Indian Meteorological Society, Chennai Chapter

Newsletter Vol. 12, Issue Nos.1 and 2, May 2010

Contents

EDITORIAL

Dear member,

I have great pleasure in releasing Volume 12, combining Issue Nos. 1and 2 of Breeze despite the release getting delayed by more than six months. However, in keeping with its tradition, Indian Meteorological Society (IMS) Chennai Chapter has been very active in conducting various seminars, symposia and other scientific activities.

I have summarised all the activities of the chapter and planned future activities separately. The next issue of Breeze Vol. 13- issue 1 is proposed to be released by the end of July 2010. I request all the members to offer their continued support and send their articles limited to 3 to 5 pages which may please be sent to the Editor through e-mail to ims.chennai6@gmail.com or asokan.ramasamy@gmail.com by 30 June 2010.

I thank the Editorial Members of the Board for their help in the preparation of this volume of BREEZE.

Finally, the success of any chapter mainly depends on the members. Their collective involvement and enthusiasm is the driving force. I take this opportunity to thank all the members for their support in bringing out this issue. We still would like to enrol more members to spread the science of meteorology amongst various sections of the society. In this connection, we wish to increase our membership. I request you to inform your friends and colleagues to become members of IMS, Chennai Chapter.

With best wishes
R. Asokan
Editor
May 2010 Chennai

Those who wish to become members of IMS Chennai Chapter may please mail to

E-mail : ims.chennai6@gmail.com

Membership details of IMS-Chennai Chapter as on May 2010
Life Members: 111 Ordinary Members: 61 Total : 172

Disclaimer : The Editor and IMS Chennai Chapter are not responsible for the views expressed by the authors.

Report on activities of Indian Meteorological Society (IMS) Chennai Chapter (since the last issue of Breeze)

1. IMS Chennai Chapter conducted a scientific talk on "Total Solar Eclipse on 22nd July 2009 over India" by Dr. P. Iyamperumal, Science City, on 21st July 2009 at Conference Hall No. 1, Regional Meteorological Centre(RMC), Chennai.

2. The two-days seminar on "Recent advances in agrometeorology and space technology for sustainable food security in Tamil Nadu" was managed by a Scientific Advisory Committee (SAC) and a Scientific and Organising Committee (SOC) headed respectively by Dr Ajit Tyagi, Director General Meteorology (DGM), IMD, New Delhi and Dr. Y. E. A. Raj, Deputy Director General Meteorology (DDGM). There were several sub-committees of the organising committee to attend to various tasks such as scientific programme, fund raising, reception, registration, hall arrangements, press and publicity, printing, accommodation and transport.

The SAC activities were coordinated through email communication. The SOC met twice on 27th July 2009 and 15th September 2009 prior to the seminar and the sub-committees met once. A team of nearly 10-15 support staff assisted the organising committees. The seminar was attended by 57 delegates. The participants hailed from various scientific departments, research institutes, Krishi Vigyan Kendras and Universities spread over Tamil Nadu, as well as two participants from Thailand. No registration fee was collected for participation in the seminar.

The inaugural function of the seminar was held at 1000 hrs on 08th October 2009 at the Conference hall No 1, Regional Meteorological Centre. Dr. Ajit Tyagi, DGM, IMD, New Delhi was the Chief Guest and Shri S. Kosalaraman, IAS, Commissioner of Agriculture, Tamil Nadu state government was the guest of honour for the inaugural function The inaugural function was attended by nearly 150 participants including delegates of the seminar, special invitees, dignitaries etc and was covered by the media.

In all, 9 invited talks were delivered during the sessions. The Abstract Review Committee had received and reviewed abstracts of 52 research papers, out which 45 papers were accepted for oral presentations in the seminar. During the course of the seminar, 21 out of the 45 papers were orally presented. There were stimulating discussions on the papers. The scientific programme and the book of extended abstracts were distributed to all the delegates. In the fifth technical session panel discussion was held on the topic "Food security and the science of meteorology".

3. On 25th February 2010 A/N, a half-day seminar on **"Monsoon 2009"** was conducted as part of celebration of National Science Day and was arranged by Indian Meteorological Society, Chennai Chapter, jointly with Regional Meteorological Centre, Chennai, in the Conference Hall I at Regional Meteorological Centre, Chennai.

The following talks were delivered.

1435 - 1450 : Onset, withdrawal phase and Global features of NE monsoon 2009 by Dr. Y. E. A. Raj, DDGM, RMC, Chennai
1450 - 1505 : Performance of monsoon 2009 by Dr. S. R. Ramanan, Director, RMC Chennai
1505 -1520 : Radar hydrology by Dr. R. Suresh, Scientist E, AMO, Chennai
1540 – 1600 : Water scenario at Chennai and monsoon 2009 by Shri A. L. Radhakrishnan, Superintending Engineer, Metrowater
1600- 1620 : Disaster associated with northeast monsoon 2009 (land slide in Nilgiris district during 2009) by Dr. P. Ganapathy, Assistant Professor, Vellore Institute of Technology(VIT), Vellore.

The meeting was attended by about 150 participants and the function was covered by both visual and print media. Vote of Thanks was given by Dr. R. Asokan, Director, Secretary, IMS Chennai Chapter.

4. World Meteorological Day (WMD) function was organised by IMS Chennai Chapter jointly with RMC, Chennai on 23rd March 2010 at Regional Meteorological Centre, Chennai. Dr M. Rajeevan, Scientist SG, National Atmospheric Research Laboratory(NARL), Gadanki was the Chief Guest and Dr. N. Jayanthi, ADGM, IMD (Retd.) was the Guest of Honour. On 23rd March 2010 at 1000 hrs IST, the function commenced with the prayer song by Shri Sriram. Dr Y. E. A. Raj, DDGM welcomed the gathering. Dr N. Jayanthi, ADGM (Retd.) gave the Guest of Honour lecture on the theme of this year's WMD. Dr M. Rajeevan gave a lecture on the topic "Climate Change in India". The meeting ended with the vote of thanks by Dr. R. Asokan, Secretary, IMS Chennai Chapter. The function was attended by about 200 persons and well covered by both print and visual media.

5. On 27th April 2010, IMS organised two lectures, one on *"Weather Support for rocket launch at Sriharikota"* by Dr G. V. Rama, Dy. General Manager(Met. facilities), ISRO, Sriharikota and the other on "*Coastal HF Radar network in India"* by Dr. B. K. Jena, Scientist 'E', National

Institute Ocean Technology (NIOT), Chennai. Dr. G.V. Rama was felicitated in the function, on the eve of his retirement from ISRO. Ms. B. Amudha, Joint-Secretary delivered the formal vote of thanks.

Planned activities of the chapter for 2010-11

1. Scientific talk on "High performance computing" during June 2010.
2. Release of Breeze Vol. 13-Issue No.1 during July 2010
3. Quiz programme for students during July 2010
4. Essay writing in English/ Tamil for school students during July 2010
5. Study visit to NARL, Gadanki during August 2010
6. Scientific talk on Alternate Energy during September 2010
7. Release of Breeze Vol. 13 - Issue No.2 during December 2010
8. Scientific talk during November 2010 and January 2011
9. Regional seminar on " Northeast monsoon" during February 2011
10. Annual General Body Meeting, election of new office-bearers during April 2011

(contd….)

OBSERVED CLIMATE CHANGE OVER INDIA*

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The World Meteorological Organization (WMO) was formally established on 23 March 1950. In 1951, in the first WMO Congress, the Commission for Climatology (CCl) was established as one of the eight technical commissions. Climate change first appeared on an agenda in 1960, at the CCl-III. The commission established a working group on climate change and its report was published as a technical note "Climate Change" (WMO Technical Note No. 195) in 1966, which had become an excellent reference. It was WMO, in 1976, issued the first authoritative statement on the accumulation of carbon dioxide in the atmosphere and the potential impacts on climate. This was a key trigger that focused the attention of policy makers to the potential threat of climate change and its impacts for generations to come.

Important activities of WCP on Climate Change

The World Climate Programme (WCP) was established in 1979. Annual Climate Statements on the status of global climate are being prepared since 1994, through the Climate Change Detection project. Open Programme Area Group (OPAG) on Monitoring and analysis of climate variability and change is an important group of WCP. Climate Change Indices are proposed by WCP expert teams which have been used widely in third and fourth reports of the IPCC. Regional capacity building workshops are designed to facilitate the development and exchange of climate indices. WCP is responsible for the establishment of IPCC. Three World Climate Conferences were held by WCP.

In 1987, the tenth Congress of the WMO recognized the need for objective, balanced, and internationally coordinated scientific assessment climate change. In 1988, the WMO Executive Council with support from UNEP established the Intergovernmental Panel on Climate Change (IPCC). First IPCC Assessment report was published in August 1990 and the Fifth Assessment Report (AR5) is due in 2013. Human and natural drivers of climate change are the concentrations of carbon dioxide, methane and nitrous oxide. The amounts have far-exceeded the pre-industrial values, increasing markedly after 1750 due to human activities. Relatively little variation was observed in the pre-industrial era.

