Influence of orography on southwest monsoon over south peninsular India

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ABSTRACT

The regional scale variability of land processes plays an important role in modulating regional climate. In this view an attempt was made to ascertain whether the characteristics of Indian summer monsoon change with orography. The regional climate model (RCM) WRFV3 was used to carry out the sensitivity experiment with and without orographic effect. The simulation results revealed that the orographic barriers enhanced the precipitation across west coast of southern peninsular India which includes Kerala and coastal Karnataka.

Keywords: Orography; southwest monsoon; climate; simulations

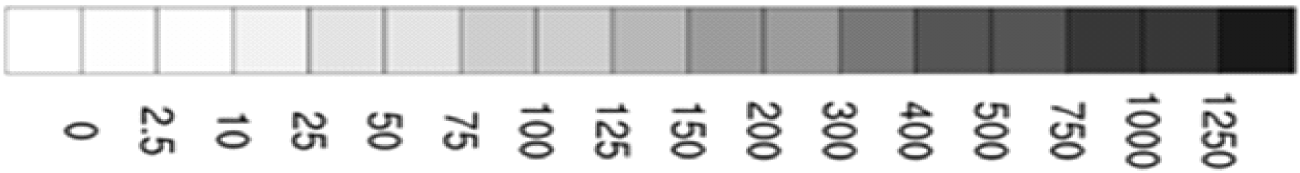
INTRODUCTION

Summer monsoon rainfall over India provides livelihood to 65 per cent of the population of the country. The regional scale variability of land processes plays important role in modulating regional climate. The modulations in rainfall are dominated by orographic features and local land surface irregularities. The complexities of monsoon phenomenology can be studied effectively with atmospheric general circulation and coupled atmosphere-ocean (AOGCM) models. In this approach the rate of precipitation is calculated by using physical equation describing the atmospheric phenomenon. Global climate models (GCMs) have reasonable skill in predicting large scale circulation features in agreement with observation. Climate forecast system (CSFV2) is a fully coupled atmosphere-ocean-land model used for seasonal prediction (Saha et al 2014).

However the regional scale features cannot be represented by GCM. RCMs are capable of representing regional climatic features and can be used to simulate Indian summer monsoon through sensitivity experiments on orography. In order to examine the effects on rainfall distribution due to orography on monthly scale weather research forecasting (WRFV3) model is employed. WRF utilizes CSFV2 for initial and boundary condition for generating seasonal variations of the monsoon over peninsular India.

METHODOLOGY

The retrospective Indian summer monsoon forecast was carried out for contrasting years with normal monsoon period (2016, 2017) and monsoon period (2015) with El ~ Nino effect. A regional climate simulation experiment of the Indian summer monsoon was performed using WRF model version 3.9.1. WRF was adopted to cover the Indian region with a horizontal resolution of 18 Km. The model was integrated for a four and half month period starting from 16 May 2015 to study the Indian summer monsoon during the months of June, July, August and September and allowing May month for model spin up. The initial and boundary conditions were taken from CFSV2 analysis data available at 0.5 degree resolution. The boundary conditions were forced at the frequency of six hours (0000, 0600, 1200 and 1800 UTC) throughout the simulation. The sensitivity analysis for orography was carried out by excluding the input for height in model simulation unlike control domain. The model simulations



