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Influence of Pacific and Indian Ocean Temperatures on Monsoonal Rainfall in India

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Abstract

PDO is a strong, recurring shape of the ocean surroundings in climate change variability central along mid-latitude in Pacific Ocean basin. The large climate change indices like PDO (Pacific Decadal Oscillation) and IOD (Indian Ocean Dipole) presence and their relationships for the hydrologic ways on surface response is an important scale of influences on maximum values of precipitation. PDO have particular implications for world climate changing Pacific dry spell and the flooding is under Pacific Ocean basin, the efficiency of sea ecosystems, and world surface temperature models. So, the main purposes of this research were to analyse the relationships of PDO and monsoonal rainfall at all 40 meteorological rainfall stations across the country. The present study focuses on the investigation in linking the point rainfall with ENSO than conventional method of average precipitation in the big region. The results presented a negative connection PDO index versus rainy season precipitation at most of rainfall stations take into consideration for this research. Six rainfall stations such as, Hissar, Gaya, Kolkata, Guwahati, Mysore and Bhubaneswar show a correlation that is positive between PDO and monsoonal rainfall in India. It is established that based on analysis of relationships of with rainy season precipitation at various rainfall stations that a PDO is correlated along imperfect Indian storm. The high level in comprehension the relationships of huge scale indices such as PDO and IOD with terrain hydrologic actions have ability to improve Indian monsoon season forecasting capability across the India.

Keywords: Rainfall; Monsoonal; Pacific; PDO; Indian Ocean; IOD

Introduction

PDO index is a large-scale climate index that explain monthly sea surface temperature anomalies (SST-A) during October to march along the North Pacific (at 200 N) next the global average sea surface temperatures (SST) has been removed. The indication of expand body of high levels the strong movement for the PDO influences in Southern Hemisphere, along with some surface climate season anomalies around the mid-latitude in the South Indian Pacific Ocean, Australian and South America. During period of Normal years, the high-pressure process develops along coast of Peru, but the Indonesia and northern Australia occurrence a low-pressure process. The PDO contains a warm phase and the cool regime phase which changes higher-level surroundings winds.

The PDO can keep in the identical stage about 20- 30 years, whereas ENSO phase typically at most last 6-18 months. For a warm phase, West Indian Pacific Indian Ocean enhances cool and the wedge in an east warm. Cool phase happened from 1947-1976 and warm phases from 1977- 1999. Hence, more recently, then warm and the cold phases have been much shorter. The last PDO regime shift was in 2014, when it moved strongly positive.

The present research investigated the linkages of both warm and cool phases of PDO with monsoonal seasonal precipitation at 40 rainfall stations across our country. The influences of PDO index on monsoonal seasonal precipitation at various stations of India was investigated in this research. In our country, the main influences of the phenomena are upon the intensity of monsoonal precipitation.

A big part of annual precipitation across country is received during October to March. A big strength of the spatial and the temporal flexibility are surely evident on seasonal precipitation across India. Hence last many decades, the PDO, and its harmful influences on Indian seasons have a matter of big actual importance. Our Country is a farming established economy, where the crop creation is greatest dependent upon the monsoonal season rainfall. So, it is certain to understand about PDO process and their influences on the seasonal rainfall. A detailed understanding of a PDO process and its different impacts is essential to against the harmful influences of PDO on agricultural creation.

Literature Review

It is popular that most of the precipitation in India occurs during periods of JJAS rainy season. The summer monsoon precipitation first arrives in the south-western state of the Kerala between late May and the early June each year. Loo has evident that the distribution of rainy season rainfall is highly influenced by a number of the weather processes [1]. Ratna conducted the inspection of daily precipitation for 329 rain gauge rainfall stations values data across Maharashtra, India, through period of summer season monsoon, JJAS, about 11 years' period during from 1998- 2008 [2]. Ahmed describe an effort has form to get difference in magnitude of rainfalls achieved through observed values data and the derived data through proceeds Imphal rainfall values which are available about 15min period interval [3]. Dourte investigated the rainfall magnitude period frequency linkages for Andhra-Pradesh, in India: Two values sets were used by gage, capital of the Andhra Pradesh in the Hyderabad city [4]. Bennett studied influences of maximum spatial rainfall intensities on catchment flooding. Gershunov analyzed and developed signature of the ENSO in cold season frequencies for large rainfall and the temperature peak, which are obtained from both the inspections and the atmospheric GCM model achievement for the contiguous United States [5]. Kim and Olivera describe the comparable

