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Effect of change in aerosol concentration and temperature over Indian region on rainfall variability in SW monsoon season

S.S.Dugam

Indian Institute of Tropical Meteorology, Pune-411008.

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ABSTRACT

In this paper, to see the climate change on monsoon variability, the analysis of aerosol concentration, Global and surface air temperature over central Indian region and South West (SW) Monsoon season rainfall (June-September) variability have been study. For the study different set of data have been consider. The trend analysis of aerosol concentration and rainfall over different regions of India has been carried out for recent period 1981 to 2002. The analysis reveals that there is decreasing trend in aerosols concentrations and decreasing trend in West central monsoon rainfall goes hand in hand. To see the temperature effect in pre-monsoon months on monsoon variability the Principal component Analysis (PCA) technique is used. By using PCA the monthly temperature gradient series have been prepared. For analysis, the grid (1°*1°) point surface air temperature data taken from the Climate Research Unit (CRU) at the University of East Anglia is used. The analysis is carried out for 105 years 1901-2006. From the analysis it seen that the North South surface air temperature gradient in month of May over the central India can be useful for seasonal prediction of monsoon rainfall over the North East India. To see the global warming effect on rainfall, the analysis of global surface air temperature 125 (1880-2004) years of data have been used. It is found that during warming or cooling episodes, there is a general below-normal rainfall activity over almost all the homogeneous regions expects the CNEI and NEI.

Introduction

In recent years, in Asian monsoon countries, such as China and India, the aerosol problem is becoming increasingly acute, especially in large cities and rural areas due to the increased loading of atmospheric pollutants from waste gas emissions and from rising energy demand associated with the rapid pace of industrialization and modernization. On the other hand, sustainable development in the Asian monsoon countries depends on the vagaries of the mighty monsoon, which supplies almost all the freshwater for the region. Uneven distribution of monsoon rain associated with flash flood or prolonged drought has caused major loss of human lives and damages in crops and properties, with devastating societal impacts on Asian countries these aerosol effects can lead to a weaker hydrological cycle, which connects directly to availability and quality of fresh water, a major environmental issue of the 21st century. Global warming and aerosols concentration are emerging as burning issues of the century. It is showing its effects in the form of climate change and related consequences. Human activities are releasing small particles called as aerosols into the atmosphere. These man-made aerosols enhance scattering and absorption of solar radiation. They also produce brighter clouds that are less efficient at releasing precipitation. These in turn lead to large reductions in the amount of solar irradiance reaching Earth's surface, a corresponding increase in solar heating of the atmosphere, changes in the atmospheric temperature structure, suppression of rainfall. These aerosol effects can lead to a weaker hydrological cycle, which connects directly to availability and quality of fresh water, a major environmental issue of the 21st century *Aerosols* are fine, airborne particles consisting at least in part of solid material. Density of the basic materials of aerosols range from 1.0 g/cm^3 (for soot) to 2.6 (for minerals). The ocean is a major source of natural aerosols. Air-sea exchange of particulate matter contributes to the global cycles of carbon, nitrogen, and sulfur aerosols, such as dimethyl sulfide (DMS) produced by phytoplankton. Ocean water and sea salt are transferred to the atmosphere through air bubbles at the sea surface. As this water evaporates, the salt is left suspended in the atmosphere. Four other significant sources of aerosols are terrestrial biomass burning, volcanic eruptions, windblown dust from arid and semi-arid regions, and pollution from industrial emissions Recently Shepherded et al. (2002) study the rainfall modification by aerosol.

Monsoon is basically a thermally-driven large-scale circulation. It is, therefore, logical to expect that any global and regional scale thermal anomaly may have its influence on the monsoon rainfall. Particularly the pre-monsoon months (April-May), north- South surface air temperature gradient over the central Indian region is a crucial for advancement of forth-coming monsoon activity. Therefore, temperature change in pre monsoon over central Indian region and the regional Aerosol concentration are important for study of long term change of rainfall during the monsoon (June-September). The number of scientists studied the relationship between surface and upper air temperature with the rainfall activity during the summer monsoon period (June-September). Viz. Parthasarathy et .al. (1990); Rajeevan, (1991) and Verma, R. K.et al (1985) and many others A number of studies addressed the relationship between Indian Summer Monsoon (ISM), and land and sea surface temperatures (e.g., Sikka (1980); Verma *et al* (1985)

Tele:
E-mail addresses: dugam@tropmet.res.in

examined the global land surface air temperature anomaly patterns in association with inter-annual variability of ISMR. However, similar attempts related to North East Monsoon (NEM) were limited. Recently Pai (2003) discussed the prominent tele connection patterns in the monthly global gridded surface air temperature anomalies associated with the inter-annual variability of ISMR.

