

# VARIATIONS IN THE REGIONAL AND SEASONAL WARMING IN INDIA

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## Introducing the Climate Change:

The most important concern for the current generation is the unwanted changes occurring in the earth-atmosphere-ocean system due to some of our activities. The whole issue of man-made climate change can be looked into from two broad perspectives: emissions of Greenhouse Gases (GHGs) and damage to the environment.



The global warming occurs due to the excessive release of GHGs into the atmosphere. Primarily, Carbon Dioxide (CO<sub>2</sub>) is the culprit which is released in excess due to the use of fossil fuels as the main source of energy for industrial growth. This is a global issue. The country which emits large amount of CO<sub>2</sub> due to excessive use of energy is not the only sufferer. Once the GHGs enter the atmosphere, they do not follow any geographical boundary of the nations. They become the cause of worry for the entire globe. Reduction of GHG emissions is closely linked to national economy and hence a matter of global politics. This problem can only be handled with global negotiations and most importantly through the invention of alternate sources of energy and clean technology. The global agencies concerned with climate change have to make heavy investments on climate change sector as in any other technological marvels such as the space technology.

Climate also changes due to over exploitation of the nature. Pressure on the climate system due to the land overuse, deforestation, tapping of vulnerable water sources, destruction of the ecosystems, environmental pollutions etc. also causes changes on regional sectors in the short time scale and on the whole global climate in the long run. This second category of adverse impacts on the climate system is more dangerous, since the recovery procedure may take much more time. Also the corrective majors for the environmental damages made so far are more complicated than those for the GHG abatement. Issues related to environmental degradation are local and for their remedies the direct involvement of the natives is very essential. Large scale mass movements are necessary to tackle this second cause of climate change. No Government alone can solve the problem by formulating laws alone. These arguments are more applicable to India than to any other country in the world because of the wide diversity in the socio-economic bases in our country.

## **Diversities in Indian Weather and Climate:**

Some of the important weather related events affecting India are heat waves, cold waves, land slides, prolonged fog, snowfall, intense rain events, floods, droughts, and cyclonic storms. Peoples' perception is in favour of increase in the frequency of occurrence of these weather phenomena. It is very essential to examine the observed meteorological parameters very carefully in order to categorize those as scientific evidences. The most important parameter which directly indicates the global warming is the increase of the mean surface air temperature of the globe by about 0.70C in the last century. India is also experiencing the rise in its surface air temperature. However, due to the heterogeneity in the topography and climatic conditions in India, the rise in the surface temperature need not be same in all its regions. The climate of the whole of peninsula is Tropical Savana and that of the West Coast is basically Tropical Rain Forest. On the other hand, the climate of the northern part of India is Warm with Dry winds and that of western India is Dry Steppe. Due to the large extensions of India both along north-south and west-east, different parts of the country experience different ranges of temperature and rainfall even during the same month or season. The mountains in the country add to the wide variation in the climate of places located in the same latitudinal and longitudinal belts. The ecosystems in the coastal belts, the rich biodiversity in the mountainous regions, and the tropical rain forests form the life line of the climate of India. In addition to this geographical inhomogeneity, there is the issue of large seasonal variations in weather and climate. During the four months from June to September, the southwest summer monsoon is predominant and during October to December, the northeast winter monsoon controls the weather of the country in general. Farmers mostly depend on the performance of monsoon rain and the others living in rural tribal areas look for the forests and ecosystems for their daily needs. The socio-economic conditions of the Indian populace added to the above scientific issues make the study of the spatial and temporal variations in the rise in temperature in India a major problem to understand in details so as to find appropriate adaptation strategies.