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Importance of various rainfall statistics in measure of stochastic rainfall for generation models [6]. Nayagam studied the impact of the Indian Ocean SST on variability of rainy season rainfall across India [7]. Pacific sea surface temperatures (SST) for Interdecadal variability have been described in many researches such as Dai, Deser, Zhang and Mantua [8-10]. Many indices have been growed to quantitatively discuss the ENSO such as PDO in Indian Interdecadal Pacific Oscillation [11-13].

The PDO and Interdecadal pacific Oscillation are necessary the identical interdecadal flexibility, within the North Pacific with the PDO traditionally explain while the Interdecadal pacific Oscillation surround the whole Pacific basin. Sharif and Burn investigated the relationships between maximum flow measures and the climate season indices for several stations in Canada. Dong and Dai discuss the impact of Interdecadal Indian Pacific Oscillation based upon Temperature, rainfall along the Globe [14]. Amudha investigated the spatial difference of clouding rainfall above southeast Indian season peninsula and the adjoining Bay of Bengal related with active and the dry spells of the northeast monsoon [15]. The models for crop creation apply information through basin scale climate generators like those improved by Sharif and the Burn and also Sharif [16-19]. Much research has established that the climate season has generated in an increasing mode in temperature in the parts across the globe. Due to influence of climate change based upon the temperature, ENSO is maintained to have strengthened below climate season change. A study was conducted by Deng to describe that ENSO may have any considerable impact on the production of Chinese rice [20]. The investigation of big changes in global patterns of climate was done by Cobb over a period of years [21]. It was analyzed by the authors that are driven by ENSO, the sensitivity of it to anthropogenic greenhouse forces continued to be uncertain. It is investigated inter-annual flexibility in the precipitation in various parts of China by Deng for the time period of 1979-2012 [22]. It was investigated relationships of the ENSO to ISM precipitation in observations with models by the results of this research by authors surely presented an effective teleconnections of the ISM to ENSO [23]. It is established that spatial shape of ENSO above Australia has rotated in the past several decades by Roy and Collins. So, the overarching purpose of this study is to analyses relationships of PDO index along with seasonal precipitation at all different rainfall station [24].

Data Used

The different rainfall stations data of average monthly maximum temperature, monthly precipitation (PPT) and average monthly minimum temperature, and data values was achieved by India Meteorological Department (IMD), Pune, India. In present research, totally of 40 rainfall stations were considered. In present study, the geographical locations of different rainfall stations were considered as shown in Figure 1. The precipitation data is available from 1950-2015, at all rainfall stations except Gopalpur, Akola and Agra. The rainfall data values are available upto 2000 only at Agra, Akola, and Gopalpur stations. The different rainfall stations latitude, longitude and elevations are shown in Table 1. From Climate Analysis Section, The PDO index that is Sea Surface Temperature anomaly above the PDO region during October to March in Indian pacific was achieved by National Centre for Atmospheric Research in the USA.

