Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-11: x-3348-3354

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-11 pp. 3348-3354**
Journal homepage: http://www.ijcmas.com

Original Research Article

Trend Analysis of Temperature over Marathwada Region, Maharashtra Using RClimDEX' Model

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A B S T R A C T

The objective of this study is to assess the change trends of daily temperature extremes in Marathwada region in Maharashtra state which includes Aurangabad, Beed, Latur, Osmanabad, Nanded, Jalna and Parbhani district locations during the period between 1981 and – 2010. Analysis of the changes in trends of temperature extremes in marathwada region were studied by extreme indices series in RClimDex software. Climate change threatens to increase air temperatures and evapotranspiration, increase the risk of heat waves associated with drought. temperature extreme hot days, warm nights, warm days and warm spells showed significant positive trends over the respective district locations. Marathwada region was particularly affected by warm extremes than cold extremes based on day time indices. From 1981 to 2010 cold days and nights has decreased, while over the same period the incident of extreme hot days and nights has increased. Therefore, length of growing season (LGS) has increased over the studied period, temperature extremes show patterns consistent with warming over most of the analyzed indices. Moreover, the highest decadal trends of Diurnal Temperature Range (DTR) Tmax and Tmin observed in Nanded district during the year 1981-1990, 1991-2000 and 2001-2010 and lowest observed in Latur district during the decadal trend in 2001 to 2010 respectively.

Keywords

Temperature, Trend, Precipitation, Extremes, Index and Variability etc.

Introduction

Weather and climate extremes have always posed serious challenges to society. Climate is a vital component in the lives and sustenance of the people and socio-economic evolution as a whole. Changes in extreme weather and climate events have significant impacts and are among the most serious challenges to society in coping with a changing climate. The anthropogenic cause of current climate change has been identified by researchers and is a widely acknowledged issue in the political sphere during the last decades. The different emissions of greenhouse gases linked mainly with industrial production increase the global mean temperature via the greenhouse effect, affect the whole Earth system (Lavinia, 2011). IPCC has provided since the early 1990's proof of accelerated global warming and climate change. The global average temperature from 1998-2012 show a rise of 0.05 (+0.15 to -0.15) ^{O}C per decade, compared with a longer term rise of 0.12 (0.08–0.14) ^{O}C per decade over the period from 1951 to 2012 (IPCC, 2013). The understanding of the indices in the extreme temperature and precipitation fields are necessary to look at their variability and trend. With this view, the extreme climatic events have been examined and any change

in climate can have large impacts on daily life of the population and environment. The climate communities unanimously agree that any changes in the frequency or intensity of extreme climate events would have deep effect on the nature and societies. It is therefore very crucial to analyze extreme events.

Materials and Methods

Location and extent

Marathwada is located in the middle and south eastern portion of Maharashtra State. Godawari river basin is covered in northern part of Marathwada region and southern part of Marathwada region is covered by Krishna river basin. Marathwada region lies between 17o 35' to 20o41' North Latitude and 70o 40' to 78 o 16' East Longitude.

The RClimDex model is developed and maintained by Xuebin Zhang and Feng Yang. It was designed to provide a user friendly interface to compute indices of climate extremes. It computes all 27 core indices recommended by the CCl/CLIVAR Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI) as well as some other temperature and precipitation indices with user defined thresholds.

How to install R

RClimDex requires the base package of R and graphic user interface. The installation of R involves a very simple procedure. 1) Connect to the R project website at http://www.r-project.org, 2) Follow the links to download the most recent version of R for your computer operating system from any mirror site of CRAN.

For Microsoft Windows (95, 98, 2000, XP, 07 and 10), download the Windows setup program. Run that program and R will be automatically installed in your computer, with a short cut to R on your desktop. The TclTk is included in the default installation of R 1.9.0 or later versions. It may need to be installed separately if you are running an earlier version of R.

How to run R

Under the Windows environment, double click the R icon on your desktop, or launch it through Windows "start" menu. This usually gets you into the R user interface. For some computers, you may need to first setup an environment variable called "HOME". See R for Windows FAQ for details if you have any problems. Under a unix environment, just run R to give you the R console. Exit from R by entering q in the R console under both Windows and unix. Under Windows, you may also click "File" menu and then "Exit".