## **Source of Data Used in this Study:**

Observed monthly mean, maximum and minimum temperatures for the period 1901-2003 used in this study are based on the measurements made by the India Meteorological Department (IMD) and available in their data archive. In recent studies by Dash et al. (2007) and Dash and Hunt (2007) these data have been extensively analyzed to examine the changes occurred in the last century. The anomalies in each category of temperature (such as mean, maximum and minimum) have been calculated first by taking the average of 388 available station observations over India spreading over all the 103 years of study and then deducting the 103 years mean values from the mean value of each year. These data are obtained from [www.tropmet.res.in](http://www.tropmet.res.in) of the Indian Institute of Tropical Meteorology (IITM) and [www.ncdc.noaa](http://www.ncdc.noaa) of the National Climatic Data Centre (NCDC).

## **Rise in the Surface Air Temperatures in India:**

Examination of the trends in the annual temperature anomalies averaged over India during the last century indicate that the annual mean temperature over India has increased by about 0.7oC and the maximum temperature has increased by about 0.8oC. On the other hand the annual minimum temperature over India does not show any appreciable enhancement. It may be noted here that the surface air temperature undergoes changes as the sun's position with respect to the earth changes in a day. Normally the surface temperature is the least in the early morning and it attains its maximum value sometimes in the afternoon. These values are recorded by the minimum temperature and maximum temperature thermometers. The day time mean temperature is obtained by taking the average of all the measurements made at a place during the day. Similarly the night time mean temperature can also be found.