* *Lecture delivered at Regional Meteorological Centre, Chennai on 23 March 2010 as part of World Meteorological Day celebrations.*

Observed Climate Change over India

A network of stations in India (as in Fig. 1) for which data is available for the period 1901 – 2008 was identified to study the temperature trends over India. It was found that over India, temperatures are increasing. Most of the warming over India is due to increase in Maximum Temperatures. However, during the recent years, minimum temperatures showed some rapid warming suggesting an influence of increase in greenhouse gases. Along with the increase in annual temperatures, frequency of heat waves over central India and NW India also has increased. Time series of frequency of heat wave days over central and NW India indicates that the frequency has increased significantly over the period 1969-2005. The time series of frequency of days with maximum temperatures more than 45 C has also increased significantly.

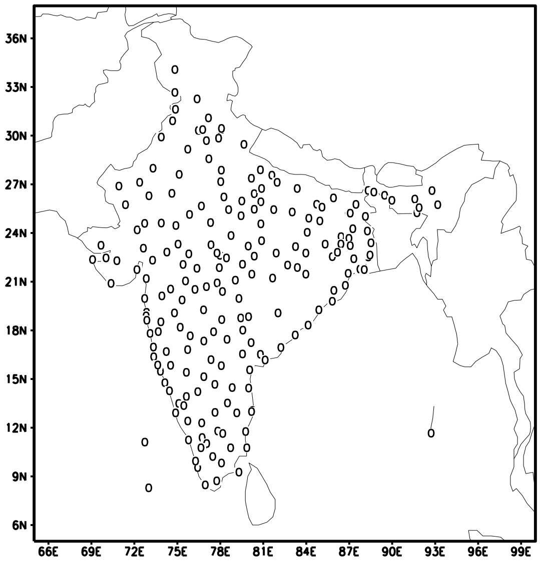

Fig. 1 Network of stations in India identified for the study

All-India monsoon season rainfall time series(Fig.3) shows NO long term trends. It is marked by large year to year variations. There is a tendency of occurrence of more droughts in some epochs (for example, 1901-1930, 1961-1990). Trends of annual rainfall using 104 years of high resolution (100 km) gridded rainfall data show significant reduction of annual rainfall over east central India and Kerala. Analysis of mean cloud amount shows significant decreasing trends of total cloud cover over the east central India. Monsoon Depressions are important synoptic systems during the monsoon season, which contribute to widespread rainfall over the country. The frequency of monsoon depressions shows substantial decrease during the 1980s and 1990s. This decrease was seen in spite of an increase in Sea Surface Temperature over Bay of Bengal, but possibly due to other dynamical parameters. There is an increase intense rainfall events like that of the Mumbai deluge of 26 July 2005.

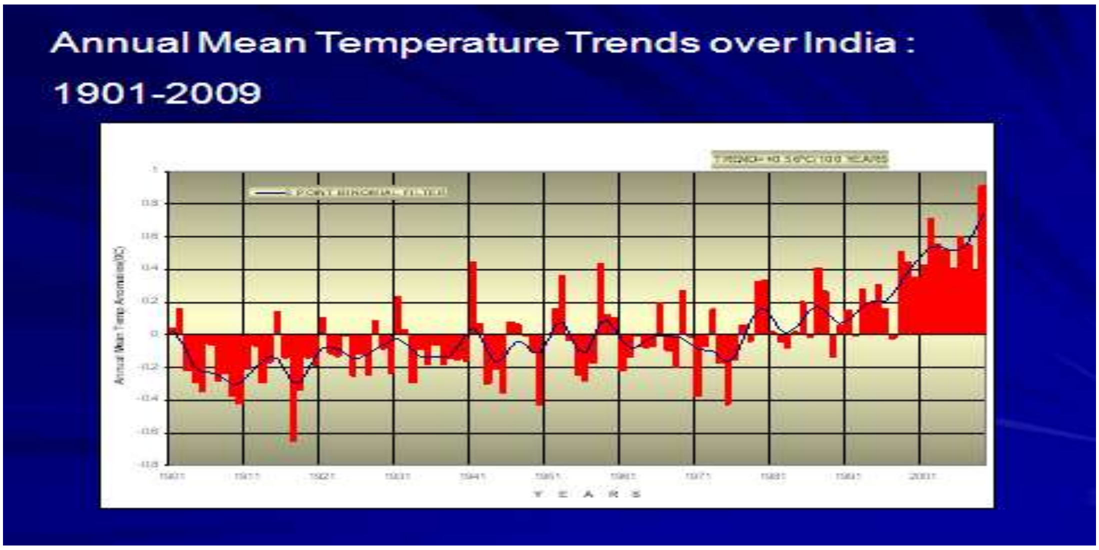

Fig. 2 Annual Mean temperature trends over India 1901-2009

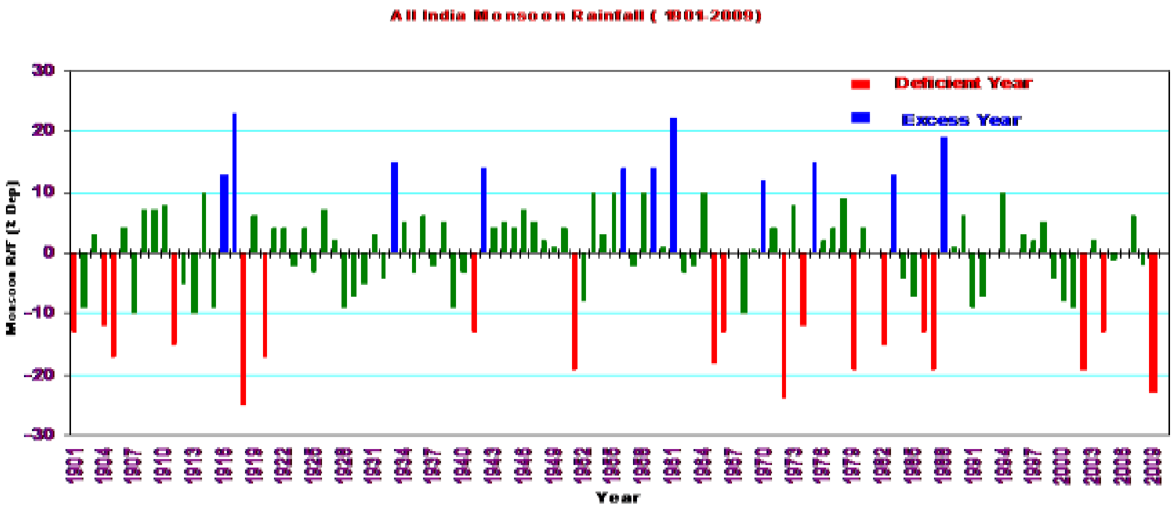

Fig. 3 All India Monsoon rainfall time series

Trends of Intense precipitation

One of the most significant consequences of global warming due to increase in greenhouse gases would be an increase in magnitude and frequency of extreme precipitation events. These increased extreme precipitation events can be attributed to increase in moisture levels, thunderstorm activities and large scale storm activity. Trends of rainfall indices suggest increase in intense rainfall events along the west coast and Maharashtra. Goswami et al. (2006, Science) using high resolution gridded rainfall data of IMD examined long term trends of extreme rainfall events over India. They found that frequency of intense rainfall events (more than 15 cm) has increased over a large area of Central India. However, frequency of moderate rainfall events (less than 15 cm) had decreased, so that the annual rainfall does not show any significant trend. Rajeevan et al. 2008 (Geophys. Res. Letters) have found that the frequency of heavy rainfall events over central India is increasing as seen in Fig. 4. Analysis of ship data from the Indian

Ocean suggests an increase in atmospheric moisture and wind speed, which means more moisture convergence

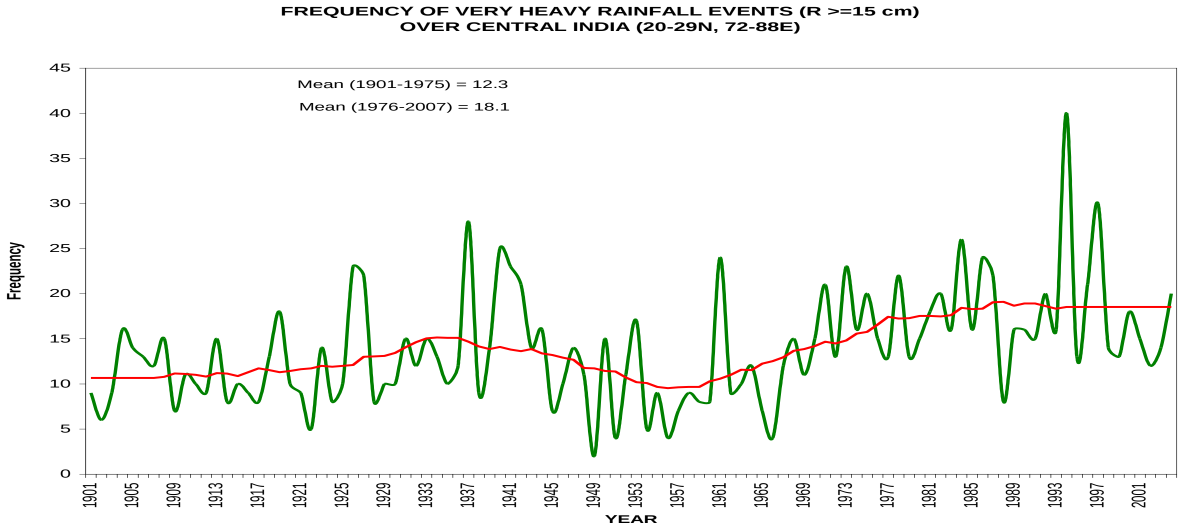

Fig. 4 Frequency of heavy rainfall events over central India

However, there is a small decreasing trend of strength of monsoon circulation. Strength of monsoon circulation is determined as the area averaged wind speed at 1.5 Km over southern parts of India/north Indian Ocean. This could be due to artifact of the reanalysis data, may not indicate the real change in monsoon circulation. During the monsoon season, there are significant variations with suppressed rainfall activity (breaks) and enhanced rainfall activity (active). The analysis of time series of break days for the period 1901-2007 shows there is no appreciable trend in the number of break days, confirming that there is no significant trend in the monsoon circulation. Tropical Cyclones over India do not show any increase in frequency, only multi-decadal variations. However, ratio of severe storms to total storms over north Indian ocean has shown an increasing trend. NOAA satellite derived NDVI shows a large increase in NDVI suggesting increase in vegetation over north peninsula and NW India around Rajasthan.

