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Projection of Changes in Monthly Climatic Variability at Local Level in India as Inferred from Simulated Daily Data by Hadley Center Regional Climate Model Version 2.0

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Abstract- This study attempts to project the changes in monthly climatic variability at six locations situated in six different geographical regions of India. Changes in monthly variability in climatic parameters were calculated in terms of ratio of standard deviations from simulated daily data by Hadley Center Regional Climate Model Version 2.0 for present and 2050's climate. Increase in maximum temperature variability for both dry and wet days is most pronounced in the month of May in North, South and West India. In Central India maximum temperature variability for dry and wet days decreases in summer month (except for May) and increases in most of winter month. In North and south India maximum temperature variability for both dry and wet days decreases in most of the summer month (except for May) and increases in most of the winter months. In West India maximum temperature variability for both dry and wet days decreases in most of the month. In East India maximum temperature variability for both dry and wet days decreases in most of the months and in North East India it increases in most of the months. Minimum temperature variability in North India decreases in most of the months. In South India minimum temperature variability increases in May June July, October, November and December. In West and Central India minimum temperature variability increases in most of the months. In East India minimum temperature variability increases from January to April and then increases afterwards up to December. In North East India minimum temperature variability increases in most of the months. Number of rainy days in North and South, West and Central India decreases in most of the months whereas it increases in most of the month in East India. In North East India number of rainy decreases in most of the months. Rainfall intensity increases in all the geographic regions of India for most of the months. However decrease in some of the months has also been simulated.

Index Terms- Local; Climate; Variability; Regional, Wet, Dry,

I. INTRODUCTION

In the last decade, an overwhelming consensus has emerged among scientists that the world has entered an era of rapid global climate change, much of which is attributable to green house gas (GHG) emissions from human activity. The exact nature and degree of these changes for any given region will be difficult to predict. Assuming no emission control policies, the Intergovernmental Panel of Climate Change (IPCC) predicted that average global surface temperatures will increase by 2.8ºC on average during this century, with best-guess increases ranging from 1.8 and 4.0ºC (IPCC 2007a). Global warming would alter natural climate and environmental systems in many ways, leading to an increased frequency of extreme weather events, rising sea levels, a reversal of ocean currents, and changes in precipitation patterns. These changes could impact social-economic activities, with serious implications for the well being of humans long into the future. Reliable projection of climate change due to radiative forcing of greenhouse gases are therefore essential requirement for impact studies. There have been several studies in the past on projection of climate change at different spatial and temporal resolution in different part of world. To date, most regional climate change information has been based on the use of coupled Atmosphere-Ocean General circulation models (AOGCMs) enabled by the World Climate Research Programme (WCRP) during the past 30. They have also provided valuable information on climate change at the global to sub-continental scale (IPCC, 2007). Although we have seen significant improvements in these models, especially in the past decade, due to better representation of atmospheric and Earth surface processes and enhanced computational capabilities, the horizontal resolution of most present-day AOGCMs is still of the order of a few hundred kilometers (Meehl et al., 2007). This prevents them from capturing the effects of local forcings (e.g. complex topography and land-surface characteristics) which modulate the climate signal at fine scale.

Rapid global climate change is expected to impact agriculture by causing shifts in temperature, precipitation, soil quality, pest regimes, and seasonal growth patterns. Many ecosystem models used to assess impact of climate change require climate projection at a very fine resolution or local level and at daily and sub daily temporal resolution. Providing climate change information at the regional to local is therefore necessary for realistic impact assessment. Recent advancement in regional climate modeling technology have made it possible to simulate the changes in climatic mean and variability for base climate as well as for enhanced CO_2 conditions at a very fine resolution or local level (Wood et al., 2004; Diffenbaugh et al., 2005; Mearns et al., 2009; Giorgi et al., 2009; Roy et al. 2011; Mearns et al. 2012; Dominguez et al. , 2012; Sobolowski and Pavelsky 2012;

Li et al. ,2012). Aaccurate projection of extreme events, and climate variability are of fundamental importance to users of climate information with respect to the regional and local impacts of climate variability and change. In India such studies are at nascent stage and rarely reported. Recent studies by Tripathi and Singh 2013 has shown that simulated climate do not replicate the features of observed climatology and therefore can not be applied directly into impact assessment models for impact studies. However, Carter et al., 1994 have shown changes from the present (control) to future (anomaly) climate are more realistic than the prediction of present or future climate alone. Present study therefore attempt to derive the changes in variability of climatic parameter at local level as inferred from the simulated daily climate by Hadley Center Regional Climate Model Version 2.0. Detail methodology adopted in the study is discussed in the following section.