### **Temperature Changes in Different Seasons:**

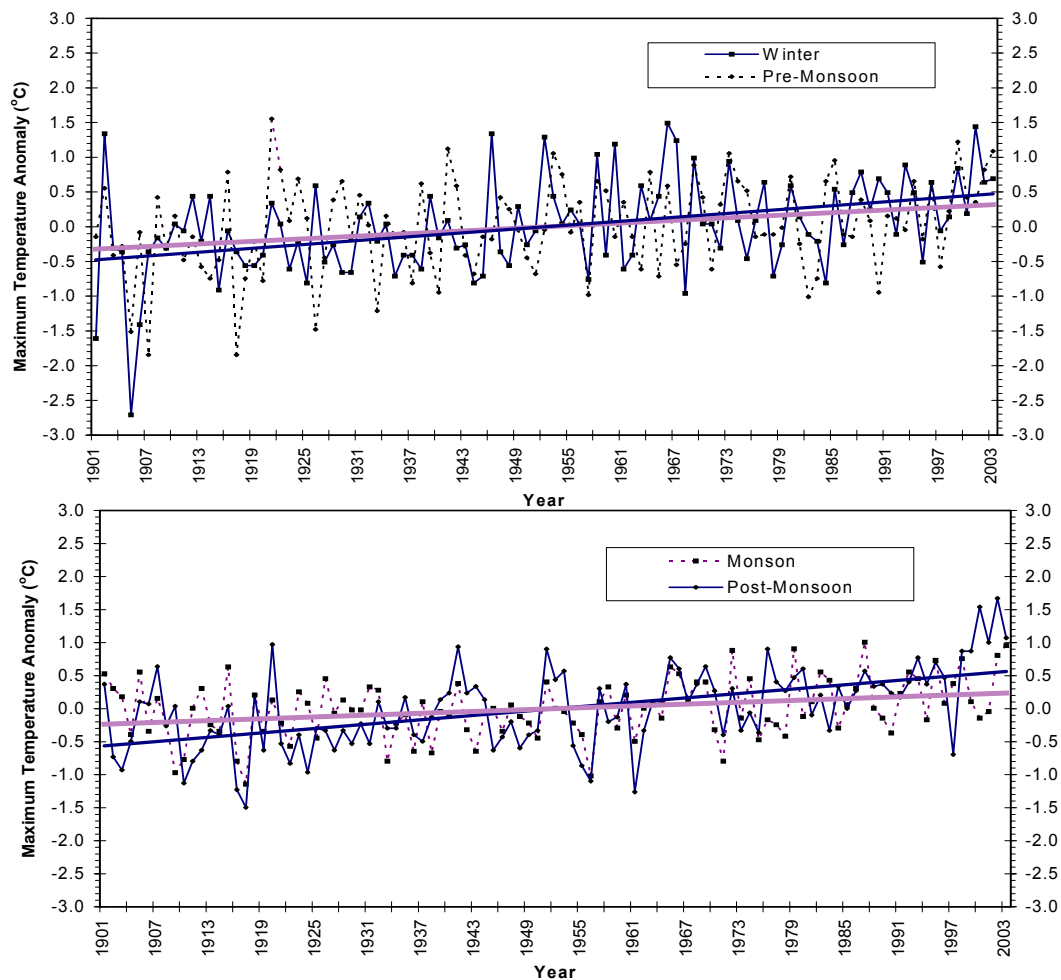
In order to examine the temperature trend over India during different seasons, in this study, the entire year has been divided into four seasons namely, winter (January and February), pre-monsoon (March to May), monsoon (June to September) and post-monsoon (October to December). Analysis of temperature fields reveals that the winter-time increase in the mean temperature over India is about 1.0oC whereas during post-monsoon months there has been a rise of about 1.1oC in the last century. During pre-monsoon and monsoon months the mean temperature has increased by about 0.3 and 0.4oC respectively. It may be noted that the temperature rise is the highest in post-monsoon months followed by winter. Also, during winter and post-monsoon months the temperature enhancement is more than double of that in pre-monsoon and monsoon months. Such large difference in the temperature rise between the two halves of the year may lead to changes in spatial position of heating sources over the Indian region and adjoining area and hence in the atmospheric circulation patterns. The time series of maximum temperature over India during the four seasons in the last century are shown in Figure 1. The increase in the maximum temperature during winter is also 1.0oC and that in post-monsoon months is 1.1oC. Similar increase during pre-monsoon and monsoon are about 0.6 and 0.4oC respectively. On the other hand, the minimum temperatures during winter and pre-monsoon months have negligible changes in the last century. The minimum temperature during summer monsoon months has decreased by about 0.2oC and that during post-monsoon months of October to December has increased by about 0.6 oC.