Data and discussions:

Aerosol and monsoon rainfall

In this paper, to see the effect of aerosols concentration on rainfall activity over Indian region the satellite derived monthly aerosols data over Indian region (5°N to 40°N and 50°E -100°E) have been analyzed from 1981 to 2002. Comparative study of the trend analysis has been carried out between aerosols concentrations and monsoon rainfall (June- September). It is found that in recent period there is decreasing trend in aerosols concentrations over Indian region during the monsoon period. The trend analysis has been carried out for rainfall departure over different homogeneous region of India (Figure1). It is observed that the trend in summer monsoon rainfall and trend in aerosols concentrations shows decreasing trend over west central Indian region (Figure2a and 2b). Probable reason may that the less aerosols concentrations may provide the lesser cloud condensation nuclei for the formation of rain producing clouds also because this region is more far away from sea shore it might get lesser sea salt for the formation of cloud in recent period due to weak of cross-equatorial flow

Figure 1: Different homogenous regions of India

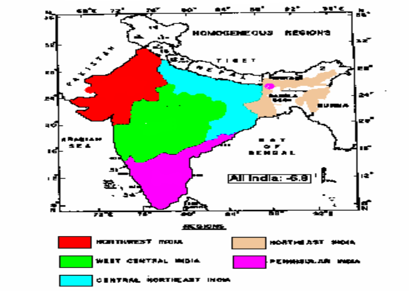


Figure 2A Average aerosol concentrations for monsoon period (1980-2000)

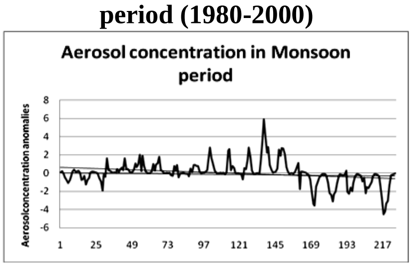
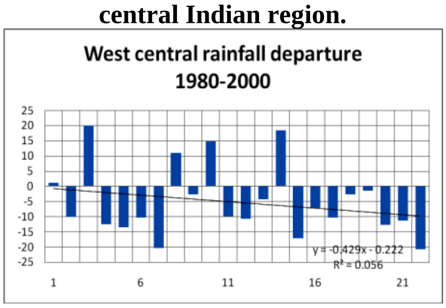
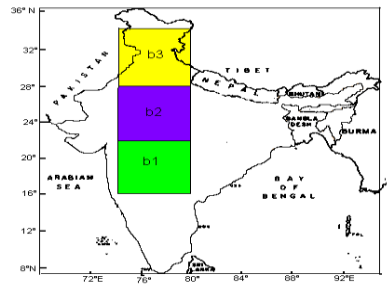


Figure:2B Monsoon rainfall percentage departure for West central Indian region.



Pre- Monsoon temperature and monsoon variability

To see the temperature effect in pre-monsoon months on monsoon variability the Principal component Analysis (PCA) technique is used. By using PCA the monthly temperature gradient series have been prepared. For analysis, the grid (1°*1°) point surface air temperature data taken from the Climate Research Unit (CRU) at the University of East Anglia is used. The analysis is carried out for 105 years 1901-2006. For finding the thermal index gradients anomalies, we have consider the three blocks ;one block (74-80°E, 16-22° N), second block (74-80°E, 22-28° N) and third is (74-80°E, 28-34° N)(Figure3). The monthly time series are prepared from the PCA analysis over these blocks. From these monthly series the north-south temperature gradient anomalies are calculated and the statistical relationship between the Indian southwest monsoon rainfall over all India (AIR), northwest India (NWR) , north east India (NEIR), central north east India (CNEIR) and peninsular India (PIR) and surface temperature gradient (STG) anomaly over central Indian region has been examined for the period 1901-2006. The correlation analysis is carried out for month of April and May (Table 1and2). The results indicate that the previous Mays STG anomaly has a strong and direct relationship with southwest monsoon rainfall, suggesting that positive STG over central India in May leads to good/bad southwest monsoon rainfall over India. The correlations are stronger for AIR and CNEI followed by NEI. The result also suggests that antecedent May STG anomaly may be useful in the long range prediction of the following southwest monsoon rainfall over India. The April STG doesn't show significant relationship with monsoon rainfall with different homogeneous regions.