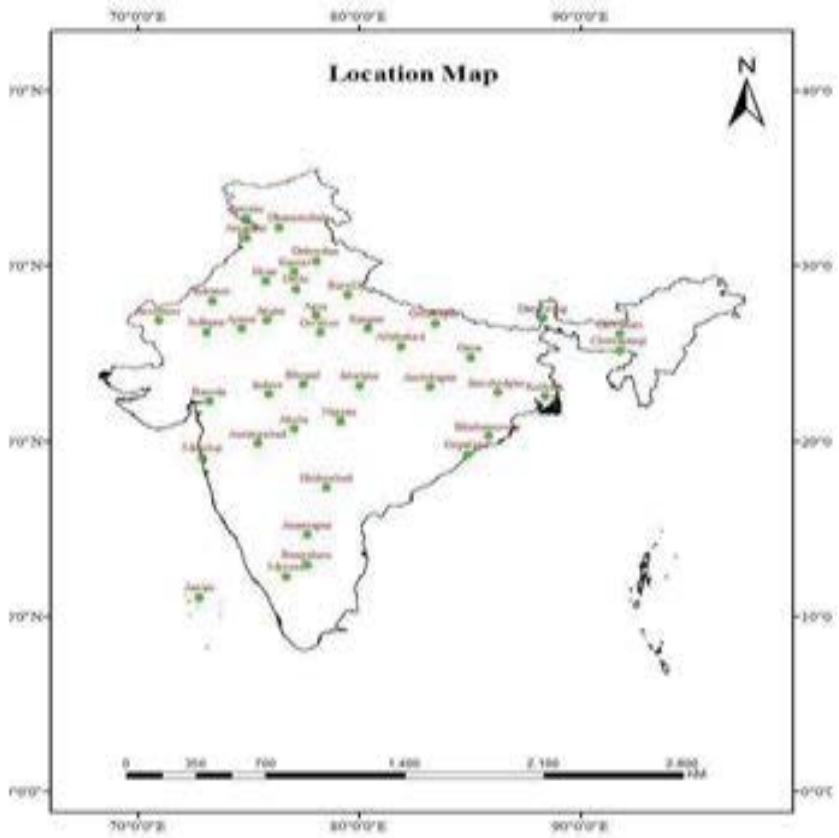

Figure 1: Seographical locations of Rainfall stations.

Rainfall Station	Elevation (M)	Latitude (N)	Longitude (E)
Akola	286	20° 00'	76° 00'
Allahabad	98	25° 28' 22.9224"	81° 52' 42.0852"
Agra	171	27° 10'	>78° 05'
Ajmer	200	26° 27'	74° 42'
Amritsar	219	31° 37'	74° 55'
Anantapur	335	14° 41'	77° 39'
Ambikapur	623	21° 30'	82° 0'
Amini	2	11.1142°	72.7204°
Aurangabad	568	19° 53'	75° 23'
Baroda	129	25° 25'	76° 70'
Bhopal	527	23° 15' 35.7588"	77° 24' 45.4068"
Bangaluru	920	12° 58'	77° 38'
Bareilly	268	28° 22'	79° 27'
Bikaner	242	28° 01'	73° 22'
Bhubaneswar	45	20° 15'	85° 52'
Cherrapunji	1484	25° 18' 0"	91° 42' 0"
Delhi	216	28° 36' 0"	77° 12' 0"
Dharamsala	1457	32° 16'	76° 23'
Darjeeling	2042	27° 03'	88° 18'
Dehradun	435	30° 19'	78° 04'
Gorakhpur	84	26° 45'	83° 24'
Guwahati	55	26° 11'	91° 44'
Gaya	111	42° 49'	85° 01'
Gopalpur	1	19° 16'	84° 57'
Gwalior	196	26° 13' 5.8332"	78° 10' 58.1916"
Hyderabad	505	17° 23' 13.7040"	78° 29' 30.0624"
Hissar	215	29° 19'	76° 23'
Indore	553	22° 44'	75° 50'
Jaisalmer	225	26° 55'	70° 57'
Jammu	327	32° 43'	74° 54'
Jabalpur	412	23° 10'	79° 59'
Jaipur	431	26° 55' 19.4520"	75° 46' 43.9860"
Jamshedpur	135	22° 50'	86° 10'
Jodhpur	231	26° 18'	73° 04'
Kolkata	9.1	22° 34' 21.5220"N	88° 21' 50.0112"
Kanpur	126	26° 26' 59.7228"	80° 19' 54.7356"
Karnal	228	28° 16'	77° 05'
Mysore	763	12° 18'	76° 42'
Mumbai	14	18° 55'	72° 54'
Nagpur	310	21° 8' 47.8788"	79° 5' 19.8960"

Table 1: Latitude, longitude elevation of 40 Rainfall stations.