Future climate change projections

With increased greenhouse gases, surface air temperatures are likely to increase, more in winter season. With the increased global warming, precipitation is likely to increase, especially during summer monsoon season. Most of the models predict an increase in precipitation over India. Models are predicting a late withdrawal of monsoon from India, or prolonged monsoon. High resolution model (20 km resolutions) projections showing increase in monsoon rainfall over India. Extreme temperatures are also expected to increase in future climate.

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ONSET, WITHDRAWAL AND GLOBAL FEATURES ASSOCIATED WITH NORTHEAST MONSOON 2009

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1. Introduction

The Indian northeast monsoon (NEM) is a small scale monsoon affecting the five meteorological sub divisions of Coastal Andhra Pradesh (CAP), Tamilnadu (TN), Rayalaseema (RYS), Kerala (KER) and South Interior Karnataka (SIK) (Fig.1) during October to December. These sub divisions receive about 35% rainfall of their annual total. The normal rainfall received by each of these sub divisions during the NEM season is 326mm, 433mm, 212mm, 499mm and 200mm respectively. Whereas the sub divisions of KER, SIK, CAP and RYS receive significant rainfall during the preceding southwest monsoon season, the sub division of TN which is in the rain shadow region during the southwest monsoon season depends chiefly on the NEM rainfall for its agricultural sustenance. About 47% of the annual total of 91cm is received during this season in this region.

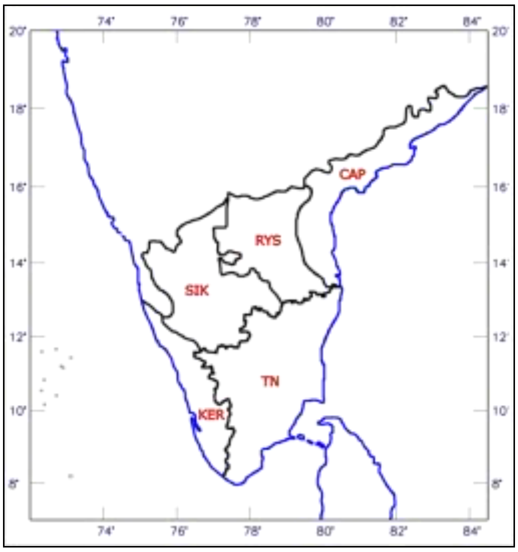


Fig.1. The five meteorological sub divisions affected by Northeast monsoon

Further, the coastal districts of Tamil Nadu normally receive about 75-100cm of rainfall during this season thereby constituting nearly 60% of their annual total. The NEM activity is very important from the hydrological point of view for the state of Tamil Nadu and a forecast of onset of this monsoon is an important input for agricultural planners of the state. A good number of works on the performance of NEM in relation to its onset, active, weak and withdrawal phases have been carried out in the past (Rao (1963), Raj(2003)) to understand the synoptic and dynamical features associated with each of these phases.

2. Onset of NEM 2009

Based on the results of these works, sequence of events that take place during the NEM onset has been identified and a thematic model of NEM onset has been proposed (Raj et al, 2007) as follows: (i) During one pentad before onset of NEM, the equatorial trough (ET) is weak and diffused over the Bay of Bengal with clouding confined to south of 9˚N. (ii) At the time of onset, strong easterlies override the weak westerlies of the lower latitudes pushing the ET further south. (iii) The temperature gradient from MDS to TRV, hitherto positive, changes sign to become negative. (iv) The cloud belt over Bay of Bengal which was earlier confined to south of 9˚N increases in its intensity and spreads rapidly north and west wards into coastal TN.

During the year 2009, following are the sequence of events observed in association with onset of NEM.

(i) Reversal of low level winds (850 hPa) from westerlies to easterlies took place around 10-11 October as is the normal feature (Table 1).

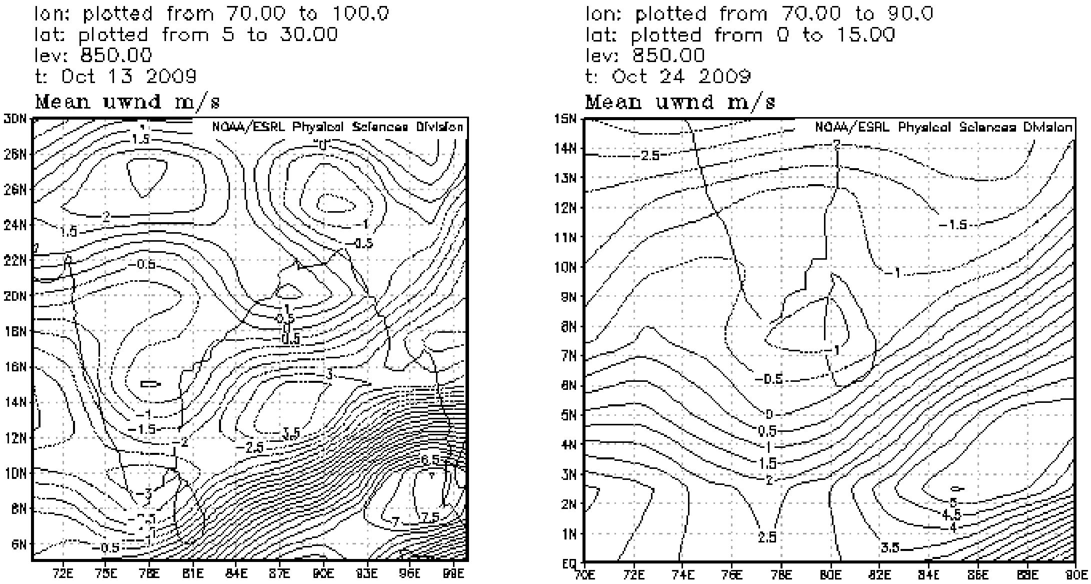
(ii) On 13th October, equatorial trough at 850 hPa was located at about 22˚N over the central Indian longitude (78˚E) (Fig.2a).

Table 1

Date	Wind direction	Wind speed in knots	Date	Wind direction	Wind speed in knots
1-Oct	W	37	16-Oct	N	15
2-Oct	W	37	17-Oct	NE	13
3-Oct	W	37	18-Oct	NE	15
4-Oct	W	37	19-Oct	E	10
5-Oct	W	28	20-Oct	E	12
6-Oct	WNW	20	21-Oct	E	10
7-Oct	WNW	12	22-Oct	NE	18
8-Oct	WNW	14	23-Oct	SW	15
9-Oct	NNW	12	24-Oct	N	9
10-Oct	ENE	4	25-Oct	NNE	14
11-Oct	E	11	26-Oct	NNE	18
12-Oct	ESE	8	27-Oct	WSW	12
13-Oct	ESE	8	28-Oct	ENE	15
14-Oct	ENE	11	29-Oct	E	19
15-Oct	ENE	14	30-Oct	ENE	18

(iii) As the withdrawal of southwest monsoon was very much delayed (It withdrew from the entire country on 22 October only) westerly anomalies prevailed during most part of the month and easterlies at lower levels did not strengthen to the extent expected.

(iv) Only on 24th October, the equatorial trough at 850 hPa was located south of Comorin, at about 5˚N over the central Indian longitude (78˚E) (Fig.2b).



(a) (b)

Fig.2. Zonal wind at 850 hPa over Indian region indicating the location of equatorial trough (u=0m/s) over Indian region on (a) 13th October (22˚N) and (b) 24th October (5˚N) (Source: NCEP reanalysis data)

(v) On 26th a trough of low pressure over southwest Bay off Tamil Nadu-Sri Lanka coast was observed and isolated rains of 1cm over Chennai, Thiruchendur (Tuticorin district), Tenkasi (Thirunelveli) and Thuckalay(KYK) were realised on 27th.

(vi) Most of the coastal stations reported rainfall on 28th and 29th.

(Chief rainfall amounts: 28th: Tuticorin 6mm, Tondi 6, Pamban 17, Nagapattinam 6, Karaikal 9, Pondicherry 3, Cuddalore 1, Chennai AP 6 and Chennai 14;

29th: Kanyakumari 28 mm, Tuticorin 23, Tondi 17, Pamban 11, Vedaranyam 27, Adiramapaattinam 11, Nagapattinam 20, Karaikal 16, Pondicherry 48, Cuddalore 51, Chennai AP 31 and Chennai 42)

(vii) Onset of NEM declared on 29th. The onset was late by a week and the October month ended with a highly deficient rainfall figures of TN: -65%, CAP: -63%, RYS: -30%, KER: -28% and SIK: -25%.