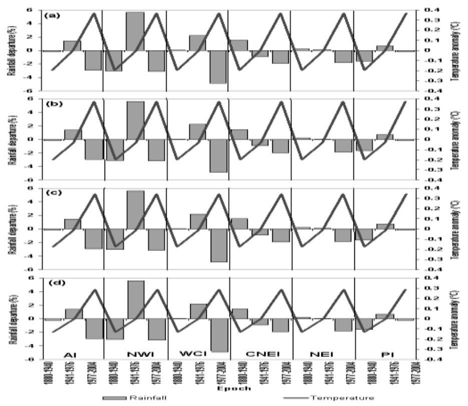


Figure4: Three decadal variability of monsoon rainfall for different homogeneous of India and global temperature anomalies

Global warming and Indian monsoon rainfall variability on smaller spatial scale

To see the effect of Global warming on monsoon rainfall on smaller different homogeneous regions of India viz. West Central India (WCI), North West India (NWI), Peninsular India (PI), Central North East India (CNI) and North East India (NEI) and All India, the analyses of global surface air temperature 125 (1880-2004) years of data have been used. The monthly global surface air temperature anomaly data for the period 1880-2004, have been taken from the Goddard Institute for Space studies New York, (NASA). From the monthly time series, the seasonal series have been prepared and used for the analysis. The updated the summer monsoon (June- September) rainfall data (here after referred to as monsoon rainfall) of all India and its different homogenous regions, are obtained from web site http://www.tropmet.res.in the data is divided in to three epochs based on the average temperature anomaly. The epochs are called as cold, stable and warmer depending upon the negative, zero and positive mean global temperature anomaly respectively. The three epochal periods are 1880-1940(cold), 1941-1976(stable) and 1977-2004 (warming). From the analysis figure4 it is found that during warming or cooling episodes, there is a general below-normal rainfall activity over almost all the homogeneous regions expects the CNEI and NEI. The cooler epoch seems to be favorable for rainfall activity over Central North East India and North East India. An epoch of stable global temperature is also an epoch of above-normal rainfall except Central North East India.

Conclusions

(1) It is found that in recent period there is decreasing trend in aerosols concentrations and decreasing trend in west central monsoon rainfall (June- September) departure rainfall activity during summer monsoon period goes hand in hand. Probable reason may that the less aerosols concentrations may provide the lesser cloud condensation nuclei for the formation of rain producing clouds also because this region is more far away from sea shore it might get lesser sea salt for the formation of cloud in recent period due to weak of cross-equatorial flow

(2) The North South surface air temperature gradient in month of May over the central India can be useful for seasonal prediction of monsoon rainfall over the North East India. The physical reason may be like this ; the weak STG during pre-monsoon will slow down the progress of onset of monsoon and subsequently affect the performance of monsoon over the different part of India and vice versa.

(3) Changes in seasonal global temperature have their impact on monsoon rainfall over different homogeneous regions of India on short-term climatologically scale. During warming or cooling episodes, there is a general below-normal rainfall activity over almost all the homogeneous regions expect the CNEI and NEI. (figure4)

(4)The cooler epoch seems to be favorable for rainfall activity over Central North East India and North East India. An epoch of stable global temperature is also an epoch of above-normal rainfall except Central North East India.

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Table 1: Relationship between April thermal gradient (b2-b1) and rainfall for period 1901-2005

	JJAS	June	July	Aug	Sep
All India	0.03	0.09	0.10	-0.07	-0.07
Hom India	0.00	0.07	0.06	-0.08	-0.05
Cor India	0.02	0.11	0.12	-0.09	-0.08
NW India	-0.03	0.01	0.02	-0.06	-0.02
WC India	0.02	0.09	0.09	-0.08	-0.06
CNE India	0.09	0.14	0.14	-0.02	-0.12
NE India	0.05	0.00	0.04	0.00	0.05
Pen India	-0.02	-0.03	0.00	0.00	-0.02

Table 2: Relationship between May thermal gradient (b2-b1) and rainfall for period 1901-2005

Regions	JJAS	June	July	Aug	Sep
All India	0.02	0.14	-0.05	0.01	-0.03
Hom India	-0.04	0.05	0.00	-0.08	-0.05
Cor India	-0.07	0.09	-0.03	-0.10	-0.06
NW India	-0.18	-0.19	-0.03	-0.12	-0.09
WC India	0.06	.0.16	0.02	-0.04	-0.01
CNE India	0.14	0.18	-0.18	0.25	0.06
NE India	0.29	0.24	0.05	0.20	0.07
Pen India	-0.12	-0.03	-0.03	-0.07	-0.14