Research Methodology

Pacific decadal oscillation for the warm phase and the cold phase for Linkages of PDO index values with rainfall data values at 40 meteorological rainfall stations across India in a basin have been analyzed. The methodology of initial stage worked was to identify the Normal years with PDO cycle events. The classification of PDO years of main objective during October to March period using the data, the SST anomalies was determined for the obtained data from the NCAR. Figure 2 show Monthly mean values for PDO Index from 1900-2018 and Figure 3 shows Precipitation at Allahabad and Sea Surface Temperature in PDO Index. Figure 4 shows Precipitation at Bhuvneshwar and SST in PDO Index Figure 5 shows Precipitation at Delhi and SST in PDO Index. Table 2 shows the classification of years into two different categories normal years and PDO years. Figure 6 shows Precipitation at Guwahati and SST in PDO Index.

The types of various years are established on threshold temperature at 0.4°C for the anomaly. The next move was to calculate correlation coefficient PDO index versus monsoonal seasonal precipitation at all 40 rainfall stations considered in this research. The PDO index versus precipitation correlations coefficients have been computed byR-

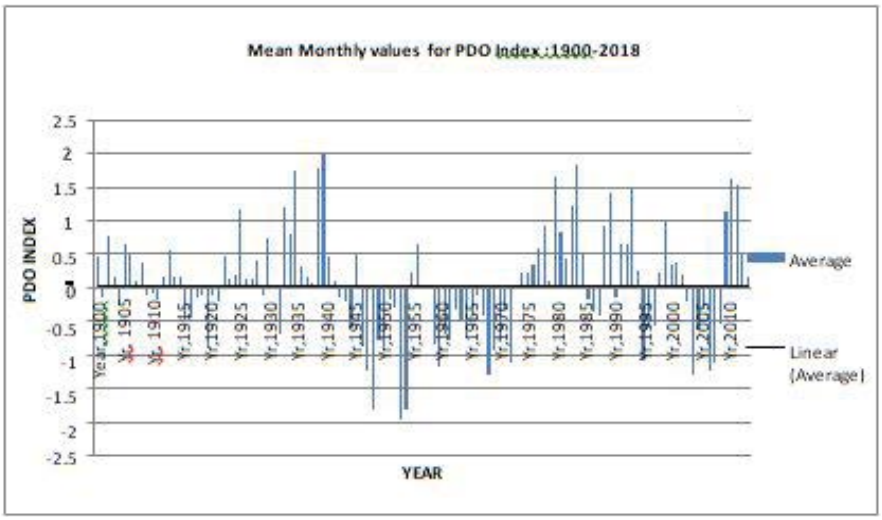

Figure 2: Monthly mean values for PDO Index from 1900-2018.

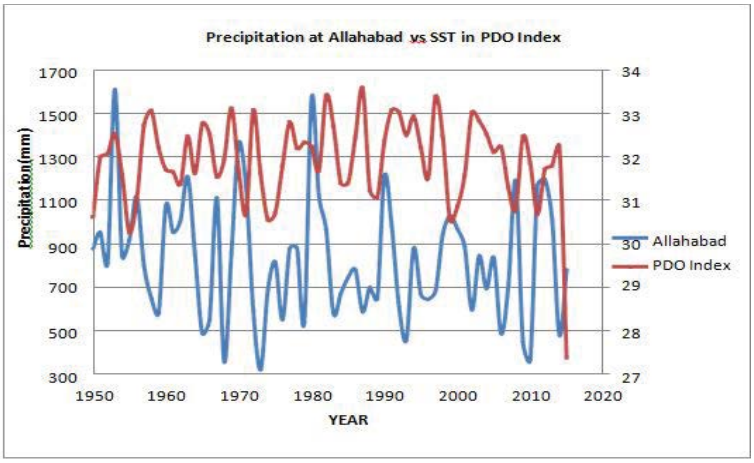

Figure 3: Precipitation at Allahabad vs SST in PDO Index.