(viii) The spreading of equatorial cloud zone (ECZ) from SE to NW during the onset phase is very well depicted by the OLR pattern (Fig.3a-d). During 24-26th October, clouding was confined to south of 5˚N and east of 90˚E. Then gradually, clouding spread NWwards and by 28th, it covered the entire coastal TN. DWR imageries also revealed this feature (Fig.4a-d).

(ix) Temperature gradient at 850 hPa from MDS to TRV was positive (+0.5˚C) one pentad before onset (24th Oct) and was negative (-0.4˚C) one pentad after onset (3rd Nov) (Fig.5a-b).

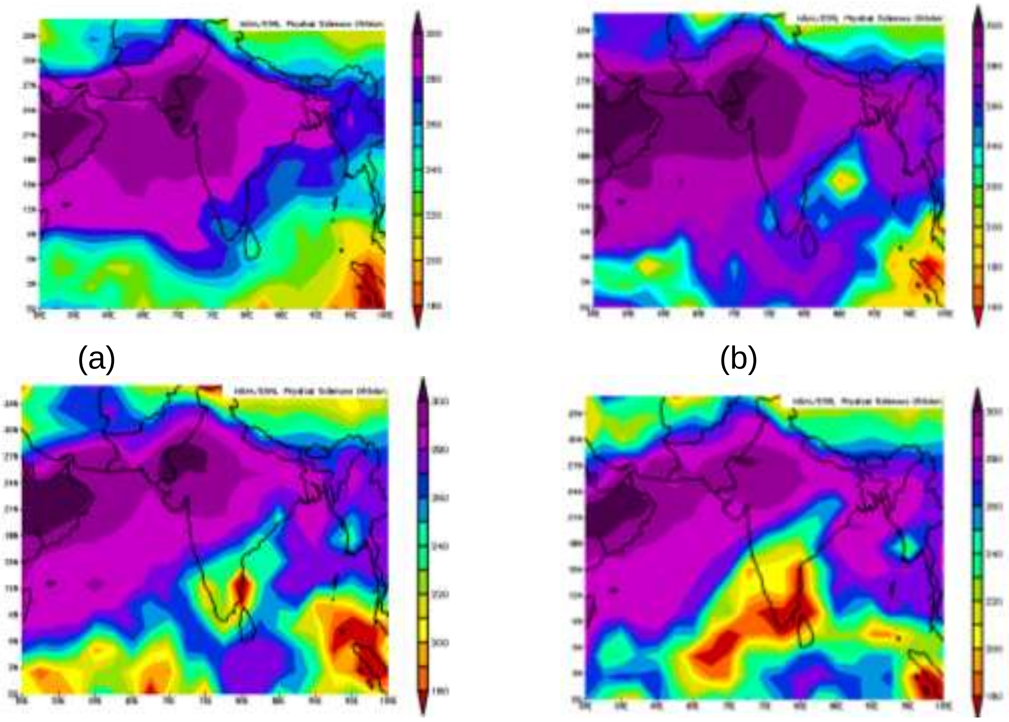


Fig.3. Mean OLR distribution during the onset phase of NEM 2009 – (a) Oct24-26 (b)Oct 27 (c) Oct 28 and (d) Oct29 (Source: NCEP daily composites)

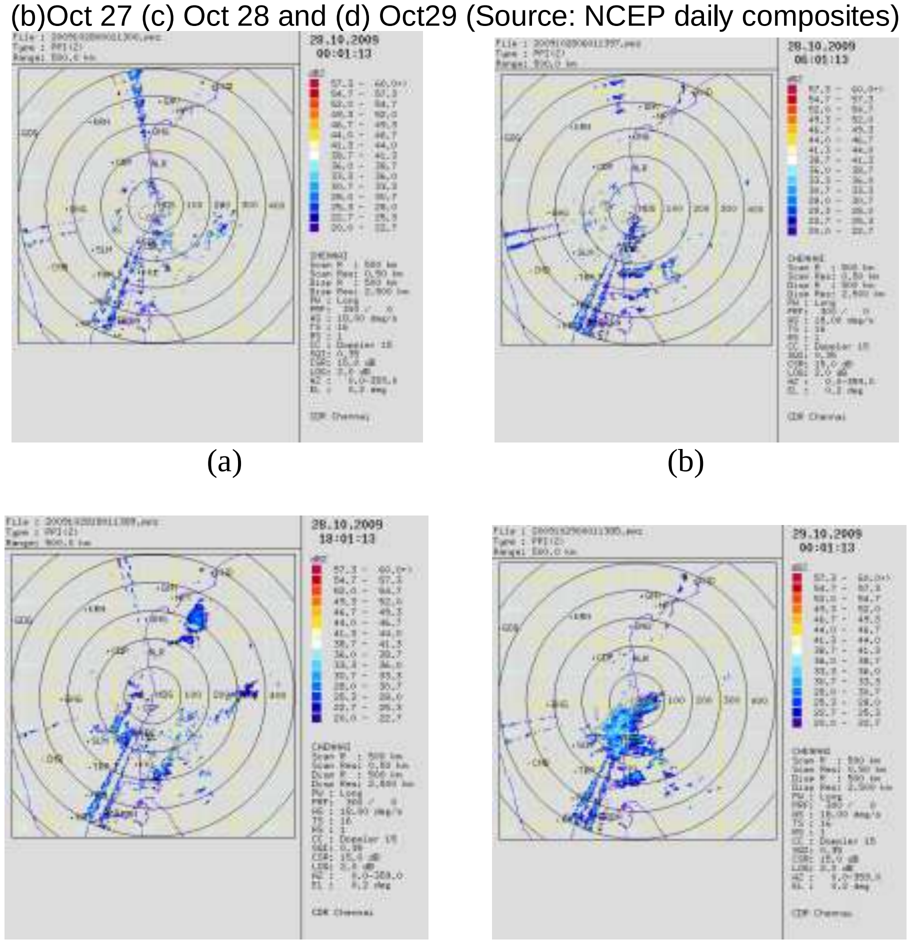
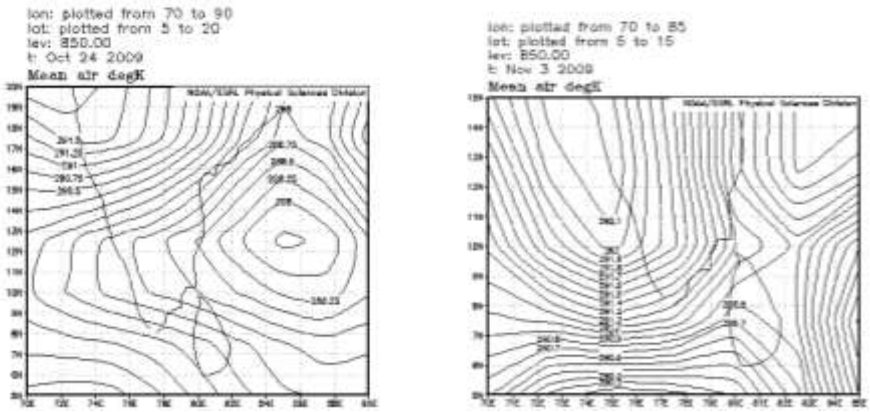


Fig.4. DWR imageries [PPI(Z)]during the onset of NEM 2009 (a) Oct 28 / 0000 UTC, (b) 28 / 0600 UTC, (c) 28 / 1500 UTC and (d) 29 / 0000 UTC



(a) (b)

Fig.5. Air temperature at 850 hPa over peninsular India during one pentad before and after onset – (a) 24 October (b) 03 November 2009 (Source: NCEP reanalysis data)

3. Withdrawal of NEM 2009

Whereas the onset of NEM is associated with a sequence of synoptic events, the withdrawal of NEM over CTN is not clearly marked. The withdrawal date is determined diagnostically from the date of cessation of NEM rainfall over CTN. The normal date of withdrawal of NEM over CTN is 27th December with a standard deviation of 14-15 days. During December 2009, NEM was quite active over TN and 25% excess rainfall was received over that sub division. The season further spilled over to January of 2010. A few days of scattered / isolated rainfall was realised over TN during the first half of January before the withdrawal of NEM 2009 on 18th January 2010.

4. Global features associated with NEM 2009

It has been observed that El Nino (positive SST anomalies over the four Nino regions in the equatorial Pacific) and negative Southern Oscillation Index (SOI) during the preceding southwest monsoon season and during the beginning of the NEM are favourable for good NEM activity (Raj and Geetha, 2008).

