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Precipitation Trend Analysis in Pakistan using TRMM 3B42 Product (2001-2015)

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Abstract

Globally climate change is influencing the patterns of natural processes and thus the lives of the communities; it is evident from different disastrous events like glacier melting, consecutive floods & droughts, storms & cyclones, loss of habitat and natural ecosystems. Climatic Change has significantly influenced the precipitation events in Pakistan. This study aimed at analysing the precipitation trend in Pakistan since last fifteen years that is from the year 2001 to 2015 using (TRMM 3B42 daily product V7). Tropical Rainfall Measurement Mission (TRMM) satellite data was collected from different websites affiliated with National Aeronautics and Space Administration (NASA). Analysis was carried out using Microsoft Excel by plotting time series for both monthly and annual precipitation. Time series revealed insignificant changes in annual precipitation whereas significant changes in monthly precipitation events. Monsoon season, the raining season in Pakistan normally lies between June and September but in the flooding years in Pakistan that are 2001, 2003, 2006, 2007, 2010, 2011, 2012, 2014 and 2015, it was found that the monsoon season is shortening whereas its intensity is increasing. Highest amount of rainfall is available within a less time period, so collective load of rainfall runoff and river waters along with low storage capacity of Pakistan exert immense pressure on the existing water infrastructures of the country which ultimately leads to severe floods resulting in heavy socio-economic losses.

Keywords: Climate Change; Precipitation; TRMM; Floods

1. Introduction

Intergovernmental Panel on Climatic Change (IPCC) has claimed that in future due to various extreme events of precipitation, the world will face devastating flood and droughts[1]. Pakistan is a country, where lands of different geography and climate do exist[2]. Most of the areas of Pakistan are therefore very sensitive to the changes in precipitation rates. Some of the areas of the country located over higher latitudes are vulnerable to flood disaster, while most of the southern regions are extremely vulnerable to droughts[2]. Pakistan has faced severe floods in the history that fall in the years 2001, 2003, 2006, 2007, 2008, 2010, 2011 and 2012. The intensity and frequency of extreme precipitation events, mostly associated with monsoon season have also increased during recent decades. Monson contributes about 60% of the rainfall throughout the year and got great significance for Pakistan [2]
Pakistan receives a good amount of rainfall every year. As the water resources in Pakistan are dwindling day by day and our country is now considered as water stressed country; rainwater harvesting could be extremely beneficial option for Pakistan.

There is a need to estimate and predict the precipitation rates in Pakistan, to design better infrastructures and manage that rainfall for storage and sustainable water availability rather than causing floods and droughts. Throughout the world, there is a strong need to study rainfall patterns because there exists a lack in surface rainfall gauge stations to measure amount of rainfall [3].

The hydrological cycle can be affected by the future climate change in many ways such as precipitation trends, snowfall [4]. To study the global warming and climate change impacts in Pakistan there is need to study the changes in hydrologic cycle for Pakistan incorporating rainfall data. But there exists a difficulty to estimate rainfall in far flung and inaccessible areas due to absence of ground based observatories. In such areas satellite based TRMM data is quite useful in estimating rainfall whereas in the areas where ground based observatories represent then TRMM data again serves in validating that rainfall gauge data[5][6].

TRMM stands for “Tropical Rainfall Measurement Mission”. It was the joint mission between NASA and the Japan Aerospace Exploration (JAXA) Agency to study rainfall for weather and climate research. This mission was launched in late November 1997, with a design lifetime of 3 years, the TRMM satellite produced over 17 years of valuable scientific data. The TRMM dataset became the space standard for measuring precipitation, and led to research that improved our understanding of tropical cyclone structure and evolution, convective system properties, lightning-storm relationships, climate and weather modeling, and human impacts on rainfall. The data also supported operational applications such as flood and drought monitoring and weather forecasting.