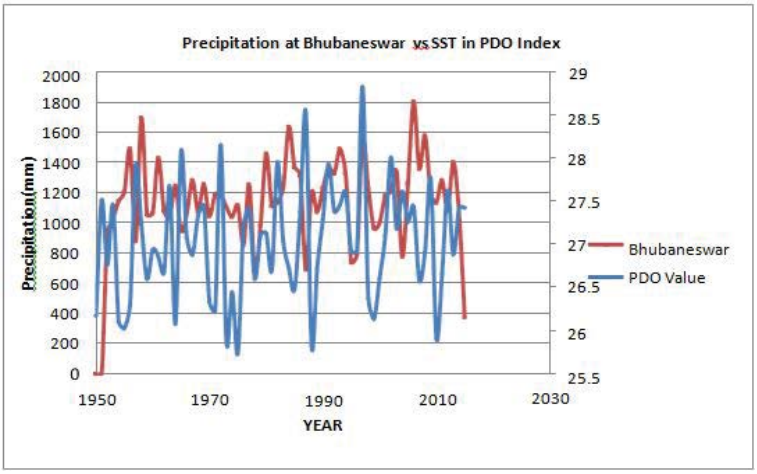

Figure 4: Precipitation at Bhubaneswar vs SST in PDO Index.

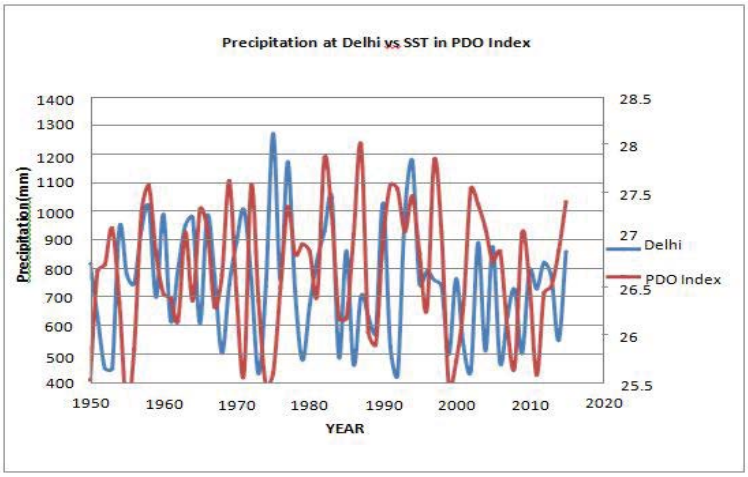

Figure 5: Precipitation at Delhi vs SST in PDO Index.

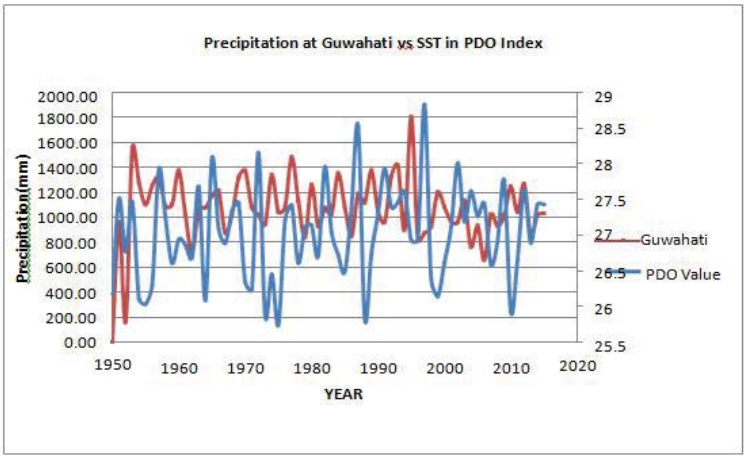

Figure 6: Precipitation at Guwahati vs SST in PDO Index.

Normal Year	PDO Year	Phase
1952,1958,1960,1961,	1905-1946	Warm phase regime
1962, 1966, 1967, 1960	1947-1976	Coldphase regime
1976,1977,1979,1980,	1977-1998	Warmphase regime
1981,1983,1984,1986,	2008-2013	Coldphase regime
1989,1990,1992,1995,	2014-onwards	Warm phase regime
1996,2001,2003,2005,		
2007, 2008		

Table 2: Normal year and PDO years

package(R-Console) open source statistical tool and the computing software PDO years with Normal years' classification related with PDO index and monsoonal rainfall different parts in India.