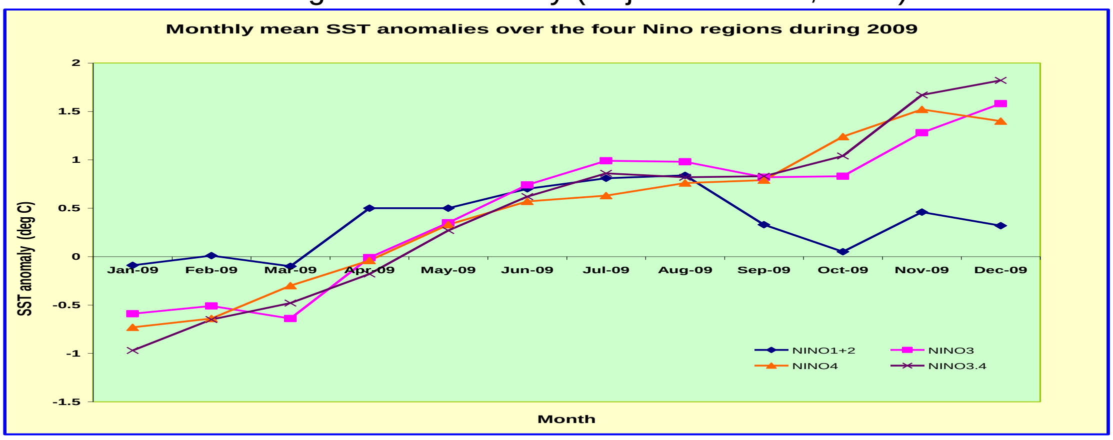


Fig.6a. Monthly mean SST anomalies over the four Nino regions of the equatorial Pacific during 2009 (Data source: Climate Diagnostics Bulletin, Jan 2010)

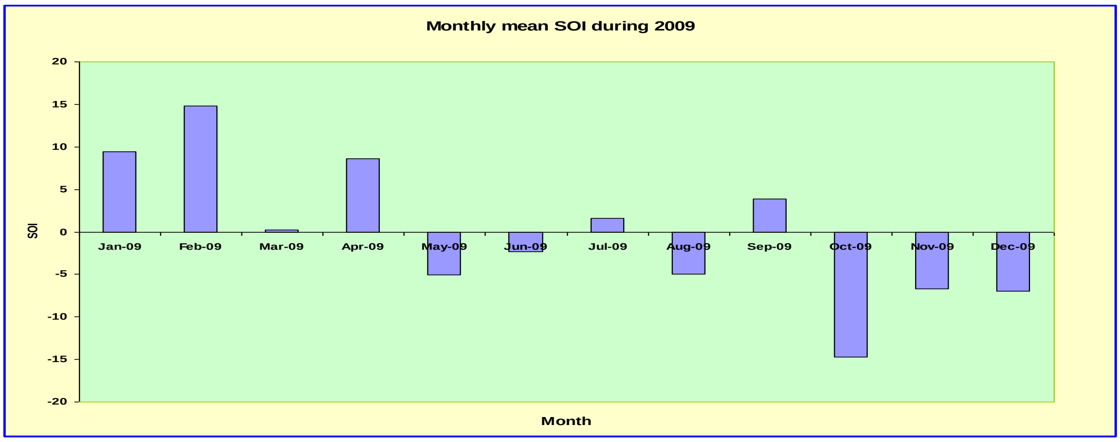


Fig.6b. Monthly mean SOI during 2009
(Source: website of Australian Bureau of Meteorology)

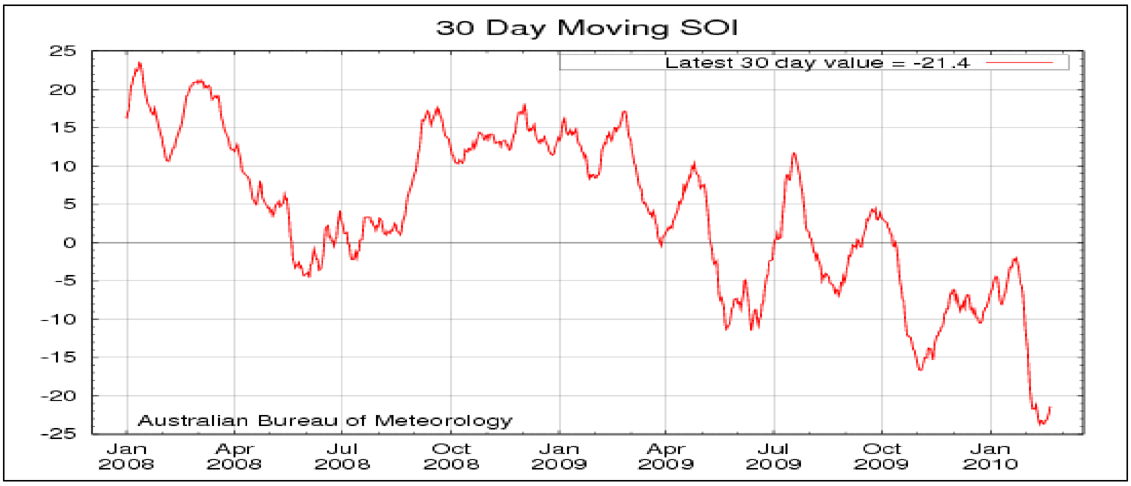


Fig.6c. 30 day moving SOI indicating an increasing tendency from Nov 2009 to Jan 2010
(Source: website of Australian Bureau of Meteorology)

However, the extension of NEM into December / January has been found to be, by and large, associated with positive SOI. During NEM 2009, positive SST anomalies prevailed over the four Nino regions from June to December (Fig.6a), SOI during this period was also normal to negative (Fig.6b), both indicating good NEM activity during October-November. Very late onset and highly deficient October rainfall were not indicated by these parameters. Similarly, negative SOI during December did not indicate a good NEM (Dec) of 25% excess over TN and the extension of NEM into January of 2010. However, there was an increasing tendency in SOI from -15 in November to -5 in January as indicated by the 30 day moving SOI curve (Fig.6c).

5. Validation of *Outlook on performance of NEM 2009*

An experimental outlook on Northeast monsoon rainfall of Tamilnadu for the year 2009 prepared at Regional Meteorological Centre, Chennai during

September 2009 is furnished in *Appendix 1*. Three out of the four predictors indicated near normal to positive departure for the rainfall of NEM 2009. Hence the overall outlook was **normal rainfall for Tamilnadu for the period Oct-Dec 2009.** A good NEM performance during the first half of the season (with normal onset) and tapering off slightly during the latter half was expected. The ***forecast for the seasonal performance proved to be correct*** but the forecast on onset and intra seasonal variation, mainly based on El Nino and SOI, were not up to the mark.

6. Summary

During the year 2009, El Nino and normal-negative SOI prevailed during June-December and northeast monsoon performance was normal. The onset of NEM took place on 29th October, late by more than a week resulting in highly deficient October rainfall. The onset phase was quite active. The rainfall over TN was excess during December which helped in offsetting the initial deficit. There were no cyclonic storms affecting the NEM region during the season. The outlook on seasonal performance of NEM 2009 prepared at RMC Chennai proved to be correct. However, the forecast on onset and intra seasonal variation were not up to the mark.

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Appendix-1

Experimental Outlook on Northeast monsoon rainfall of Tamil Nadu for the year 2009 prepared at Regional Meteorological Centre, Chennai (by Y.E.A.Raj) dated 23 September 2009

1. For the current year 2009, outlook on northeast monsoon rainfall of Tamil Nadu (NRT) has been based on 4 parameters as detailed below The type of the relation and the outlook based on each predictor are also explained. The input data have been extracted from the websites of NOAA NCEP/NCAR reanalysis datasets and Australian Bureau of Meteorology. The final forecast is obtained as an ensemble of all the individual forecasts.

Predictor	Type of relation with NRT	Conditions during 2009	Outlook on NRT based on the predictor
PR1: Apr, 200 hPa Zonal wind anomaly Over India	Strong westerly winds (positive anomaly) favour good NRT; Weak wind, poor NRT	Weaker by 5-6m/sec	Negative departure
PR2: JJAS, 150 hPa Temperature anomaly over central India	Negative anomaly favours good NRT; Positive anomaly, poor NRT	Slightly positive anomalies	Near normal to Normal
PR3: Aug-Sep, 150 hPa Strength of TEJ over the extreme south peninsula	Strong TEJ, poor NRT; Weak TEJ, good NRT	TEJ is weaker by 2-3m/sec	Positive departure
PR4: JJAS, SOI	Negative SOI, good NRT; Positive SOI, poor NRT	Normal SOI during JJAS (-1.9); Presently neutral (-1.0); strong probability of further development of El Nino as per models	Normal to positive departure
PR5: IMR of JJAS	Slightly discordant negative relationship; Conditional means (CM) give a better indication	This year IMR is expected to be negative around -20%; No indication regarding NRT	--
PR6:Aug-Sep, MSLP over Siberian region (87-103˚E; 47-53˚N)	Negative anomaly is associated with slightly deficient NRT(ON) but may lead to an excess NRT(Dec)	Parameter likely to change drastically during the 2nd half of Sep; Hence not considered; would be included in the next update	--

2. Final outlook

Except PR1, individual outlooks based on all the other three parameters indicate near normal to positive departure for NRT. With predictions of continued development of El Nino during 2009, the overall outlook could be taken as Normal rainfall during Oct-Dec 2009. The performance could be good during the first half of the season with normal onset and may taper off slightly during the latter half. (Normal onset date: 20th Oct with sd of 6-7 days). Normal RF for the season for TN is nearly 43 cm with a cv of nearly 25%.

An overall outlook could be taken as normal rainfall for Tamil Nadu for the period Oct-Dec 2009. Normal onset.

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CLIMATE CHANGE - SCENARIO OVER CHENNAI

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1. Introduction

Global warming is perhaps the most popular scientific topic today that is in the limelight of worldwide discussions and deliberations. Awareness on climate change has been kept alive by the media and during the last two decades, the periodic release of Intergovernmental Panel on Climate Change's assessment reports on climate change since 1990 have provided authentic data to the public on climate change. Whereas the advent of scientific and technological advancements such as nano technology, stem cells research etc. during the last two decades have acquired popularity amongst the scientists and technocrats involved in these fields, the scientific aspect of global warming is discussed and debated by all and sundry. Ironically, local climate scientists are frequently reluctant participants in these discussions even though they are the ones who can authenticate, or prove otherwise, based on actual verification with data, the various issues related to climate change. Here is a modest attempt to analyse the scenario over Chennai, based on actual data, that may possibly have links with climate change due to global warming.