II. Methodology

2.1. Simulated Base Line and Future Climatic Data

Location specific daily climate data for base Climate (1990's) and doubled CO_2 (2050's) climate are derived from the data generated by a state of the art Hadley Center Regional Climate Model Version 2 (HadRM2) in a numerical experiment with transient increase in greenhouse gases at fine resolution of 0.44° X 0.44° latitude by longitude (Bhaskaran et al., 1996). CO_2 is held constant in the control simulation at Base day values. The daily weather data on maximum and minimum temperature, rainfall and solar radiation for Six Locations scattered in six different regions of India were obtained by taking weighted mean of values of respective weather parameter at four nearest grid points surrounding these location.

2.2. Deriving Changes in Climate Variability from Present to 2050's Climate

Changes in monthly variability in climatic parameters were calculated in terms of ratio of standard deviations from simulated daily data for present (1990's) to future (2050's) climate. In most of the agricultural implications the maximum temperature variance is dependent on the wet and dry days separately. The Fractional changes in standard deviation of monthly maximum temperature (for wet and dry days separately) minimum temperature, number of wet days and rainfall intensity (rain per wet days) were calculated for Six locations in India. Our results on these aspects are discussed in the following section.

III. Results and Discussions

3.1. Changes in Maximum Temperature Variability

Changes in monthly maximum temperature variability from present to 2050's climate for six locations in different geographical regions of India are have been shown in Figure1. At Ludhiana (North India) and Coimbatore (South India) the maximum temperature variability for both dry and wet days decreases in most of the summer month (except for May) and increases in most of the winter months. At Anand (West India) maximum temperature variability for both dry and wet days decreases in all months except for the month of May, August and October when it increases at Anand in West India. At Powerkheda (Central India) maximum temperature variability for dry and wet days decreases in summer month (except for May) and increases in most of winter month. Increase in maximum temperature variability for both dry and wet days is most pronounced in the month of May at Ludhiana (North India), Coimbatore (South India) and Anand (West India). At Powerkheda (Central India) maximum temperature variability for wet days increases in May but for dry days it decreases in the month of May. At Pusa (East India) maximum temperature variability for both dry and wet days decreases in most of the months except for January, February, October and November when it decreases in East India. At Jorhat (North East India) maximum temperature variability increases in all months except for February, May, June and December when it decreases in North East India.