2. Material and methods

2.1. Data collection

The study area for this research is Pakistan; in this study TRMM data have been extracted to analyse the precipitation trend in Pakistan. The Data which is used in this research was TRMM 3B42 product is used. Precipitation data was collected from the website TRMM website [7]

2.2. *Data Analysis*

- The TRMM 3B42 precipitation data from the data source website was exported in the commas separated values (CSV) file format of area averaged daily values in millimeters.
- Monthly cumulative value of rainfall in millimeters is calculated using MS-Excel.
- Annual time series have been plotted in between the months and their cumulative values of precipitation on MATLAB 2009 interface using script given below;

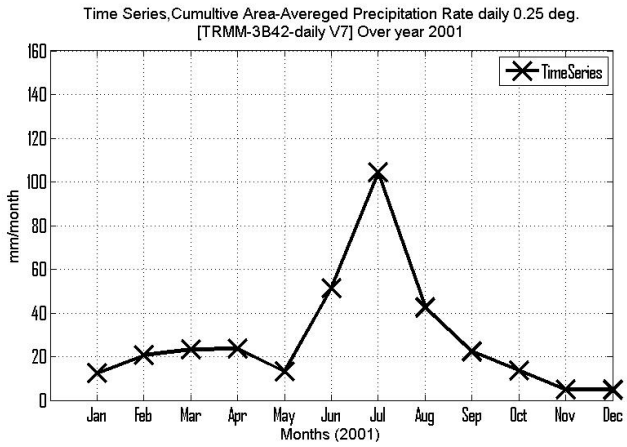
```
clear all
Raw=xlsread('year.xls');
x=1:12;
y=Raw(:,1);
plot(x,y,'k','linewidth',3)
grid on
set(gca, 'XTick', 1:12, 'XTickLabel', {'Jan' 'Feb' 'Mar' 'Apr' 'May' 'Jun' 'Jul' 'Aug' 'Sep' 'Oct' 'Nov' 'Dec'})
title({'Time Series,Cumultive Area-Avereged Precipitation Rate daily 0.25 deg.';'[TRMM-3B42-daily V7]
Over year year'})
Xlabel('Months (year)')
Ylabel('mm/month')
legend('TimeSeries') [8]
```

With the help of above script graphs can be plotted for all the years and by analysing these graphs precipitation patterns can be observed.

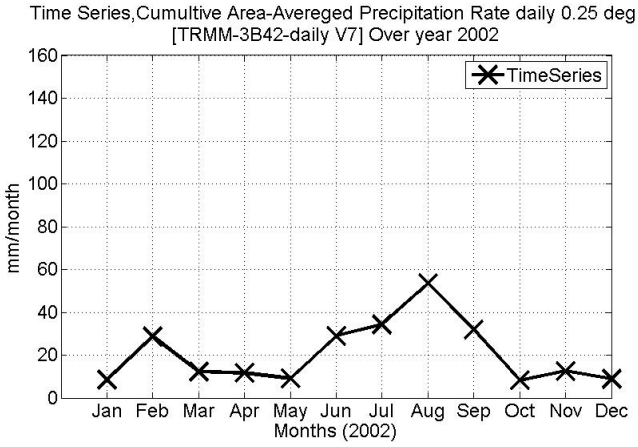
3. Results and discussions

Results of the precipitation data can be visualized through graphs given and discussed below;