### **Rise in Temperature in Different Regions in India:**

The impact of climate change may differ from one region to the other, especially for a geographically complex terrain in India. Hence following [www.tropmet.res.in](http://www.tropmet.res.in) our country has been divided into seven zones as shown in Figure 2 in order to examine the changes in maximum and minimum temperatures over these regions. The seven zones are northwest, western Himalaya, north central, northeast, interior peninsula, east coast and west coast. Figures 3 (a) and (b) indicate that the maximum temperature has been increasing during the last century over all the regions of India. However, the increase in magnitude is not the same everywhere. West coast

shows maximum increase in the maximum temperature by about 1.2oC. Next to the west coast, maximum temperature has increased by 1oC in the northeast, 0.9oC in the western Himalaya, 0.8oC in

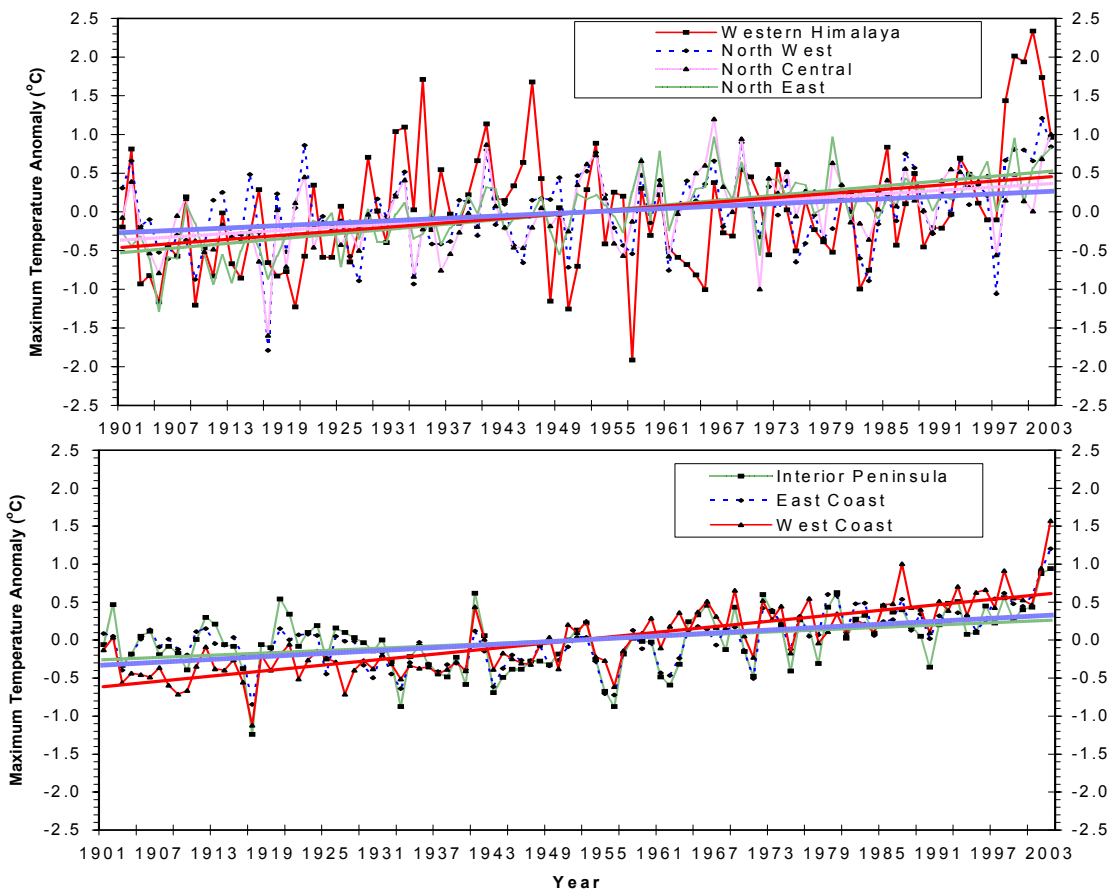
the north central, 0.6oC in the northwest, 0.6oC in the east coast and by the least amount of 0.5oC in the interior peninsula. Similarly, Figure 4 (a) and (b) show the changes in the minimum temperature over the seven regions of India in the last century. Unlike the maximum temperature, the minimum temperature in the four northern regions of India show some peculiar changes. Figure 4(a) shows that there is sharp decrease in the minimum temperature by 1.9oC in the western Himalaya, 1.4oC in the north east, 1.1oC in the north central and 0.7oC in the northwest India during 1955 to 1972 and then equally sharp rise over the past 3-4 decades. The minimum temperatures in southern regions such as interior peninsula, east coast and west coast show almost equal enhancement (Figure 4 b) during the last century. Trend lines indicate that interior peninsula shows maximum increase in the minimum temperature by about 0.5oC. Next to the interior peninsula, minimum temperature increased by 0.4oC in the east coast and by the least amount of 0.2oC in the west coast of India. Comparison of Figures 4 (a) and (b) indicates that the change in minimum temperatures in the northern and southern regions of India are almost in opposite phases although the magnitudes of fluctuation in the northern India are large during last 4-5 decades.