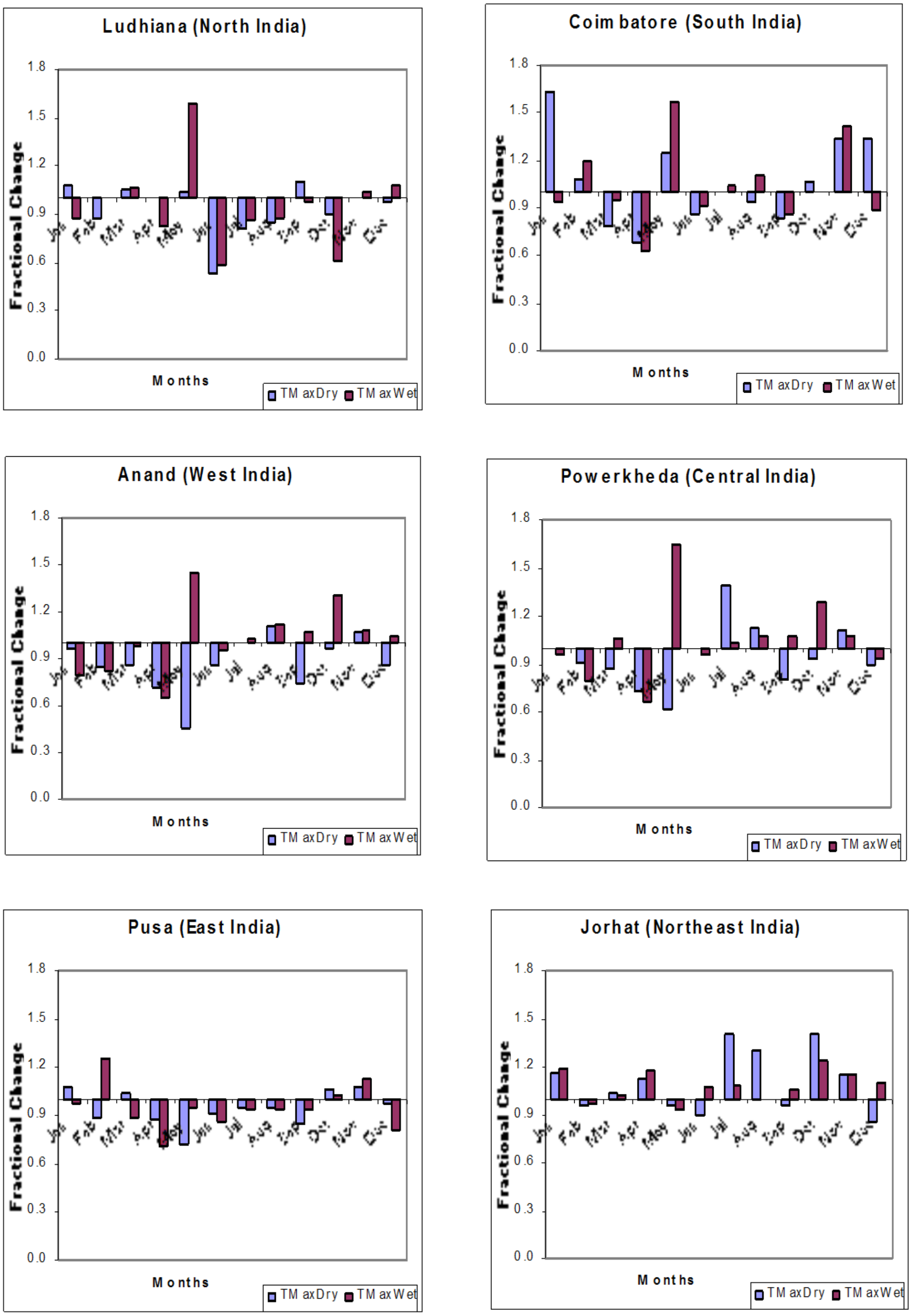

Figure 1: Fractional Change in Standard Deviations of Monthly Maximum Temperature (Separately for Wet and Dry Days) from Present (1990's) to 2050's Climate at Different Locations of India

3.2. Changes in Minimum Temperature Variability

The fractional changes in standard deviation of monthly maximum temperature from present to 2050’s climate is shown in Figure 2.

