Future change of annual cycle of Indian rainfall and Eurasian snow in the CMIP5 models

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1. Introduction

Global climate and particularly monsoon climate have varied on a wide spectrum of time scales in the past and is expected to do so in future. Of late, there has been very much concern in international scientific community regarding the behaviour of monsoon in the future climate change. Still, the present understanding of future climate change, especially over the monsoon regions, remains as one of large uncertainties with respect to circulation and precipitation [Intergovernmental Panel on Climate Change Fourth assessment report, sections 3.7, 8.4.10 and 10.3.5.2]. Multi-model projections suggest an increase in precipitation in the Asian monsoon in a warmer climate. Linkage between Eurasian snow extent/depth and subsequent Indian summer monsoon rainfall is well established (Hahn and Shukla 1976; Parthasarathy and Yang 1995; among others). The present study examines future changes pertaining to Annual Cycle (AC) of precipitation averaged over Indian land (INDP) and snow averaged over Eurasia (EURS) under anthropogenic global warming using five coupled models that participated in phase five of the Coupled Model Intercomparison Project (CMIP5) by comparing two types of runs: a historical run for 1861–2005 and Representative Concentration Pathway (RCP) runs for 2006–2100. Three RCP runs from CMIP5 namely RCP2.6, RCP4.5 and RCP8.5 are considered in the study.

2. Data

Model data of five CMIP5 models (Table 1) from historical and three RCP runs (RCP2.6, RCP4.5 and RCP8.5) is obtained from http://pcmdi3.llnl.gov/esgcet/home.htm. The detailed information on CMIP5 models and experiments is available [(Taylor et al. 2012) and (http://cmip-pcmdi.llnl.gov/cmip5/experiment_design.html)]. The radiative forcing in RCP2.6, RCP4.5 and RCP8.5 increases throughout the twenty-first century before reaching a level of about 2.6 Wm^{-2}, 4.5 Wm^{-2} and 8.5 Wm^{-2} respectively, at the end of the century (Taylor et al. 2012).

Table 1: CMIP5 models used in the present study (atmospheric horizontal resolution (in $^{\circ}$E X $^{\circ}$N))

No.	Model name	Atmosphere 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

3. Results

The ACs of INDP averaged over the domain (68-98°E, 8-38°N) in the historical and three RCP runs are shown for five CMIP5 models in Figures 1(a-e) respectively. Similarly, ACs of EURS averaged over region (20-140°E, 50-70°N) for five CMIP5 models are depicted in Figures 1(f-j) respectively. Most of the annual rainfall in India occurring from June-September is noticed in historical and RCP runs of all five models. RCP runs of the majority of models project an increase in INDP for May-December in future relative to historical run. Future change in INDP during January-April of all five models' RCP runs in comparison with historical runs is imperceptible. In contrast to abundant EURS during January-March and November-December, negligible EURS during June-August is observed in historical and RCP runs of all models. Future projections from RCP runs indicate the increment in EURS during January-February and its reduction during April-May and September-October with respect to the historical run in all models. There is no consensus among three RCP runs and also among five models in future projection of EURS during March and November-December.

References

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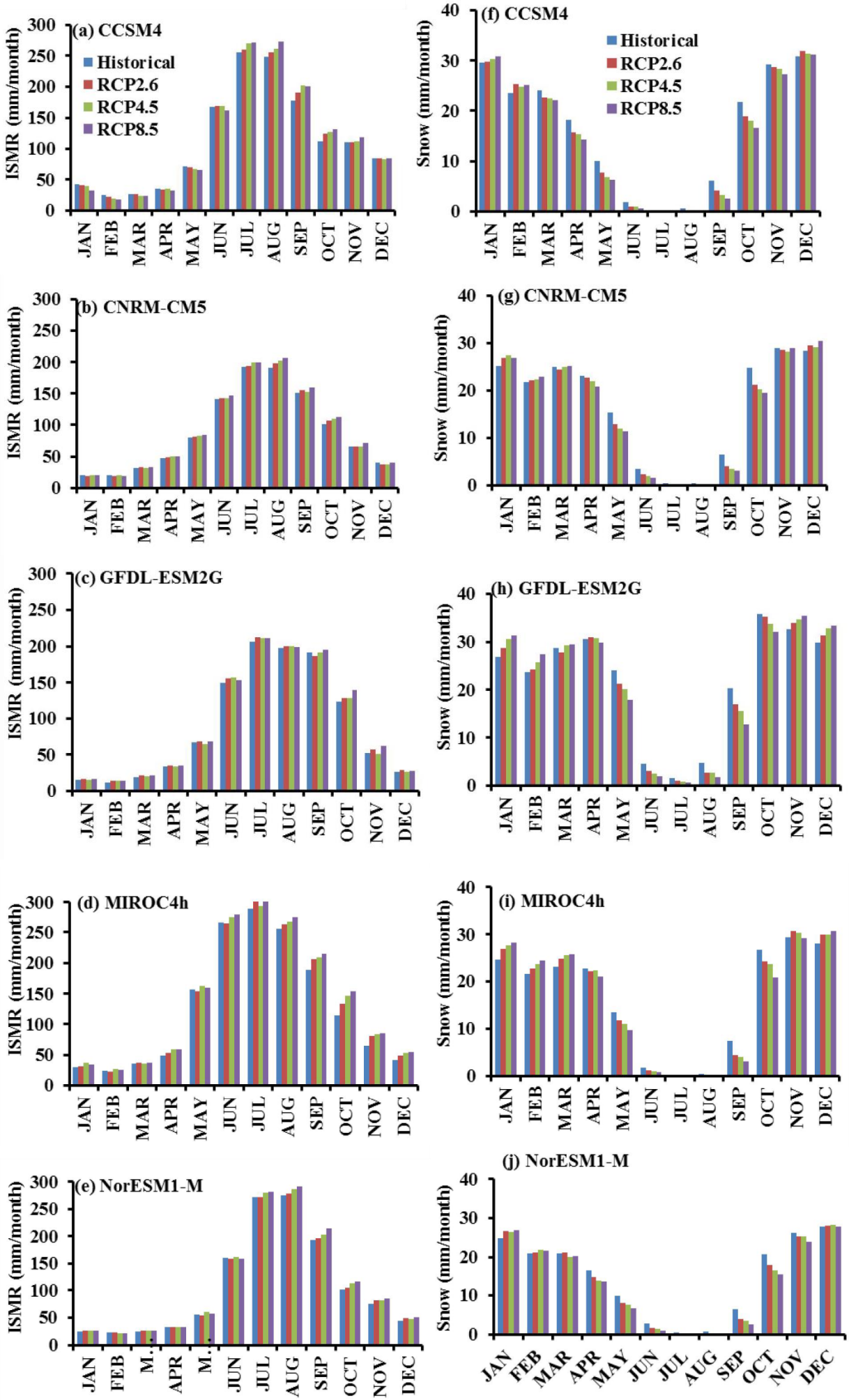

Figure 1:(a-e) Annual cycle of precipitation averaged over Indian land from historical and three RCP runs in five CMIP5 models; (f-j) Same as in (a-e) except for snow averaged over Eurasia