2. Climate change – Global scenario and projections

The mean annual heat balance of the earth is expected to maintain the temperatures of the earth and the atmosphere with no long term trends, by transport of surplus heat from the tropics to regions of deficit heat in higher latitudes by oceanic and atmospheric circulations. But, the presence of CO_2 and water vapour in the atmosphere alters the balance by allowing the incoming short wave solar radiation (The Sun radiates energy in the wavelength range of 0.5 microns corresponding to its temperature of 6000˚K) to pass through but reflecting back the outgoing long wave terrestrial radiation (The earth emits radiation in the wavelength range of 10 microns corresponding to its mean temperature of 288˚K). This causes the all important greenhouse effect that causes temporal increase in the average surface temperature of the earth and oceans leading to global warming. The atmospheric constituents responsible for this are water vapour (36-70%), $C0_2$ (9-26%), Methane (4-9%) and Ozone (3-7%).

The increase in the surface temperatures has been in the order of nearly 0.74°C during the past century (Fig.1). Since 1980, the mean global temperature has been steadily rising from an anomaly of 0°C to nearly 0.4-0.45°C as of now. Increase in CO_2 concentration in the atmosphere by increased human activities such as CO_2 emission by automobiles & aeroplanes and burning of fossil fuels in power plants and the increase of methane concentration from rice fields and the consequent green house effect are the reasons attributed for this global warming.

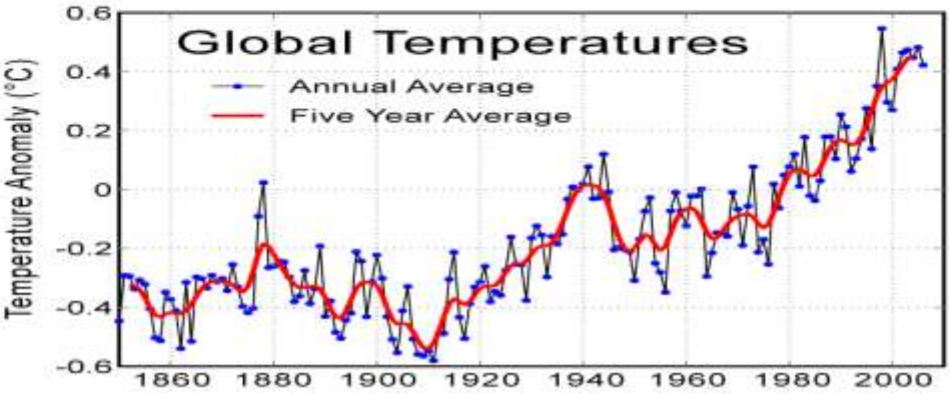


Fig.1. Global annual temperatures. (Source: wikipedia)

The CO_2 concentration in the atmosphere has been of the order of 280 parts per million in 1750, 358ppm in 1994, 370ppm in 2003 and 386ppm in 2009. It has been projected to cross 500ppm by the end of 21st century (Wikipedia). India ranks 4th in the world in global percentage of CO2 emission next to China, USA and Russia. Projections for the future imply that even if emission of CO_2 could be curtailed totally today, the present concentration itself is so high that the gas could stay up in the atmosphere for another 200 years and certain changes in the climate system, such as, melting of ice sheets and major changes in the ocean circulation pattern that are likely to take place in 21st century would be irreversible.

WMO projections for future climatic events based on comprehensive climate models include increase of global mean temperature by 1.4-5.8°C by 2100, increase in sea level by 9-88 cm from the 1990 level by 2100 (IPCC projections 1990-2100 : 110-770mm), more hot days and heat waves, increase in heat index, decrease in cold waves and frost days, increase in the occurrence of extreme weather events – increase in precipitation extremes, viz., floods and droughts. retreat of glaciers, warmer summers and milder winters. These projected climatic changes would lead to severe consequences for ecosystems and human population due to potential rise in surface temperature and speeding up of hydrological cycle, 4-7 % increase in global mean evaporation and precipitation rates, regional effects on water balance - some areas wetter, some drier, greater and longer periods of summer dryness induced by lower soil moisture content & higher evaporation rates in mid-latitudes of northern hemisphere, general reduction in potential crop yield in most tropical and sub tropical regions, decrease in winter rainfall of Australia, Central America and Southern Africa, increased risk of coastal flooding and erosion, drinking water salinisation. Some of the positive impacts would be increase of crop yield in mid latitude countries, increase of precipitation by 5-10% over higher latitudes and reduced winter mortality in extra tropics. In the

Arctic, there will be more running and standing water, thinner and reduced ice cover.

3. Indian Scenario

India being the fourth largest emitter of greenhouse gases in the world, with persistent increase in emission rates in the last decade, mean annual surface temperatures over India have shown some increase in recent years. A mild warming tendency of 0.2-0.4°C for 100 years when averaged over the whole of India has been documented (Srivastava et al, 1992) (Fig.2a). A recent study on comfort index in main cities based mainly on maximum temperature has shown a significant increasing trend in the discomfort index in about 26 Indian cities (Srivastava et al, 2007). Studies based on long term data have indicated that there is no significant trend in annual rainfall of various Indian regions (Fig.2b), no significant trend in extreme weather events such as severe cyclonic storms but mean tide level has shown a rising trend of 0.8, 1.2 and 0.9 mm per year at Mumbai, Kochi and Visakhapatnam(SMRC, 2002).

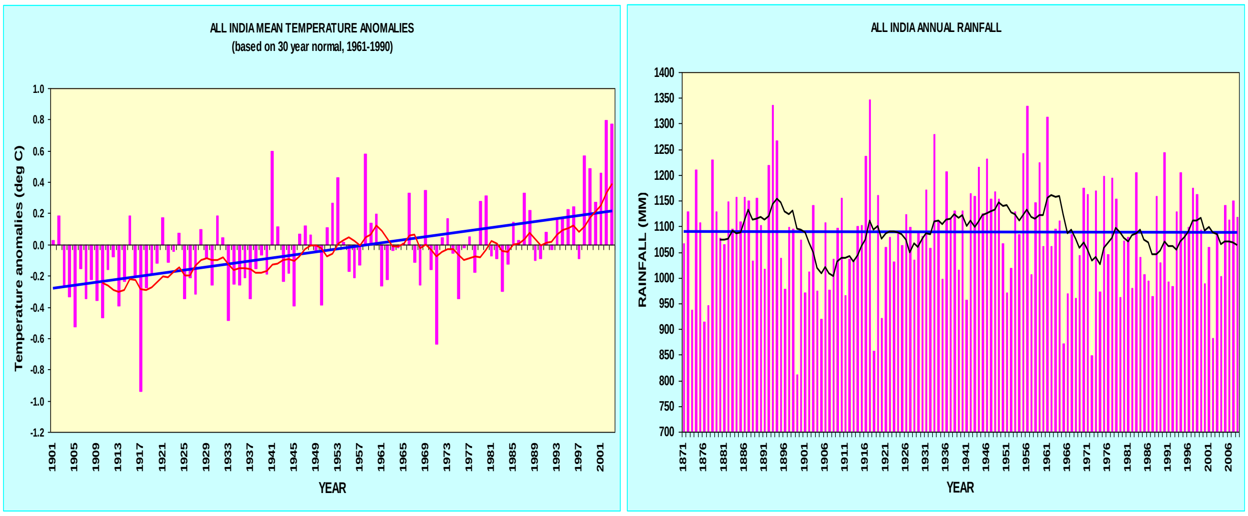
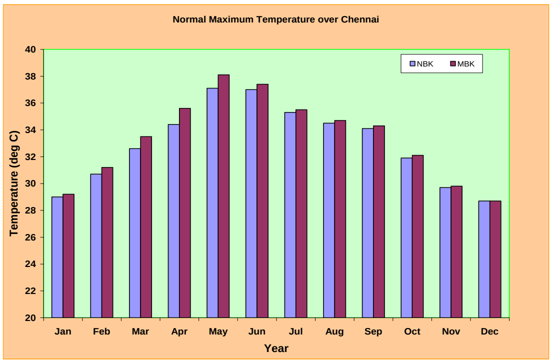


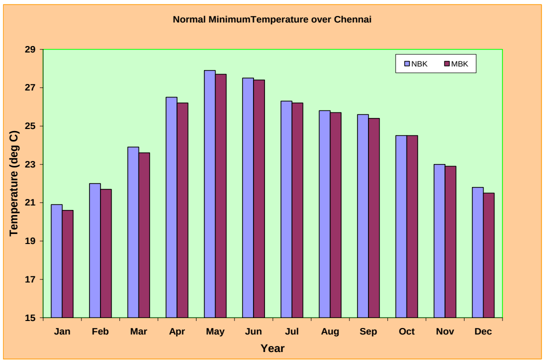
Fig.2. All India annual (a) temperature and (b) rainfall trends during the recent century (Data source: www.tropmet.res.in)