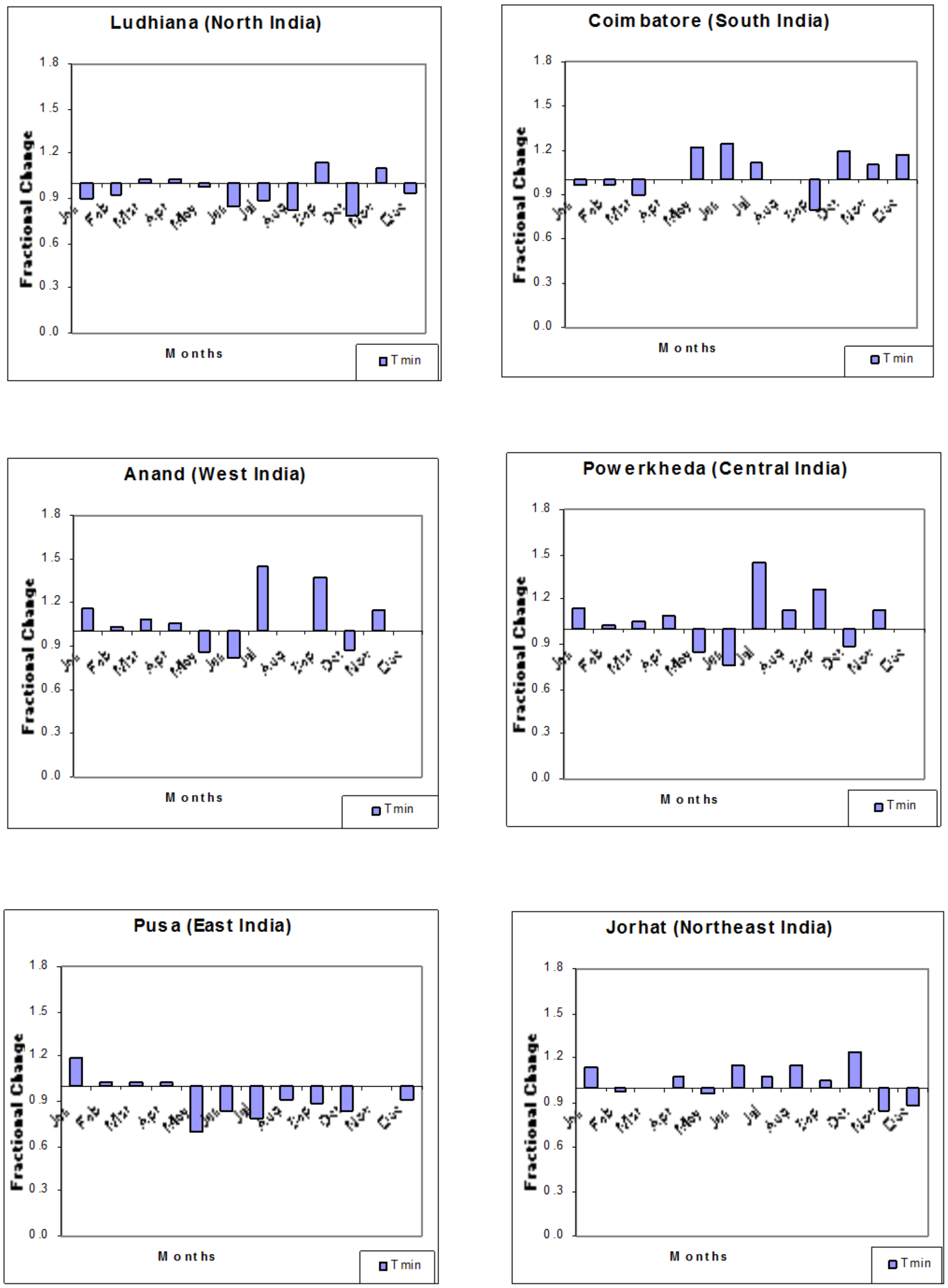

Figure 2: Fractional Change in Standard Deviations of Monthly Minimum Temperature from Present (1990’s) to 2050’s Climate at Different Locations of India

Minimum temperature variability at Ludhiana (North India) decreases in most of the months except for March, April and September when it increases marginally at Ludhiana (North India). At Coimbatore (South India) minimum temperature variability decreases in January, February, March and September where as it increases in May June July, October, November and December. In other months it does not change significantly at Coimbatore in South India. At Anand (West India) minimum temperature variability increases in January, February, March, April, July, September and November where as it decreases marginally in other months. At Powerkheda (Central India) a more or less similar trend in change in minimum temperature variability is projected as in the case of Anand (West India). At Pusa (East India) minimum temperature variability increases from January to April and then increases afterwards up to December. At Jorhat (North East India) minimum temperature variability decreases in February, May, November and December whereas it increases in other months.

Fig 3 shows the fractional changes in the no of rainy days from present to future