Year 2001



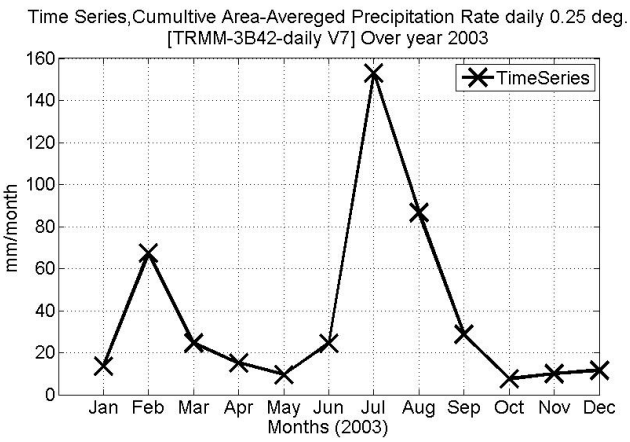
Year 2002



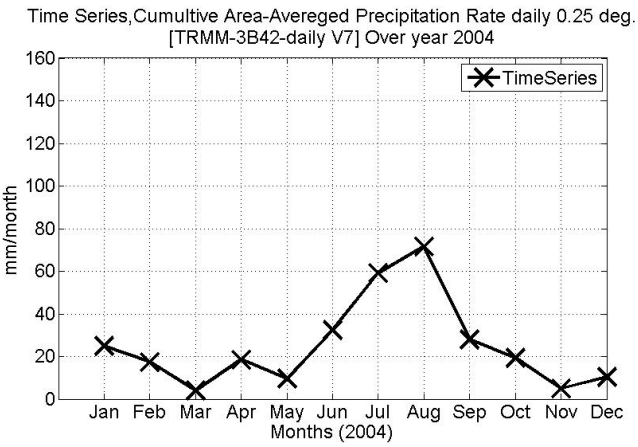
In the year 2001, the cumulative annual rainfall was 337mm, in which monsoon season contributed about 220.6mm, whereas highest amount of rainfall was recorded in the month of July that was 104.4mm.

In the year 2002, the cumulative annual rainfall was 248.8mm, in which monsoon season contributed about 148.8mm, whereas highest amount of rainfall was recorded in the month of August that was 53.6mm.

Year 2003



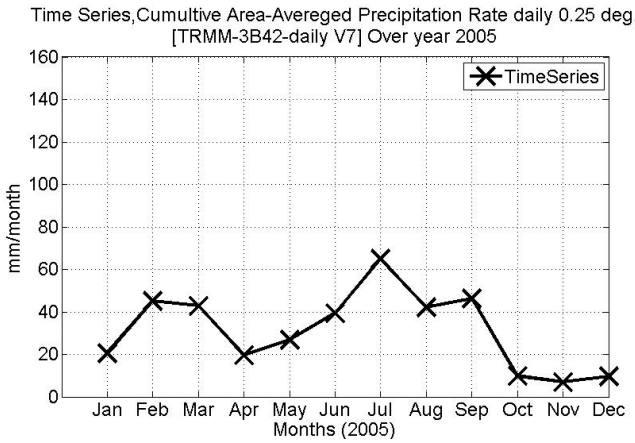
Year 2004

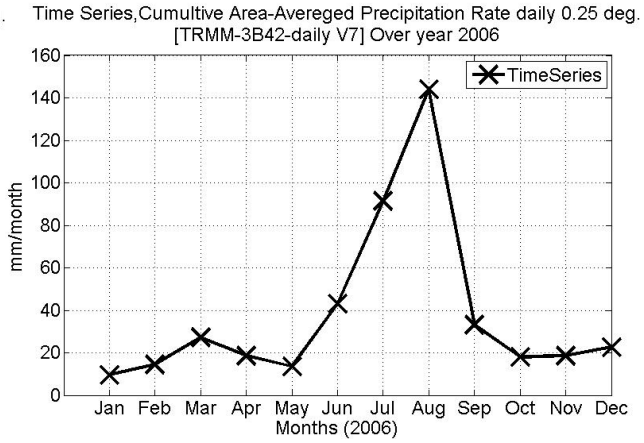


In the year 2003, the cumulative annual rainfall was 452mm, in which monsoon season contributed about 293mm, whereas highest amount of rainfall was recorded in the month of July that was 153mm.

In the year 2004, the cumulative annual rainfall was 300.7mm, in which monsoon season contributed about 191.2mm, whereas highest amount of rainfall was recorded in the month of August that was 71.6mm.