Results and Discussions

The trend of the temperature indices represents that there are decreasing and negative trend in cold days (FD10) is -0.392 while other four indices (ID20) is 0.01, (SU25) is 0.009, (SU40) is 0.039 and (TR20) is 1.196 shows the increasing and positive trend, (TR20) is 1.196 and (SU40) is 0.039 which illustrate overall rising trend of temperature in the Aurangabad district.

The trend of the temperature indices represents there are decreasing and negative trend of Ice days (ID20) is -0.001 and Hot nights (TR20) is -2.16. Other three indices such as (FU10) is 0.022, (SU25) is 0.105 and (SU40) is 0.072 shows that increasing and positive trend which illustrate overall rising of temperature in the Beed district (Fig. 1–7).

The average trends for Frost days (FD0) is 0, Cold days (FD10) is 0.068, Ice days (ID0) is

0.018, Hot nights is (0.035) and Tropical nights (TR35) is 0. It shows significant warming. Whereas summer days (SU25) is -0.114 and Very hot days (SU40) is -0.239 which shows insignificant but increasing trend for Jalna district.

All averaged anomaly series between 1981-2010 in the annual number of Frost days (FD0), Ice days (ID0), Ice days<20^0C (ID20) and Tropical nights (TR35) shows significant warming trends. Whereas, Cold days (FD10), Summer days (SU25), Very hot days (SU40) and Hot nights (TR20) are significant and Hot nights>20^0C are increasing trend with for Latur district.

The trend of the temperature indices represents that there are decreasing and negative trend for Cold days (FD10) is -0.558, Ice days <20^0C(ID20) is -0.023, Summer days (SU25) is -0.131 and Very hot days (SU40) is -592 however, increasing trend in Hot nights >20^0C (TR20) i.e.0.005. Other four indices shows increasing trend in the Nanded district.

The trend of the temperature indices represents there are decreasing and negative trend of Very hot days (SU40) is -0.094 and Hot nights >20^0C(TR20) is -5.231 while other (SU25) is 0.903 and (SU40) is 0.663 shows the increasing and positive trend which illustrate overall rising of temperature in the Osmanabad district.

The trend of the temperature indices represents there are decreasing and negative trend of Summer days (SU25) is -0.155,Very hot days (SU40) is -1.028 and Hot nights (TR20) is -0.256. Other four indices shows the increasing and positive trend which illustrate overall rising of temperature in the Parbhani district (Table 1 and 2).

Table.1 Geographical co-ordinates and location names used in the study area

Location / District	Base Period	Latitude	Longitude
Aurangabad	1981-2010	19.8762^{0}N	75.3433^{0}E
Beed	1981-2010	18.9891^{0}N	75.7601^{0}E
Jalna	1981-2010	19.8297^{0}N	75.8800^{0}E
Latur	1981-2010	18.4088^{0}N	76.5604^{0}E
Nanded	1981-2010	19.1383^{0}N	77.3210^{0}E
Osmanabad	1981-2010	18.2070^{0}N	76.1784^{0}E
Parbhani	1981-2010	19.2644^{0}N	76.6413^{0}E

Table.2 Summary information of the used Temperature Indices

Index	Descriptive Name	Definition	Units
SU25	hot days	annual count when TX > 25°C	days
FD10	frost days	annual count when TN < 0°C	days
ID20	cold days	annual count when TX < 20°C	days
DTR	diurnal temperature range	monthly mean difference between TX and TN	°C
TR20	warm nights	annual count when TN > 20°C	days
TXx	hottest day	monthly highest TX	°C
TNx	hottest night	monthly highest TN	°C
TXn	coolest day	monthly lowest TX	°C
TNn	coolest night	monthly lowest TN	°C
SU40	Hot days	annual count when TX > 25°C	%
TX10p	cool day frequency	percentage of days when TX < 10th percentile of 1981-2010	%
TN90p	hot night frequency	percentage of days when TN > 90th percentile of 1981-2010	%
TX90p	hot day frequency	percentage of days when TX > 90th percentile of 1981-2010	%
WSDI	warm spell	Annual count of days with at least 6 consecutive days when TX > 90th percentile of 1981-2010	days
CSDI	cold spell	annual count of days with at least 6 consecutive days when TN < 10th percentile of 1981-2010	days
GSL	growing season length	annual count between first span of at least 6 days with TG > 5°C after winter and first span after summer of 6 days with TG < 5°C	days