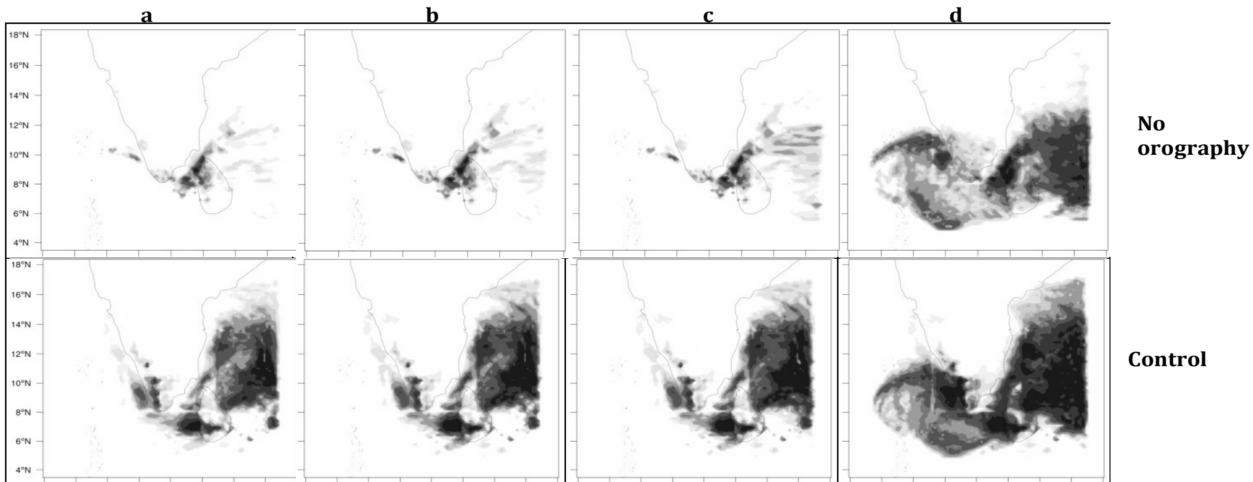


Figure 1. Spatial Distribution of mean maximum temperature for 2015 SWM

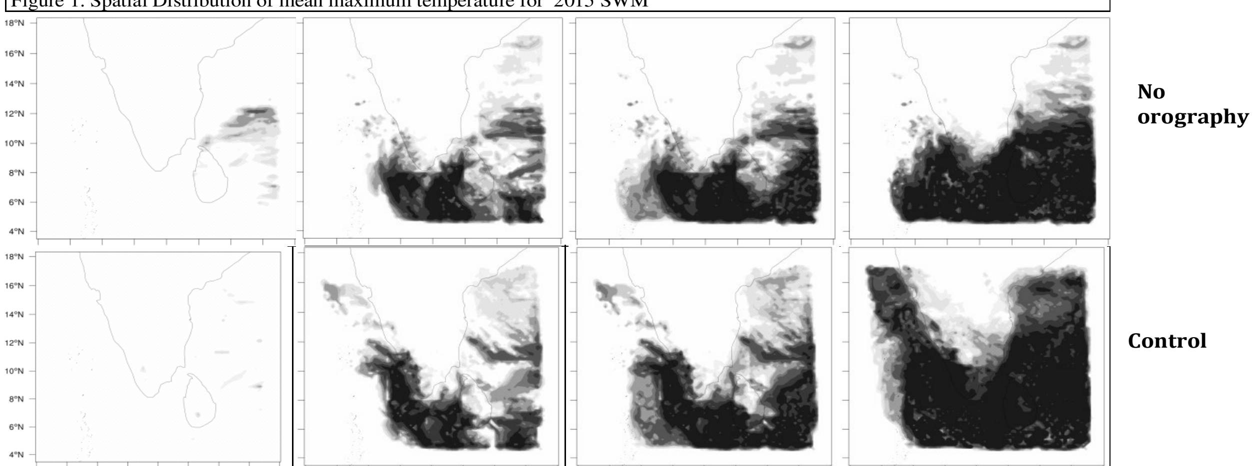


Figure 2. Spatial Distribution of mean maximum temperature for 2016 SWM

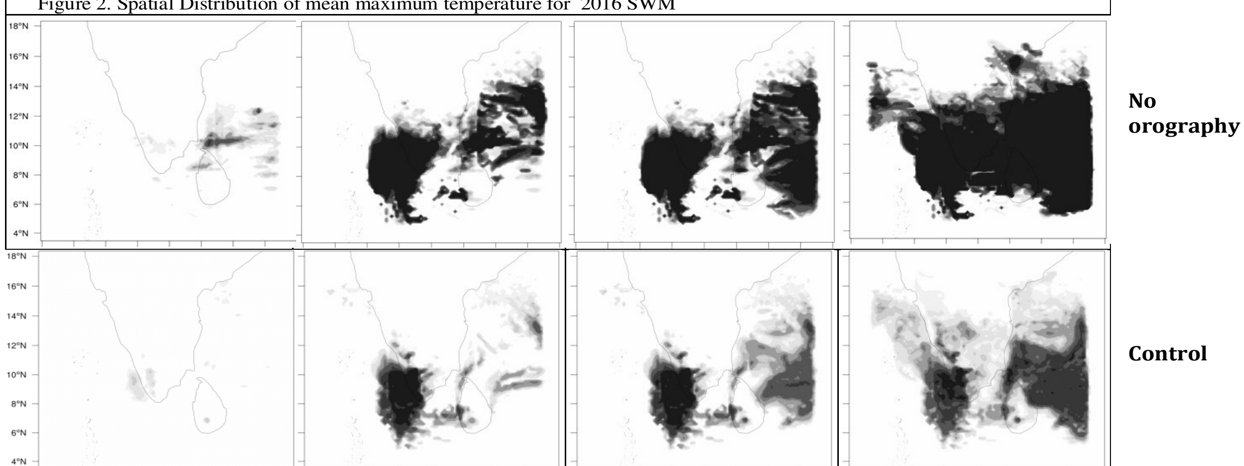


Figure 3. Spatial Distribution of mean maximum temperature for 2017 SWM

Note: a, b, c and d represent June, July, August and September respectively were conducted with 28 vertical levels with non-hydrostatic option.

RESULTS and DISCUSSION

The simulations showed that the removal of orography over the south peninsular India caused decrease in intensity of the monsoon over Kerala and coastal Karnataka in 2015 and 2016 (Figs 1, 2).

The increase in intensity monsoon was due to the inability of unstable moisture laden tropical air masses to yield precipitation. The precipitation results only when moisture laden winds are forced to rise by a landform barrier or any atmospheric turbulence. Such tropical unstable air when forced to rise by the landform barrier would lead to heavy precipitation (Chakraborty 2004). In contrast during 2017 the precipitation rate was higher since the spatial variation of monsoon became zonal-oriented in the absence of orography (Fig 3). Unlike the no-orographic domain simulation the precipitation intensity of control simulation was normal