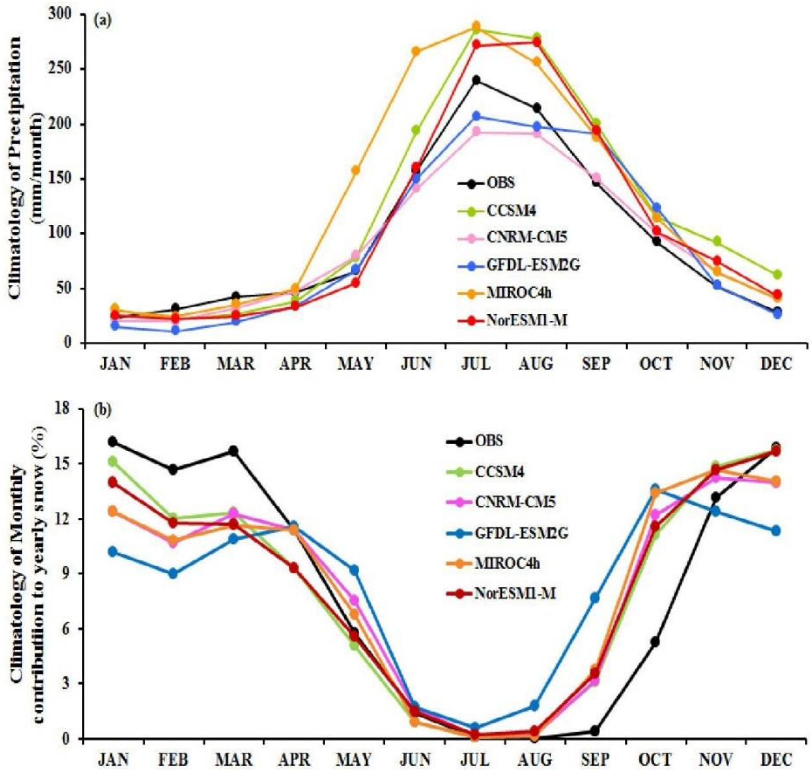

Figure 1: (a) Monthly mean precipitation climatology averaged over Indian land; (b) Monthly mean snow climatology averaged over Eurasia

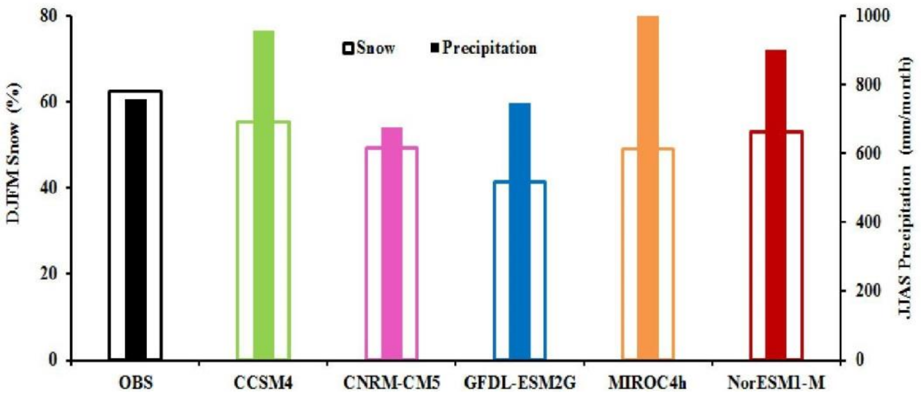

Figure 2: Summer mean precipitation climatology averaged over Indian land and winter mean snow climatology averaged over Eurasia

References

Hahn D.J., Shukla J. (1976) An apparent relation between Eurasian snow cover and Indian monsoon rainfall. J. Atmos Sci, 33:2461–2462

Kripalani R.H., Kulkarni A. (1999) Climatology and variability of historical Soviet snow depth data: some new perspectives in snow-Indian monsoon teleconnections. Clim Dyn, 15:475–489

Pai D.S., Sridhar L., Rajeevan M., Sreejith O.P., Satbhai N.S., Mukhopadhyay B. (2014) Development of a new high spatial resolution (0.25 × 0.25 degree) long period (1901–2010) daily gridded rainfall data set over India and its comparison with existing data sets over the region. Mausam, 65(1):1–18

Sperber K.R., Palmer T.N. (1996) Interannual tropical rainfall variability in general circulation model simulations associated with the AMIP. J Clim, 9 (11) : 2727—2750

Taylor, K.E., Stouffer, R.J. and Meehl, G.A. (2012) An overview of CMIP5 and the experiment design, Bull. Amer. Meteorol. Soc, 90,4 85–498.