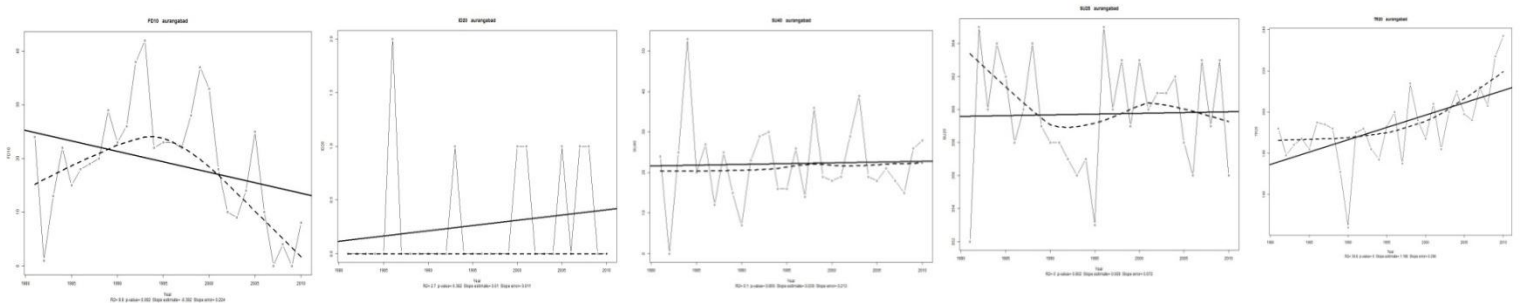

Fig.1 Trend analysis of (FD10), (ID20), (SU25), (SU40) and (TR20) of Aurangabad

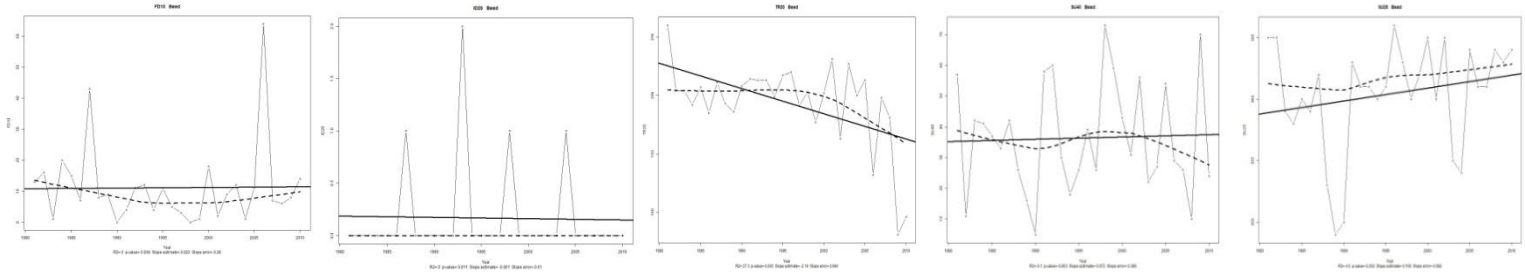

Fig 2 Trend analysis of (FD10), (ID20), (SU25), (SU40) and (TR20) of Beed

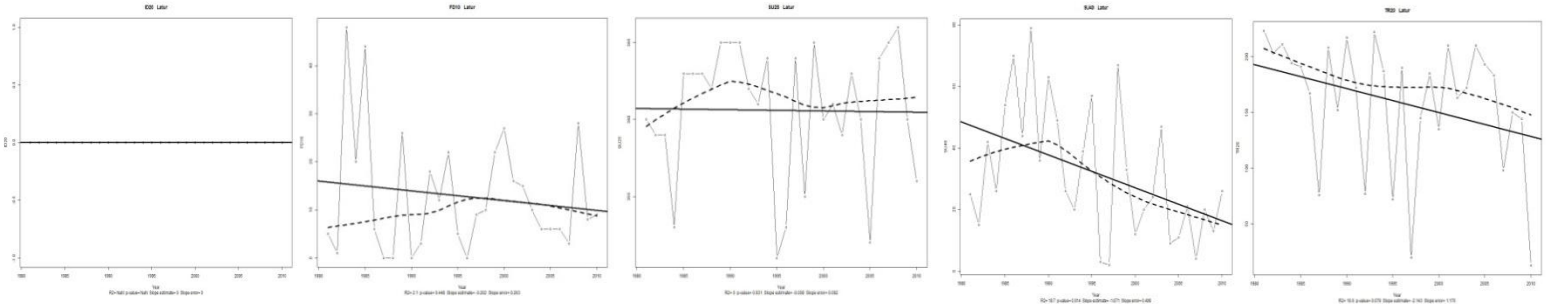

Fig.3 Trend analysis of (FD10), (ID20), (SU25), (SU40) and (TR20) of Latur

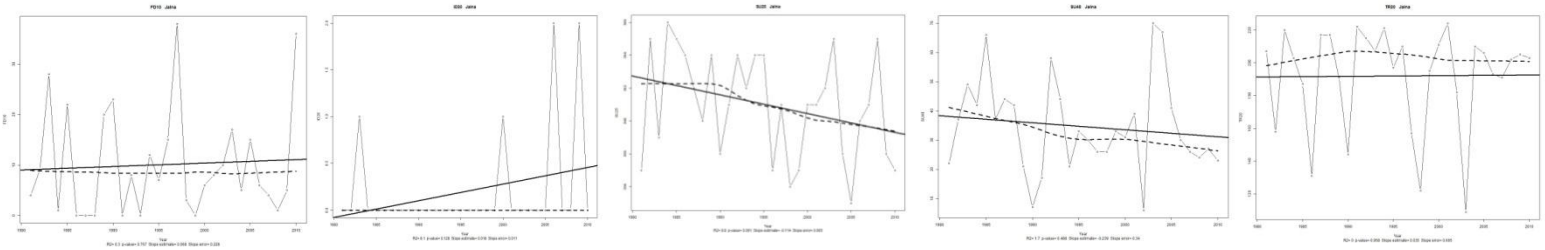

Fig.4 Trend analysis of (FD10), (ID20), (SU25), (SU40) and (TR20) of Jalna

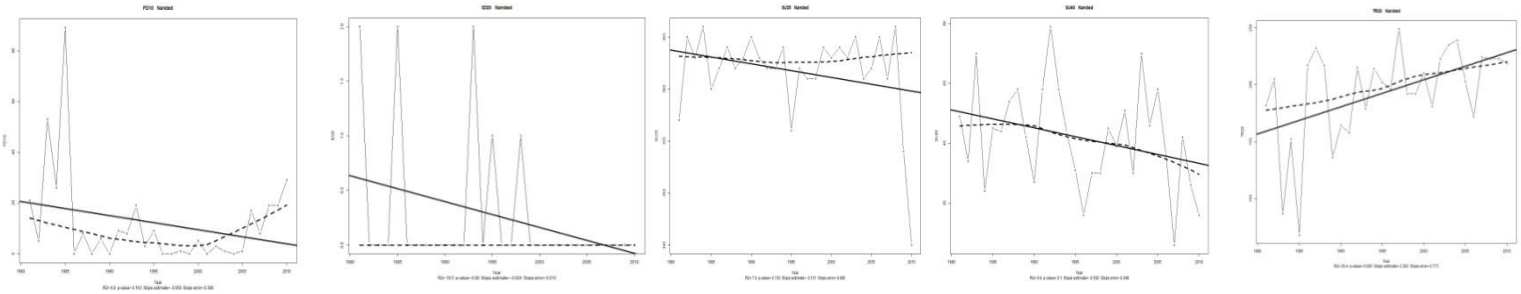

Fig.5 Trend analysis of (FD10), (ID20), (SU25), (SU40) and (TR20) of Nanded

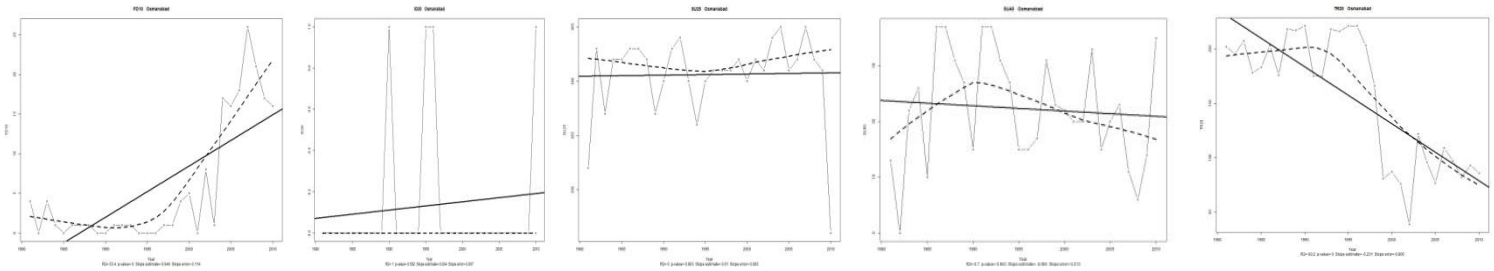

Fig.6 Trend analysis of (FD10), (ID20), (SU25), (SU40) and (TR20) of Osmanabad