3.3. Changes in No. of Rainy Days

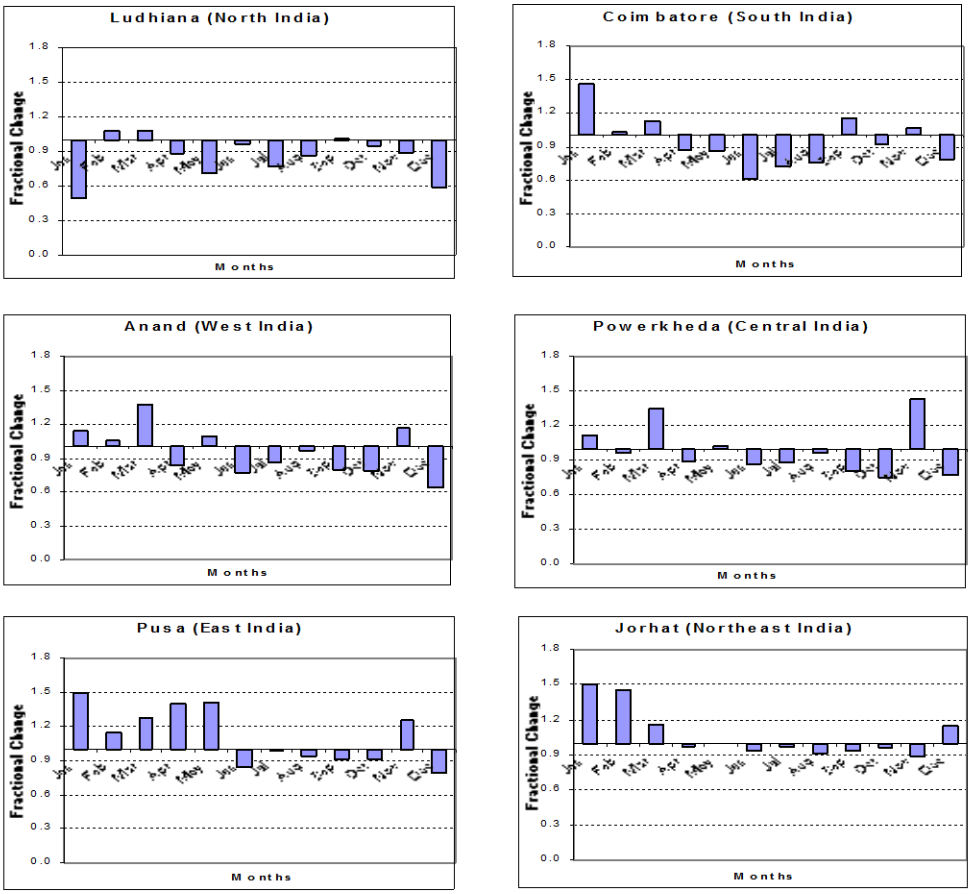

Figure 3: Fractional Chang in Monthly Means of Rainy Days from Present (1990's) to 2050's Climate at Different Locations in India

climate for the six locations in different geographic regions of India. Number of rainy days at Ludhiana (North India) decreases in most of the months except for February, March and September when it increases marginally at Ludhiana (North India). At Coimbatore (South India) number of rainy days decreases in most of the months except for January, February, March and September when it increases marginally in South India. At Anand (West India) number of rainy days decreases in most of the months except for January, February, March, May and November when it increases in West India. At Powerkheda (Central India) number of rainy days decreases in most of the months except for January, March and November when it increases at Powerkheda in Central India. At Pusa (East India) number of rainy days increases in the month of January, February, March, April, May and November where as it decreases in other months. At Jorhat (North East India) number of rainy decreases in most of the months except for the months of January, February, March and December when it decreases at Jorhat in North East India.

3.4. Changes in Rain Intensity (Rain Per Wet Days)

Fig 4. Shows the fractional change in the rainfall intensity from present to future climate for the six locations in different geographic regions of India. Rainfall intensity increases in all the geographic regions of India for most of the months. However decrease for some of the months has also been simulated. At Ludhiana (North India) rainfall intensity increases in February, March, May, August, September and November where as it decreases in all other months. At Coimbatore (South India) rainfall intensity increases in all months except for February, April and October when it decreases at Coimbatore in South India. At Anand (West India) rainfall intensity increases in all months except for January, April and December when it decreases at Anand West India. At Powerkheda (Central India) rainfall intensity increases in all months except for January, April, June December when it decreases at Powerkheda in Central India. At Pusa (East India) rainfall intensity increases in all months except for December when it decreases at Pusa (East

India). At Jorhat (North East India) rainfall intensity increases in all months.