4. Scenario over Chennai

The city of Chennai, being located in the tropics at about 13˚N,81˚E along the southeastern coast of the peninsular India normally experiences a hot and humid summer but not a very cold winter. The monthly mean maximum and minimum temperatures observed over Chennai (Nungambakkam (NBK) and Meenambakkam (MBK)) during the period 1969-2009 are furnished in Fig.3a&b. The city receives a mean annual rainfall of 140cm and 144cm at NBK and MBK respectively. The monthly and seasonal mean rainfall received by these two stations are furnished in Fig.4a&b. It can be seen that the chief rainfall period for this city is the northeast monsoon season of October to December when it receives

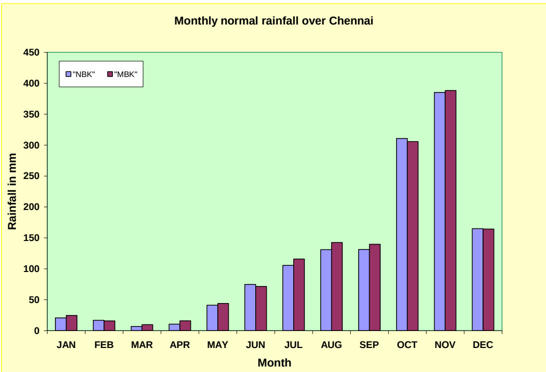
86cm (61%) and 85.8 (60%) at NBK and MBK respectively followed by the southwest monsoon season of June to September (44cm (31%) and 47cm (33%) respectively at NBK and MBK). Trend analysis of the time series of rainfall and temperature data of these stations (NBK and MBK) during the period 1969-2009 has revealed the following results:

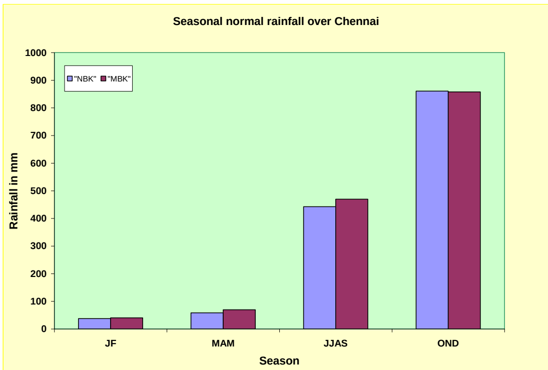




(a) (b)

Fig.3. Mean monthly (a) maximum and (b) minimum temperatures over Chennai (NBK and MBK)





(a) (b)

Fig.4. (a) Monthly and (b) seasonal mean rainfall over Chennai (NBK and MBK)

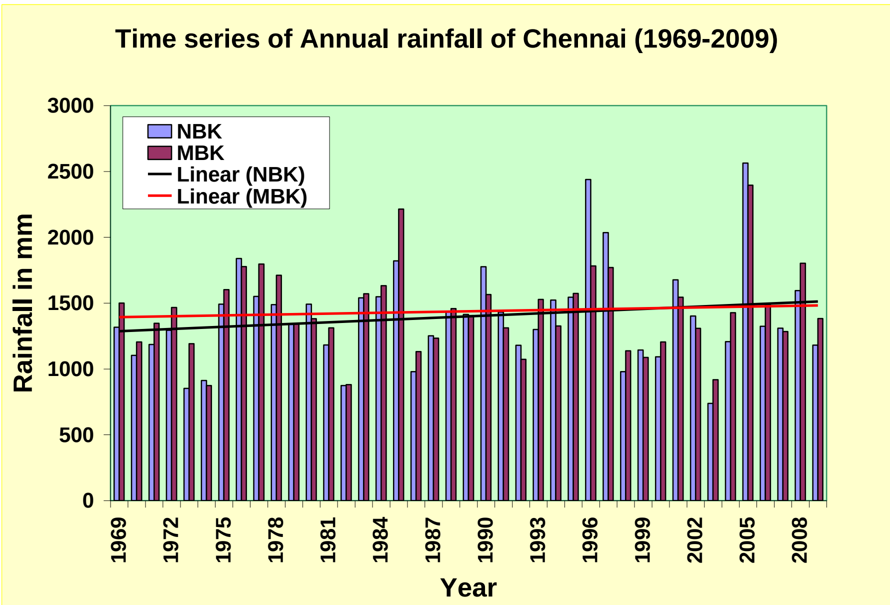
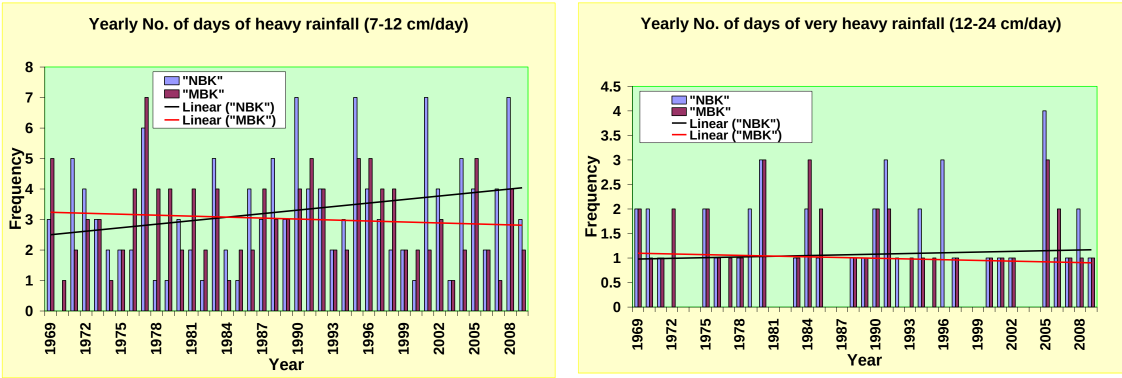


Fig.5. Annual variation of rainfall over Chennai (NBK and MBK) during the period 1969-2009. (Black trend line:NBK; red line:MBK).

i. There is a slight increase in the annual rainfall realised over Chennai. The increase is greater in the case of NBK than that of MBK (Fig.5).

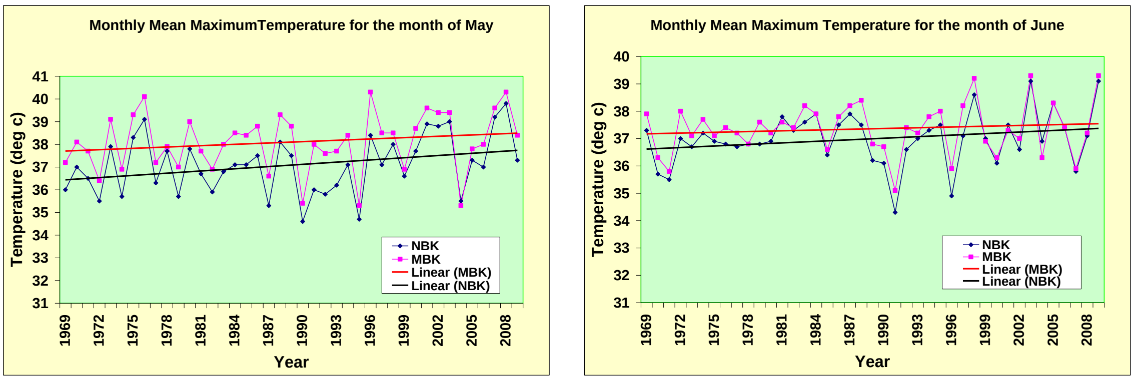
ii. Frequency of heavy rainfall days (7-12 cm/day) and very heavy rainfall days (12-24 cm/day) has shown an increasing trend over NBK but a decreasing trend over MBK (Fig.6).



(a) heavy (b) very heavy

Fig.6. Annual variation of frequency of (a) heavy (7-12 cm/day) and (b) very heavy rainfall days over Chennai (NBK and MBK) during 1969-2009. (Black trend line:NBK; red line:MBK).

iii. The mean maximum temperature for the months of May and June have shown considerable increase. The increase has been of the order of 1.1˚C and 0.7˚C over NBK and MBK respectively for the month of May and 0.7˚C (NBK) and 0.4˚C (MBK) for the month of June (Fig.7).

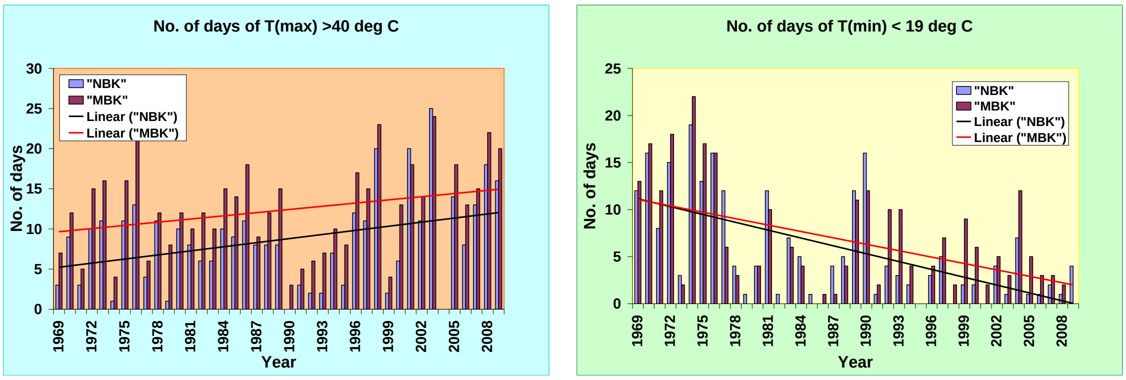


(a) May (b) June

Fig.7. Annual variation of monthly mean maximum temperature over Chennai (NBK & MBK) during (a) May and (b) June for the period 1969-2009 (Black trend line:NBK; red line:MBK).