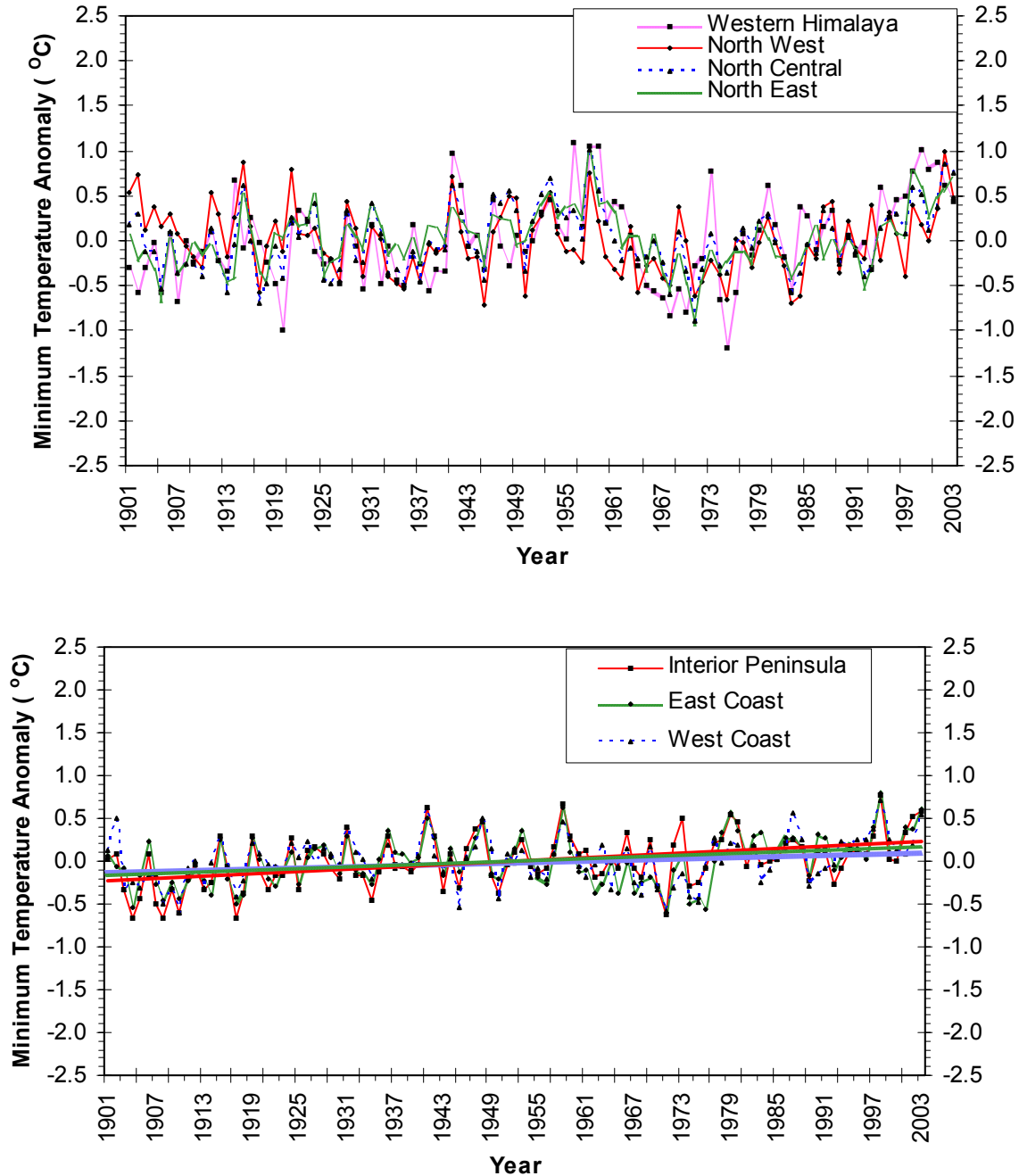
**Figure 1 (a) & (b):** Time series of anomalies in the maximum temperatures during (a) winter and pre-monsoon and (b) monsoon and post-monsoon

