# Relation between Eurasian snow and India monsoon in historical simulation of CMIP5 models

Amita Prabhu[1] and Sujata K. Mandke[1,*]

[1]Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, INDIA

amitaprabhu@tropmet.res.in, *amin@tropmet.res.in

## Introduction

Observations have lend credence to the Eurasian winter/spring snow relation with the following summer monsoon rainfall over India. Next question arises - Whether state-of-the-art atmosphere-ocean coupled models have skill to simulate this snow-monsoon relation. To answer this question, our aim is to examine the fidelity of the global coupled climate models from Coupled Model Intercomparison Project 5 (CMIP5; Taylor et al., 2012) to simulate snow-monsoon relation. Historical simulations of five CMIP5 coupled models (CCSM4, CNRM-CM5, GFDL-ESM2G, MIROC4h, NorESM1-M) are selected for the study, based on their skill in terms of highest skill scores for greater number of diagnostics to simulate Asian summer monsoon climatology and climatological annual cycle (Sperber et al. 2013).

## Data

**Model:** Monthly mean precipitation and snowfall flux of five models (Table 1) from 20th century historical simulation of CMIP5 (http://www-pcmdi.llnl.gov) are used. **Observation**: (i) Daily rainfall data developed by India Meteorological Department (Pai et al.. 2014), across the Indian landmass (ii) National Snow and Ice Data Center archived snow water equivalent data from Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager (SSM/I).

**Table 1:** CMIP5 models used in the present study (atmospheric horizontal resolution (in °E X °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 |

## Results

Correlation coefficient (CC) between summer monsoon rainfall at each grid point over the Indian landmass with the preceding winter season snow averaged over Eurasia (50-70°N, 20-140°E), using observed data is illustrated (Figure 1a). The average of four months from December of previous year to March of the following year is referred as winter season and June to September average as summer monsoon season. Similar CC between precipitation at each grid point over India and neighboring oceans with the preceding winter Eurasian snow is also analyzed for historical simulation of five CMIP5 models (Figures 1(b-f)) respectively. A close examination of observed CC (Fig. 1a) reveals a 'Negative-Positive-Negative' tri-polar spatial pattern. Clusters of significant negative CC over the northern (~ 35°N, 78°E) and south-western (~ 20°N, 75°E) boundary of India, while positive CC over east-central (~ 26°N, 82°E) regions of India with slight positive traces over Northeast India are evident. The major differences between spatial patterns of CC in observation (Fig. 1a) and models (Fig. 1(b-d) are due to the large differences in their spatial resolution, with very high resolution of observed data compared to models. However, among five models, regional features of CC in CCSM4 model are closer to observation with similar tri-polar pattern, while other four models are far from observation. Positive (negative) CC over large portion of Indian land is noticed in MIROC4h (NORESM1-M) model.

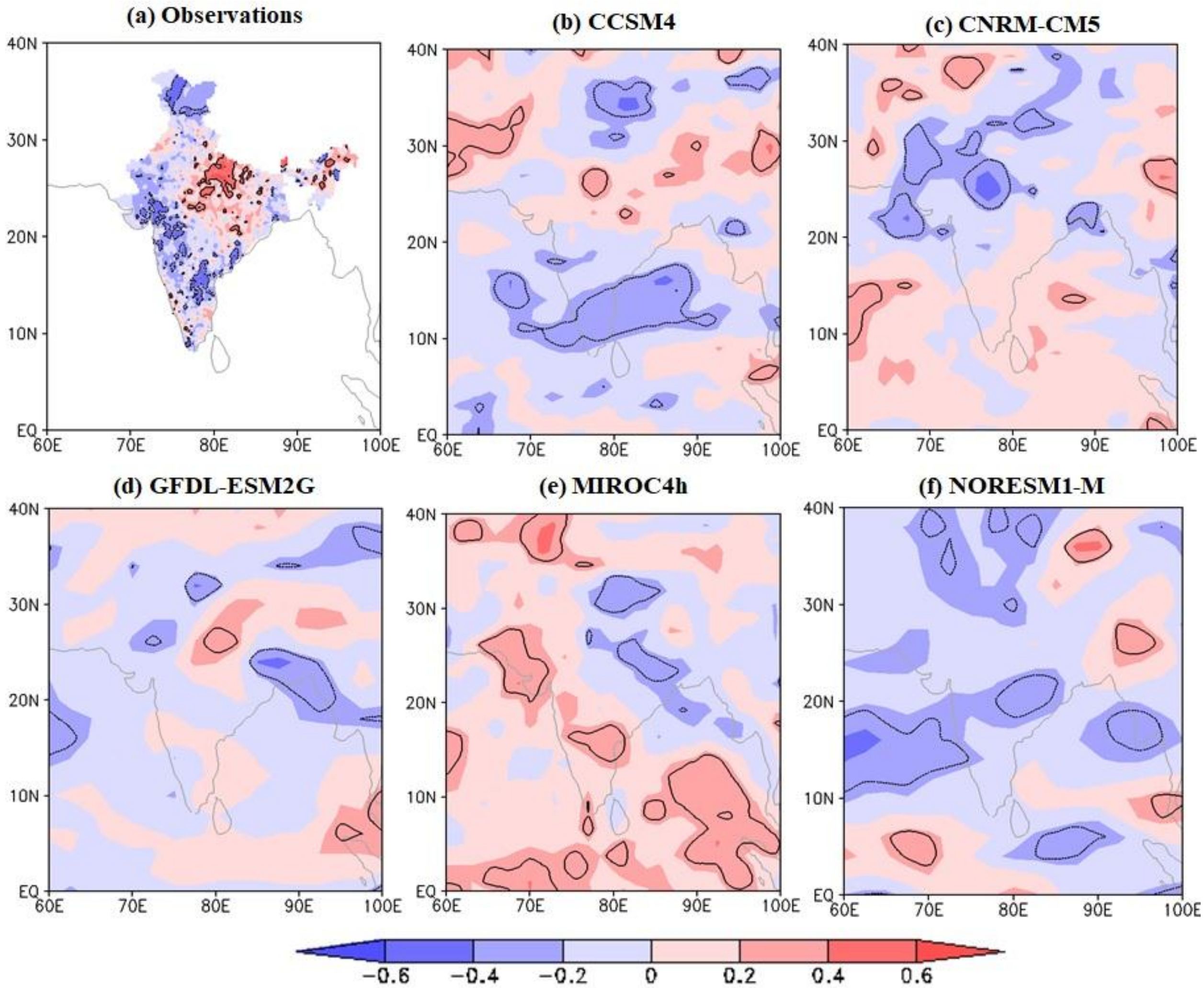


**Figure 1(a-f):** Correlation coefficient (shaded) of summer monsoon precipitation at each grid point over the Indian domain with the preceding winter snow averaged over Eurasia, for observation and five CMIP5 models respectively. Black solid contours represent significance at 95% confidence level.

**References**

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