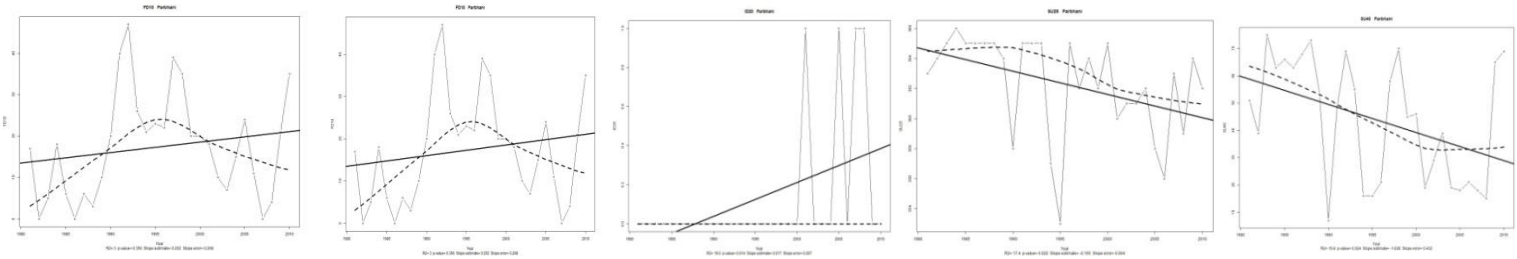

Fig.7 Trend analysis of (FD10), (ID20), (SU25), (SU40) and (TR20) of Parbhani

Diurnal Temperature Range (DTR)

The diurnal temperature range (DTR) in all the stations of Marathwada region have been analysed, the Beed, Jalna and Latur stations shows increasing trends. This put emphasis on absolutely higher pace in maximum temperature trends than in trends of minimum temperature. While, the Aurangabad, Osmanabad and Parbhani stations have significant decreasing trends this put emphasis on absolutely higher pace in minimum temperature trends than in trends of maximum temperature.

In conclusion, this study provides an assessment of observed trends in key climate extreme indices characterised by maximum temperature and minimum temperature, most of the extreme indices shows a consistent different pattern. The average trend of Temperature indices like FD10 (Cold days), SU40 (Very hot days) and TR20 (Hot nights > 20^0C) showed fluctuating trend i.e. FD10 (32 days), SU40 (35 days) and TR20 (32 days). While, the S25 (Summer days) showed ascending trend i.e. 358 days among all districts of Marathwada region from 1981 to 2010. Among the districts, the highest decadal

trends of Diurnal Temperature Range (DTR) Tmax and Tmin found in Nanded in the year 1981-1990, 1991-2000 and 2001-2010 and lowest was observed in Latur district during the decadal trend in 2001 to 2010 respectively.

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