Analysis of Central India Monsoon for above and below normal rainfall years

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ABTRACT

This Study mainly focuses on Extremely heavy rainfall events over Central India, which are very important for contribution towards all India rainfall and overall performance of monsoon during a particular year. As we look into rainfall data for the period (1901-2022) for the All India Monsoon and Rainfall over four homogeneous regions, NE India, NW India, Central India and South Peninsular India. We found that the rainfall over Central India is highly correlated (0.85) with all India Rainfall as compared to other three homogeneous regions. As some part of central India is present in the monsoon core zone like some districts of east MP and some districts of West MP. Oscillation of Monsoon trough and persistence of the monsoon trough over monsoon core zone for 2-3 days along with movement of low pressure systems like deep depression, depression, Well Marked Low pressure (WML) and Low pressure systems (LOPAR). Central India rainfall remain below normal in nine years and above normal in ten years during the above mentioned period (1901-2022). The lowest rainfall monsoon season rainfall (690mm) recorded for the year 1918 and the highest rainfall (1307mm) recorded during monsoon season for the year 1994 over central India which resulted in all India monsoon rainfall with negative normal (-13%) and positive normal (13.9%) departure respectively. Monthly mean values of specific humidity, upper as divergence, wind and vertically integrated moisture transport computed for above normal and below normal years of central India for monsoon season and pre-monsoon have been investigated.

Introduction

India receives 70% of its annual rainfall in the summer monsoon season. The rain-bearing systems like monsoon depressions, monsoon trough, off-shore vortices, mid-tropospheric cyclones, etc. contribute chief amounts of rainfall. Goswami et al. (2006) showed [i] significant rising trends in the frequency and the magnitude of extreme rainfall events and [ii] a significant decreasing trend in the frequency of moderate events over central India during the monsoon seasons from 1951 to 2000.Naidu et al. (2011a) reported that India experienced a weak summer monsoon epoch [1995–2005] which is closely associated with weak tropical easterly jet stream and coincides with the warmest decade. Moisture transport from the oceanic area to the Indian subcontinent is the key and foremost factor for deciding the behavior of the monsoon.

The ISM is a complex phenomena with nonlinear interactions between large-scale circulations and small-scale physical processes. The ISM rainfall (ISMR) exhibits temporal variability such as Intra-seasonal, Inter-annual, decadal changes.

Data & Methodology

IMD rainfall data from 1901-2023 for four homogenous regions has been taken to study the comparison of above normal and below normal monsoon years of central India with reference to all India. ERA-5 Interim data for June to September for above and below normal years like Specific humidity = 6.11 x 10^{7.5 x dew point} / {237.3 +dew point} , temperature, u wind and v-wind components for the respective years. Using these datasets we have computed divergence, Vertical integrated moisture transport and composite mean of temperature and specific humidity. Among the years selected for above and below years we selected extreme deficient year and extreme excess year of 1987 and 1994 respectively.

Results & Discussions

Fig 1 shows the divergence at 400 hPa with values of divergence 0.4 to 1.6 s-1 for above normal year over central and north India and for below years 0.5 to 1.4 s-1 showing the monsoon trough is towards the south position in the above normal years. Fig 2 shows the divergence at 200 hPa with values of divergence 0.3 to 0.9 s-1 for above normal year over central and north India and for below years 0.2 to 0.6 s-1 showing the monsoon trough is towards the south position in the above normal years. In central India the belt of Gujarat, Maharastra and Chattisgarh. Lower atmospheric levels, negative divergence is more for above normal monsoon over Central India and normal monsoon over all India.

Central India rainfall remain below normal in nine years and above normal in ten years during the above mentioned period. Fig 3 and Fig 4 shows the VIMT for excess and Deficient years which clearly shows that in excess year the moisture transport from Arabian sea is clearly seen for 1994 and where as the deficient year for below normal years the moisture transport is through winds comes from Arabian sea mainly westerly flow of moisture from peninsular India to South Hariyana region is of the order of 100 to 200 m^2/s. For Above normal years active transport of moisture from BoB and Arabian sea to central high tends of India. 200 to 210 m2/s covering states Madhya Pradesh, Gujarat, Rajasthan and Bihar. plots of above and below years indicated high specific humidity on Central India and North India of 76x10-4 to 84x10-4 while for below normal years of specific humidity content over Rajasthan state 48x10-4 to 64x10-4, Uttar Pradesh, Madhya Pradesh and Central India as 64x10-4 to 74x10-4 while NE states 80x10-4 to 88x10-4.

Fig 1 shows the divergence at 400 hPa for above(left) and below(right) years

Fig 2 Divergence at 200 hPa for above(left) and below(right) years

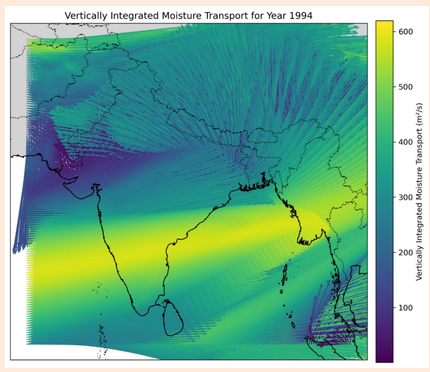

Fig 3 shows the VIMT from surface to upper level for excess year.

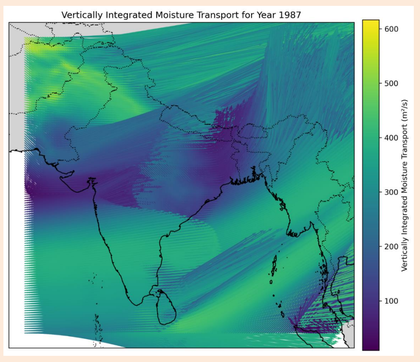

Fig 4 shows the VIMT from surface to upper level for Deficient year 1987.

	1987				1994			
	June	july	aug	sep	June	july	aug	sep
925	10	10-12	10-12	6-8	7-12	10-15	10-12	6-8
850	5-10	8-12	10-12	4-6	10-15	15-20	12-17	6-8
700	6	6	8	6-7	12-14	12-14	8-12	6-7

Below Normal Years			Above Normal Years		
	Central	All India		Central	All India
1918	-29.4	-13	1994	33.7	13.9
1987	-27.1	-14.3	1961	32.7	21
1974	-26.4	-10.4	2019	29.4	11.8
1965	-22.8	-18.6	1959	26.1	20.1
1972	-22	-22.3	1933	21	18.6
1905	-20.7	-16.8	1970	20.8	15.2
1920	-20.7	-10.6	2013	20.3	8.6
2000	-20.3	-6.2	1956	20	15
2002	-19.2	-20.9	1917	19.8	26.6
			2006	19.3	3.4

Conclusions

From this study it is concluded that i) In above normal years the divergence from 400 hPa to 200 hPa where as for excess years it is strong over Central and North India .
ii) VIMT for above normal year is very strong over Central India indicating moisture transport form Arabian sea westerlies and Bay of Bengal easterlies at Central India and North India . iii) Wind speed for above normal year and Below normal year the wind speed is high for excess years indicating jet stream occurrence during the monsoon period. iv) Studied positive and negative departure of rainfall w.r.t. normal rainfall and its impact/association with all India rainfall departures. 1987 and 1994 are extreme negative and extreme positive departure of rainfall over Central India and contributing -14.3 departure to all India rainfall and +13.9 departure to all India rainfall.

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