Result and Discussion

In Present study the main objective was to analyze the relationships of PDO with monsoonal seasonal precipitation at all 40 meteorological rainfall stations across the India. The negative related between PDO and the monsoonal seasonal precipitation was presented results at majority of the rainfall stations, observed for this research. Between ENSO and monsoonal precipitation showed positive correlation by all six rainfall stations such as Bhubaneswar, Gaya, Guwahati, Hissar`, Kolkata and Mysore. Evaluation of relationships of PDO with monsoonal seasonal precipitation at various rainfall stations is concluded that an ENSO is related with the weak Indian monsoon season. The tele-connections for SST were understood and the persistent climate change anomalies on surface have ability to improve season monsoon forecasting skills across the country.

Rainfall Station	Coefficients of Correlation	P-value
Akola	-0.425	0.006
Allhabad	-0.117	0.356
Agra	-0.262	0.062
Ajmer	-0.35	0.003
Amritsar	-0.264	0.033
Anantapur	-0.215	0.087
Ambikapur	-0.147	0.235
Amini	-0.221	0.075
Aurangabad	-0.136	0.291
Baroda	-0.103	0.423
Bhopal	-0.211	0.091
Banglore	-0.281	0.02
Baraili	-0.271	0.028
Bhubaneswar	-0.015	0.921
Bikaner	-0.197	0.118
Cherrapunji	-0.164	0.182
Delhi	-0.104	0.412
Dharamsala	-0.16	0.198
Darjeeling	-0.032	0.792
Dehradun	-0.155	0.22
Gorakhpur	-0.121	0.338
Guwahati	-0.061	0.642
Gaya	0.062	0.611
Gopalpur	-0.09	0.52
Gwalior	-0.069	0.572
Hyderabad	-0.144	0.255
Hissar	0.052	0.683
Indore	-0.29	0.018
Jaisalmer	-0.157	0.203
Jammu	-0.032	0.803
Jabalpur	-0.104	0.402
Jaipur	-0.418	0.002
Jamshedpur	-0.263	0.032
Jodhpur	-0.362	0.002
Kolkata	0.028	0.816
Karnal	-0.134	0.279
Mysore	0.003	0.987
Mumbai	-0.291	0.018
Nagpur	-0.255	0.037

Table 3: Correlation (Interaction) coefficients withrelated P-values at various Rainfall stations

The correlation investigations were carried out to calculate the influence of PDO based upon monsoonal seasonal precipitation at various rainfall stations under assumption. Interaction was established to be negative on a most of stations for rainfall. Here only four rainfall stations whereas the interaction was established to be positive, so representing that the monsoonal seasonal precipitation across our country generally lower with the higher in temperature in a PDO region. A Statistical importance of the interaction of test, p-value of interaction was calculated. Table 3 indicates various values for data of correlation (interaction) coefficients and p-values related with these coefficients of correlation. One p-value of lower than 0.05 represents that the tendency is statistically importance of level at 5%.

Conclusion

In this research the main purpose was to describe relationships of PDO index with monsoonal seasonal precipitation at all 40 meteorological rainfall stations across our country. The negative relation PDO versus monsoonal precipitation was presented results at the majority of the rainfall stations, considered for this research.

The maximum annual precipitation was notice in the year 1952 of 1139mm at Agra. The Figure 5 shows as maximum annual precipitation was observed of 1269.8mm at Delhi in 1975, whereas the long-run normal minimum precipitation is 427.2 mm at Delhi in 1992. Similarly, at Indore a high annual precipitation of 1745mm was noticed. Some stations are considered in this research that experienced almost low precipitation such as Bikaner and Rajasthan were noticed of 551mm as an annual maximum precipitation. It was of 17291mm at Darjeeling in 1993. The statistically significant correlation of rainfall stations are Indore, Jaipur, Jamshedpur, Bareli, Bengaluru, Jodhpur, Ajmer, Akola, Amritsar and Mumbai observed that the maximum annual precipitation occurred of 18656mm at Cheerapunji in 1974, while maximum annual precipitation was noticed.

PDO Index represents as shown in Figure 2 as a warm phase between 1925-1946. Then it goes in a cool phase which continue until the behind 1970s. About 1977, the warm phase regime begins and continues until upto 1998. A negative phase lasting about 6 years was observed during August 2007-2013. Finally appears to be different PDO phases of warm and cool regimes during period 2000-2016.