**Possible Consequences of Temperature Rise:**

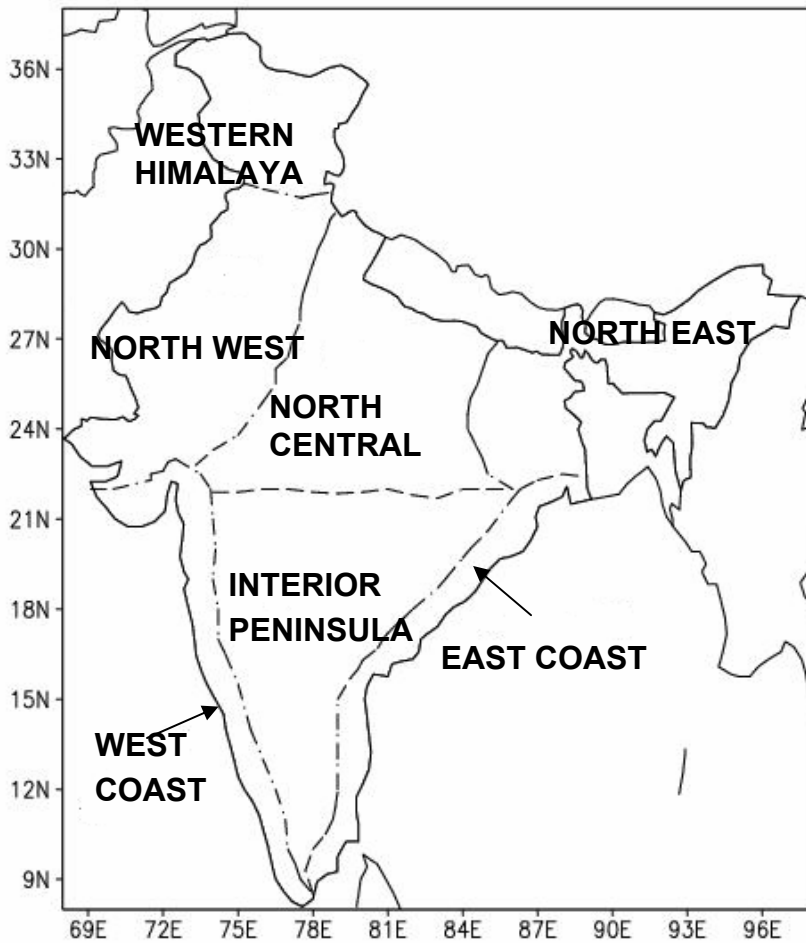
The regional and seasonal discrepancies in the rise in surface air temperature has large bearing on agriculture, water availability and power distribution besides on human comforts, health and effective working hours. For effective policy formulation and management, each region has to be considered separately. In addition, the difference in the change in inter-seasonal temperatures will have profound impact on the cropping pattern and hence a challenge to the farmers and agricultural scientists. Occurrences of some diseases, whether of human beings, animals or plants are very sensitive to small perturbations in the delicate seasonal temperature balance. Since temperature is the most important parameter controlling the overall weather and climate of a place, once it undergoes non-uniform temporal and spatial changes, the consequences are the likely intensification of the general impacts of climate change. The spatial and temporal changes in temperature are also accelerated by the non-sustainable exploitation of natural resources, notably the overuse and misuse of land, deforestation, destruction of the ecosystems, and environmental and coastal pollutions. Issues related to environmental degradation are local and for their remedies, the direct involvement of the local communities is essential. Otherwise the consequences can be particularly serious over a few years within the regions where the over-exploitation occurs. Although the corrective measures for GHG abatement are well understood, measures to decelerate regional environmental damage are more complex.



**Figure 3 (a) and (b):** Time series of anomalies in the maximum temperatures over (a) western Himalaya, northwest India, north central India and northeast India, (b) Interior peninsula, east coast India and west coast India.



**Figure 4 (a) and (b):** Time series of anomalies in the minimum temperatures over (a) western Himalaya, northwest India, north central India and northeast India, (b) Interior peninsula, east coast India and west coast India.



**Figure 2:** Map for seven homogeneous regions of India (source [www.tropmet.res.in](http://www.tropmet.res.in)) used for examining temperature trends.

**This article is based on the following scientific papers:**

1. Dash, S. K. and J. C. R. Hunt, (2007), Variability of climate change in India, *Current Science*, 93(6), 782-788

2. Dash, S. K., R. K. Jenamani, S. R. Kalsi and S. K. Panda (2007), Some evidence of climate change in twentieth-century India, *Climatic change*, 85, 299-321.

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