Aerosol induced upper tropospheric cooling and its impact on the Indian summer monsoon circulation

B. Abish [a] and K. Arun [b]

[a] Kerala University of Fisheries and Ocean Studies, Kochi, India
[b] Department of Atmospheric Sciences, Cochin University of Science and Technology, Kochi, India.

Correspondence : abishb@kufos.ac.in

1. Introduction

Observations and modeling studies concur the weakening of Indian summer monsoon in which the rainfall in the recent decade 2001-2011 recorded a departure of -5.1% from the long-term mean. Such a weakening of the monsoon circulation is related to a significant decline in rainfall along the west coast of India (Western Ghats, WG), where the local orography determines the cloud formation and rainfall.

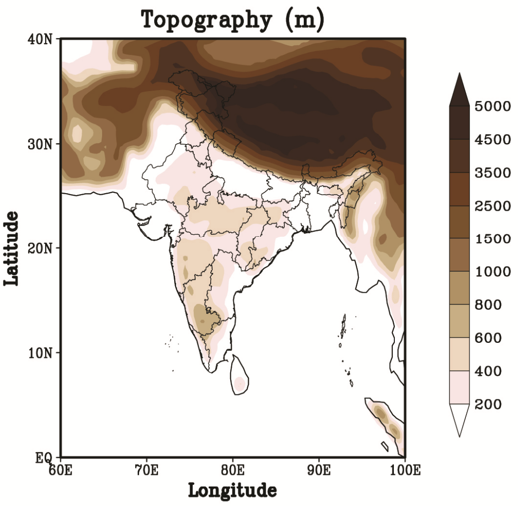

Fig 1. Study region and terrain height in meters

2. Data and Methodology

- ✓ Japanese 55-year Reanalysis (JRA-55) datasets (Kobayashi et al. 2015) with 1.25° × 1.25° grid resolution are used for the analysis of near surface temperature.
- ✓ For the analysis of monsoon rainfall, the monthly mean datasets from Climate Research Unit TS3.0 (CRU, Harris et al. 2014) at 0.5° × 0.5° grid resolution is used.
- ✓ RegCM 4.5 has been employed to examine the dynamic impacts of aerosol radiative forcing on the atmospheric temperature and circulation during the summer monsoon season.

Model configuration employed in this study

Domain		
Model domain	:	Indian Ocean CORDEX domain (22°S-61°N; 6°W-141°E)
Centre point	:	16.93° latitude and 67.18° longitude
Spatial Resolution	:	60 km
Input datasets		
Initial and boundary conditions	:	Era Intrim-15 dataset (EIN15)
Sea Surface Temperature	:	Weekly Optimal Interpolation dataset
Chemistry boundary conditions	:	MOZART climatology
Parameterization schemes		
Cumulus convection over land	:	Emanuel
Cumulus convection over Ocean	:	Emanuel
Large-scale precipitation	:	SUBEX
Radiation	:	CCM3
Lateral boundary Index	:	Index relaxation
Planetary boundary layer	:	Holtslag PBL
Air-sea flux	:	Zeng scheme

3. Results and Discussions

Analysis of the JRA reanalysis data at 925 hPa shows a relatively cooler lower continental troposphere define by the box (25 °N - 35 °N; 60 °E - 90 °E) during the recent decades 2000-2011 (Fig 2 (a, b)). A similar feature is detected when sulfate aerosol component (SULF) is included (Fig 2 (c, d)).

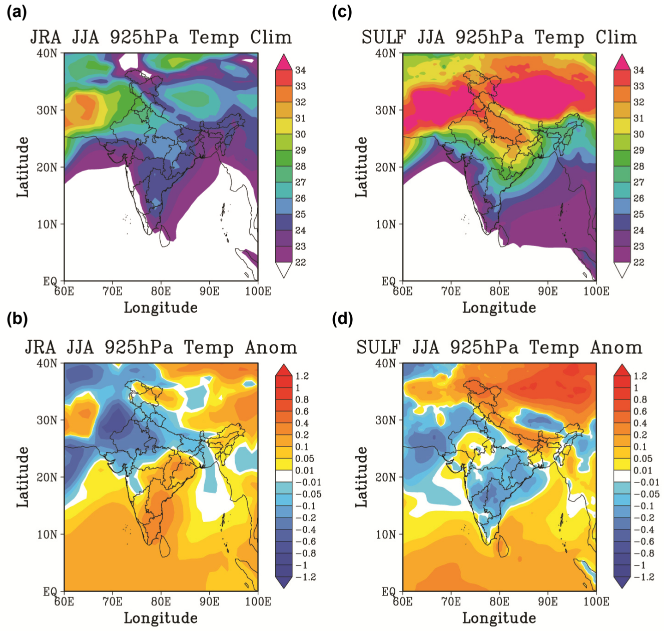

Fig 2. Temperature (° C)anomaly at 925 hPa during 2000-2011. Climatology is computed from 1980-2011

The simulated rainfall in the SULF run reveals a decreased rainfall in the southern Western Ghats (WG-S) and in the Himalayan foothills. Here the rainfall is found to decrease by 1.5 mm/day for the period 2000-2011.

However over the northern Western Ghats (WG-S) as indicated by the SULF simulations, the sulfate aerosols exerts a limited influence on the orographic rainfall. The rainfall is found to follow similar pattern when compared with the CRU reanalysis datasets (Fig 3).

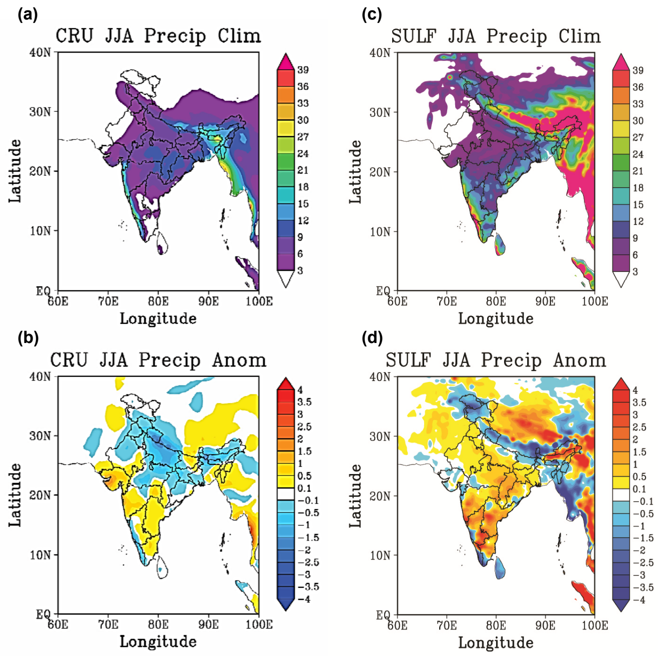

Fig 3. JJA Precipitation (mm/day) for 2000-2011. Climatology is computed from 1980-2011

4. Conclusions

Study using the high resolution regional climate model RegCM 4.5 indicates the important role of sulfate aerosols in controlling the strength and distribution of the orographic rainfall during the summer monsoon season. Simulated rainfall with the feedback of sulfate aerosols included shows a decline in rainfall over the WG-S and in the foothills of the Himalayas. Due to the slowdown of monsoon circulation, the SULF simulated orographic rainfall shows a decrease of 1.5 mm/day over the WG-S and Himalayan foothills during the recent decades (2000–2011) alone.

Acknowledgement

This research is supported by the grant (No. ECR/2016/000905) provided by the Science and Engineering Research Board (SERB) Govt. of India.