Present research for practical application is for agricultural area; here a crop creation could be projected establish upon the precipitation as projected down influence of the ENSO and PDO. Hence crops of high focus that are particularly resistant to adverse climatic season conditions are need. The seasonal rainfall is the lifeline of agriculture across the country.

Reference

1. Loo YY (2015) Effect of climate change on seasonal monsoon in Asia & its impact on variability of monsoon rainfall in Southeast Asia. 6: 817-823.
2. Ratna SB (2012) Summer monsoon rainfall variability over Maharashtra, India. Pure Appl Geophys 169: 259-273.
3. Ahmed Z, Rao DR, Raj E (2012) Rainfall intensity variation for observed data and derived data-A case study of Imphal. Arpn J Eng Appl Sci 7.
4. Dourte D, Shukla S, Singh P (2013) Rainfall Intensity-Duration- Frequency Relationships for Andhra Pradesh, India: Changing Rainfall Patterns and Implications for Runoff and Groundwater Recharge. J Hydrol Eng 18: 324-330.
5. Gershunov (1998) ENSO influence on intraseasonal extreme rainfall and temperature frequencies in the contiguous United States: Observations and model results. J Clim 11: 1575-1586.
6. Kim D, Olivera F (2012) Relative Importance of the Different Rainfall Statistics in the Calibration of Stochastic Rainfall Generation Models. J Hydrol Eng 17: 368-376.
7. Nayagam LR, Rajesh J, Mohan HSR (2013) The influence of Indian Ocean sea surface temperature on the variability of monsoon rainfall over India.
8. Dai A (2013) The influence of the inter-decadal Pacific oscillation on US precipitation during 1923- 2010. Climate Dynamic. 41: 633-646.
9. Deser C (2004) Pacific interdecadal climate variability linkages between the tropics and the North Pacific during boreal winter since 1900. J Clim 17:3109-3124.
10. Mantua NJ (1997) A Pacific interdecadal climate oscillation with impacts on salmon production. Bull Am Meteorol Soc 78:1069-1079.
11. Power S (1999) Interdecadal modulation of the impact of ENSO on Australia. Climate Dynamic 15: 219-324.
12. Liu ZY (2012) Dynamics of interdecadal climate variability a historical perspective. J Clim 25:1963-1995.
13. Zhang Y, Wallace JM, Battisti DS (1997) ENSO like interdecadal variability. J Clim 10: 1002-1004.
14. Dong B, Dai A (2015) The influence of the Interdecadal Pacific Oscillation on Temperature and Precipitation over the Globe. Climate Dynamics 45: 2667-2681.
15. Amudha B, Raj YE, Asokan R (2016) Spatial variation of clouding / rainfall over southeast Indian peninsula and adjoining Bay of Bengal associated with active and dry spells of northeast monsoon as derived from INSAT OLR data.
16. Sharif M, Burn DH (2004) Assessment of water resources risk and vulnerability to changing climatic conditions Development and application of a K-NN weather generating model. The University of Western Ontario Canada.
17. Sharif M, Burn DH (2004) Development and application of K-nearest neighbor weather generating model 57th Canadian Water Resources Association Annual Congress Water and Climate Change Knowledge for better adaptation Canada.
18. Sharif M, Burn DH, Hofbauer KM (2013) Generation of daily & hourly weather variables for use in climate change vulnerability assessment. Water Resources Management 27: 1533-1550.
19. Sharif M, Burn D (2009) Detection of linkages between extreme flow measures and climate indices World Academy of Science, Engineering and Technology. 36: 873-878.
20. Deng X (2007) Impacts of El-Nino-Southern oscillation events on China's Rice Production. J Geogr Sci 20: 3-16.
21. Cobb KM, Westphal N, Sayani HR (2013) Highly variable El Niño Southern oscillation throughout the Holocene. Sci J 339: 67-70.
22. Deng YY (2014) Regional precipitation variability in East Asia related to climate and environmental factors during. Sci Rep 4: 5693.
23. Roy I, Mathews C (2015) On identifying the role of Sun and El Niño southern oscillation on indian summer monsoon rainfall. Atmospheric Sci Lett 16: 162-169.
24. Sharif M, Archer D, Fowler H (2013) Trends in magnitude and timings of flow in the Upper Indus River basin. J HESS 17: 1503-1516.