Year 2005 **Year 2006**

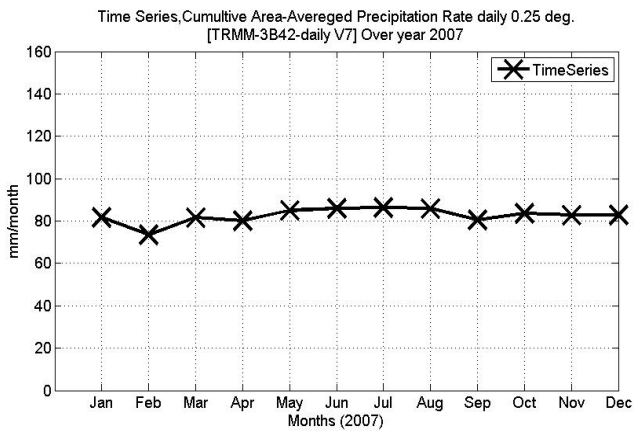




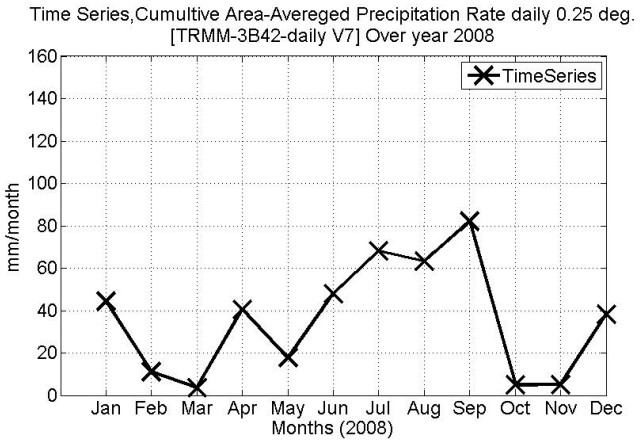
In this year 2005, the cumulative annual rainfall was 374mm, in which monsoon season contributed about 192.7mm, whereas highest amount of rainfall was recorded in the month of July that was 64.9mm.

In the year 2006, the cumulative annual rainfall was 454.6mm, in which monsoon season contributed about 311.9mm, whereas highest amount of rainfall was recorded in the month of August that was 144mm.

Year 2007



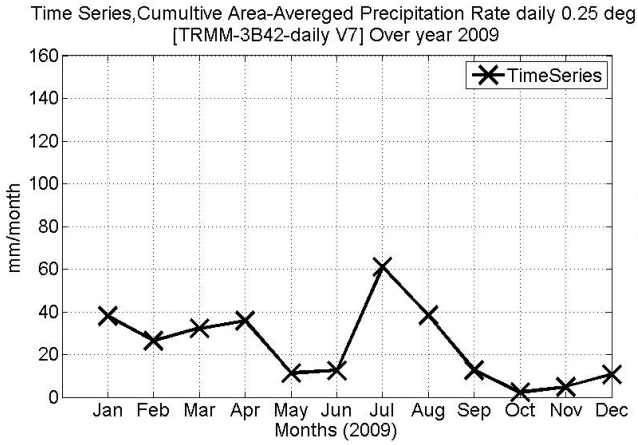
Year 2008



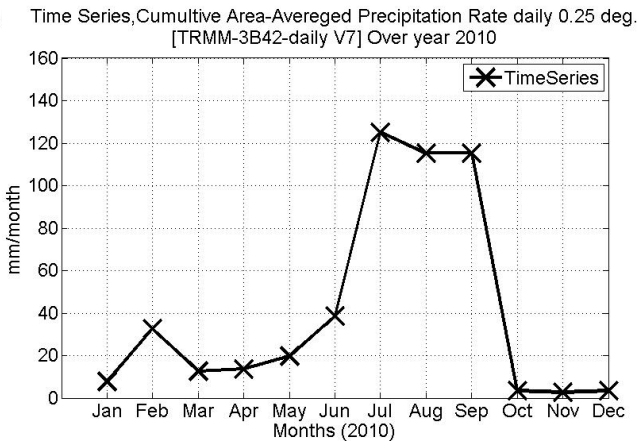
In the year 2007, the cumulative annual rainfall was 989.6mm, in which precipitation occurred throughout the year whereas highest amount of rainfall was recorded in the month of July that was 86.35mm.

In the year 2008, the cumulative annual rainfall was 427.5mm, in which monsoon season contributed about 261.7mm, whereas highest amount of rainfall was recorded in the month of September that was 82.2mm.

Year 2009



Year 2010



In the year 2009, the cumulative annual rainfall was 286.2mm, in which monsoon season contributed about 124.6mm,