which was due to the orographic blocking of western Ghats. In the absence of orography the zonal flow of precipitation pattern was attributed to the contrast in heating of land and ocean as reported by Pai and Bhan (2015). In El ~ Nino year 2015 the peninsular India received subdued rainfall than normal due to the presence of orographic barriers unlike the simulation performed without orographic effects (Table 1) which received poor or no rainfall.

CONCLUSION

The vigour and the development of ideal monsoonal circulation in southern peninsular India may be attributed to two potent factors viz vast coast and high mountains. Orography is one of the key factors that is largely responsible for bringing about precipitation extremes in the absence of which it caused subdued and intense rainfall than normal.

Table 1. Normal seasonal rainfall for peninsular India sourced at IMD

Region	June	July	August	September
Tamil Nadu and Puducherry	46.5	69.1	88.7	177.0
Kerala	649.8	726.2	419.3	244.3
Coastal Karnataka	867.3	1159.7	755.5	300.9
North Karnataka	104.7	135.0	120.4	146.0
South Karnataka	141.7	216.1	161.4	141.0
Telangana	135.0	238.4	218.8	162.3
Coastal Andhra	103.0	160	157.7	159
Rayalaseema	67.7	94.2	103.3	133.1

Pai and Bhan (2015), Kothawale and Rajeevan (2017), Balachandran et al (2017)

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