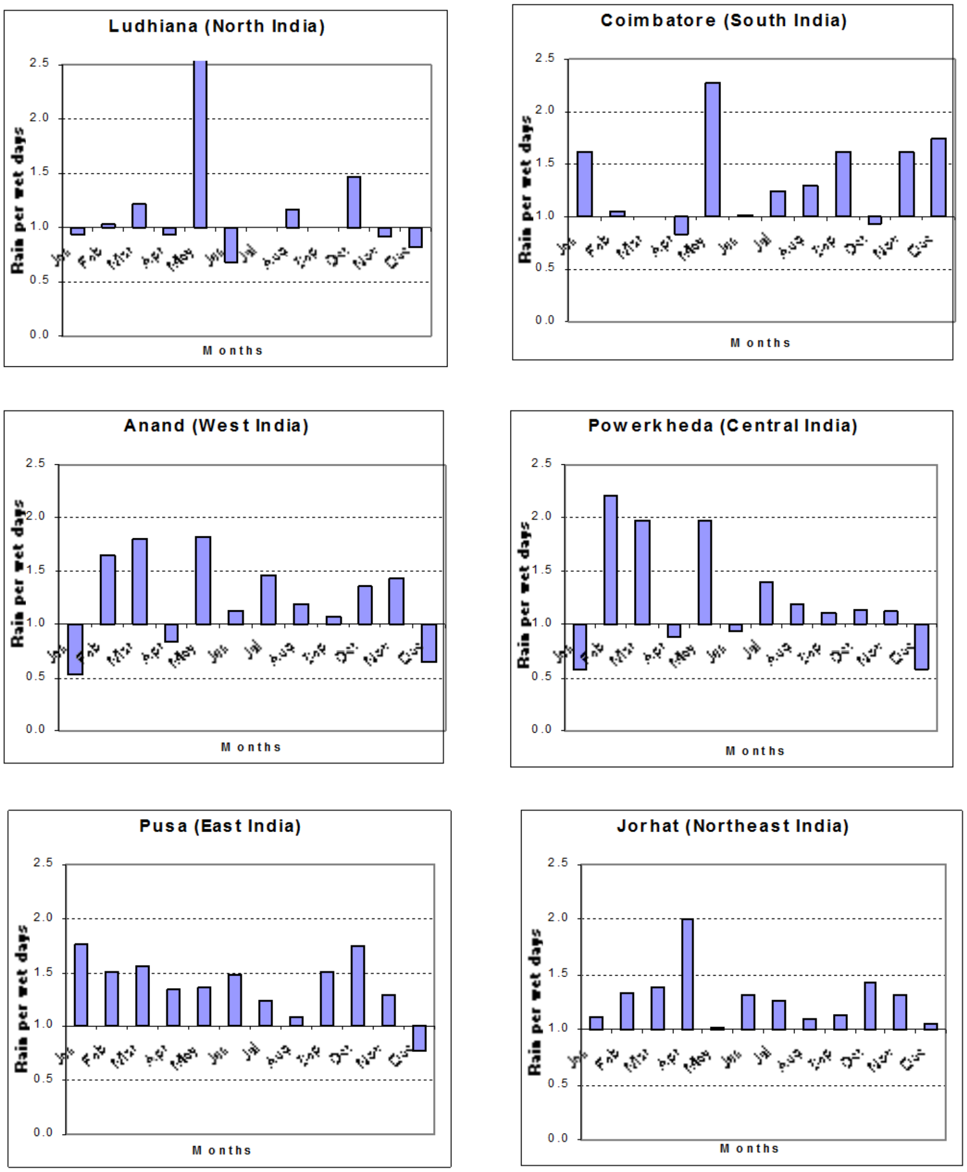

Figure 4: Fractional Changes in Rainfall Intensity (Rain per Wet Days) from Present (1990's) to 2050's Climate at Different Locations of India

IV. Conclusions

Changes in monthly climatic variability as inferred from simulated daily data by Hadley Center regional Climate Model Version 2.0 for present and 2050's climate has region specific trend in India. Increase in maximum temperature variability for both dry and wet days is most pronounced in the month of May in North, South and West India. In Central India maximum temperature variability for dry and wet days decreases in summer month (except for May) and increases in most of winter month. In North and South and West India maximum temperature variability for both dry and wet days decreases in most of the summer month (except for May) and increases in most of the winter months. In East India maximum temperature variability for both dry and wet days decreases in most of the months and in North East India maximum temperature variability increases in most of the months. Minimum temperature variability in North India decreases in most of the months. In South India minimum temperature variability decreases in January, February, March and September where as it increases in May June July, October, November and December. In West India minimum temperature variability increases in most of the months. In Central India a more or less similar trend in change in minimum temperature variability is observed as in the case of West India. In East India minimum temperature variability increases from January to April and then increases afterwards up to December. In North East India minimum temperature variability increases in most of the months. Number of rainy days in North and South, west and central India decreases in most of the months. In East India number of rainy days increases in the month of January, February, March, April, May and November where as it decreases in other months. In North East India number of rainy decreases in most of the months except for the months of January, February, March and December. Rainfall intensity increases in all the geographic regions of India for most of the months. However decrease for some of the months has also been simulated.

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