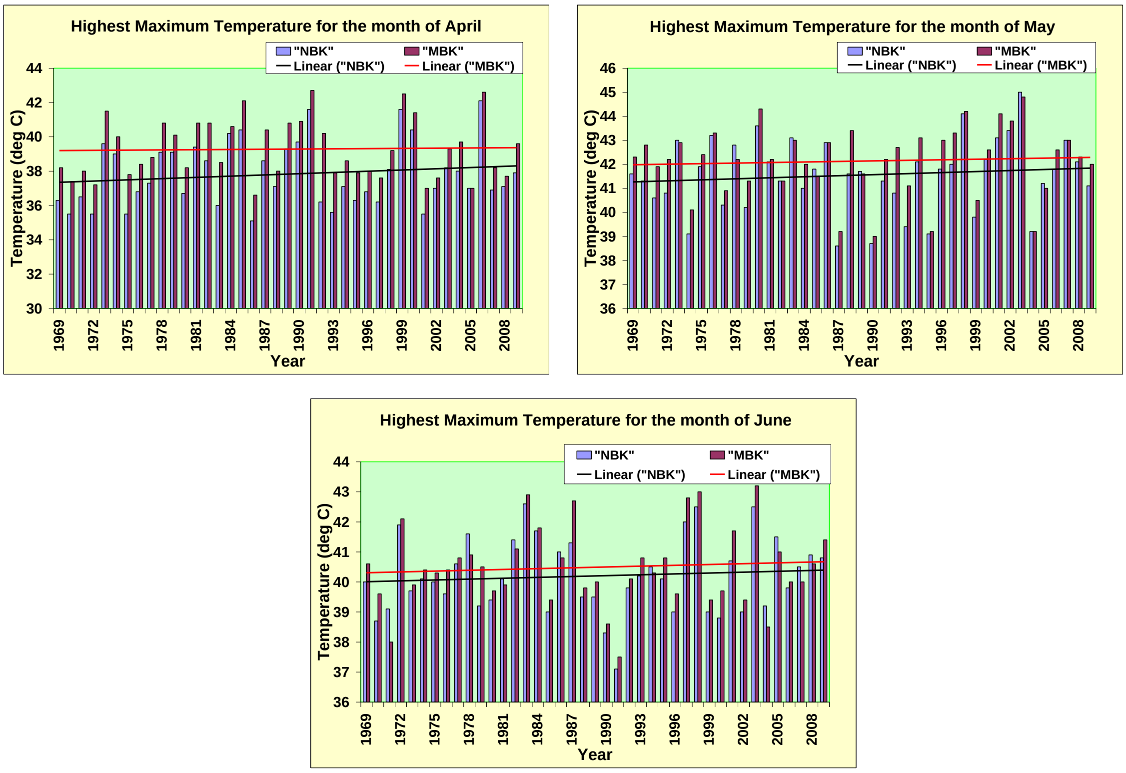
iv. The annual frequency of days with maximum temperature greater than 40˚C has shown manifold increase. It has almost doubled in 40 years over NBK and has increased by one and half times over MBK (Fig.8a).

v. The annual frequency of days with minimum temperature less than 19˚C has shown very sharp decrease from about 11-12 days during first decade to only 1-5 days in the recent decade over both NBK and MBK (Fig 8b).



(a) Tmax>40˚C (b) Tmin<19˚C

Fig.8. Annual variation of frequency of days with (a) maximum temperature (Tmax) greater than 40˚C and (b) minimum temperature < 19˚C over Chennai (NBK and MBK) for the period 1969-2009. (Black trend line:NBK; red line:MBK).



(a) April (b) May (c) June

Fig.9. Annual variation of highest maximum temperature for the months of (a) April (b) May and (c) June over Chennai (NBK and MBK) (Black trend line:NBK; red line:MBK).

vi. The highest maximum temperature for the months of April and May has shown a slight increase over NBK but no increasing trend is visibly seen in the case of MBK. The month of June is definitely becoming more uncomfortable with both NBK and MBK showing similar increasing trends in the highest maximum temperatures (Fig.9).

vii. There is no significant trend in the frequency of cyclones crossing coast near Chennai (within 100km radius) during the 41 year period (1969-2009) considered. During the first 21 year period (1969-1989) 8 low pressure systems (LPS) and during the later half period of 20 years (1990-2009) 4 LPS had crossed the coast near Chennai. Frequency of SCS crossing has been 3 and 2 respectively during the two periods considered. With such low frequencies of occurrences no inferences on trends could be drawn.

5. Summary

An analysis of 41 year data of rainfall and temperatures over Chennai (Nungambakkam and Meenambakkam) has revealed a slight increasing trend in annual rainfall over Chennai over both NBK and MBK. The frequency of heavy and very heavy rainfall days has increased considerably over NBK but decreased over MBK. The monthly mean maximum temperatures during May and June, annual frequency of days with maximum temperature greater than 40˚C and highest maximum temperatures during April, May and June have all shown increasing trends. Annual frequency of days with minimum temperatures less than 19˚C has decreased drastically from about 10-20 days to about 1-5 days. There is no significant trend in frequency of cyclones crossing coast close to Chennai. Even though these results are in line with the projections on climate change due to global warming, environmental effects due to local changes such as urbanisation have to be factored into for interpretation of results and attribution of causes.

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A STATISTICAL STUDY OF NORTHEAST MONSOON OVER TAMIL NADU

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Tamil Nadu lies roughly between the south of latitude 13° 30'N and in the proximity of the equator. It is one of the southernmost states of India and is bounded by the Bay of Bengal on its east, Western Ghats on its west, Indian Ocean on its south and Nellore and Chittoor districts of Andhra Pradesh state, on north and Kolar, Bangalore and Mysore districts of Karnataka state on its northwest. Tamil Nadu is divided into 29 administrative districts. Monsoon rainfall is the basic resource for water availability in Tamil Nadu. Tamil Nadu is the major beneficiary of the northeast monsoon rains (October to December); it gets about 475.3 mm out of an annual rainfall of 1005 mm (IMD 1962). It gets 345mm, 141mm, and 50mm during all Indian season of southwest monsoon season (June-September), pre monsoon season (March – May) and winter season (January-February) respectively. The coefficient of variation for rainfall in winter season, pre monsoon season, Southwest monsoon season and Northeast monsoon season are 98%, 32%, 19% and 27% respectively.

Out of the 29 districts in Tamil Nadu, Salem, Dharmapuri, Namakkal, the Nilgiris, Kanyakumari districts and parts of Villupuram, Cuddalore and Perambalur districts are equally benefited from southwest monsoon (SWM) season while all the 29 districts in Tamil Nadu are highly benefited from northeast monsoon rainfall (NEMR). If any deviation occurs from normal rainfall during NE monsoon season in any year, the water availability in Tamil Nadu would be always at stakes in all three sources of irrigation viz., tank, canals and wells.

1. Northeast monsoon rainfall of Tamil Nadu

Table 1 shows the mean, median, standard deviation(SD), coefficient of variation(CV) and range of October, November, December and seasonal rainfall. From the table, it can be seen that Tamil Nadu receives on an average 458 mm of rainfall during NEM season with SD of 132 mm. It receives a mean rainfall of 187mm, 185 mm and 88mm with standard deviation 66, 88 and 70 mm in the months of October, November and December respectively. The coefficient of variation in the month of December is the highest. The CV of seasonal rainfall is less compared to monthly rainfall variations of Tamil Nadu. The range in the seasonal rainfall is 626.3mm whereas in November it is 406.5 mm and 314.2 mm in December (even though the mean rainfall for December is 88 mm). It appears that October rainfall along with seasonal rainfall is more reliable than the rainfall during November and December months.

	Median	Mean	SD	CV	Range
October	166.9	186.5	65.6	35.2	359.7
November	174.6	184.9	88.8	48.0	406.5
December	63.6	88.1	70.1	79.6	314.2
NE monsoon season	435.0	458.2	131.6	28.7	626.3

Table 1: Tamil Nadu: Statistical properties of monthly and seasonal NEM rainfall (in mm) of Tamil Nadu during the period: 1896- 2005

2. Relation between monthly and seasonal rainfall

Table 2 shows the correlation efficient between monthly and seasonal rainfall. From the table, there is no significant correlation between monthly rainfalls. The November month rainfall is highly correlated with the seasonal rainfall

Month/Season	Oct	Nov	Dec	Season
Oct	1.00	-0.02	-0.05	0.45
Nov	-0.02	1.00	0.10	0.72
Dec	-0.05	0.10	1.00	0.55
NE monsoon	0.45	0.72	0.55	1.00

Table 2: Correlation Coefficient between monthly and seasonal rainfall of Tamil Nadu during NEM for 1896 – 2005

3. El Nino and La Nina relationship with rainfall.

Using the total rainfall in the month of October, November, December and total rainfall of the season, a study is made to analyse the NEMR patterns. The El Nino and La Nina years are taken from Medha Khole et al (2003). During the study period of 1896 – 2005, there are 24 El Nino and 21 La Nina years. More than LTA rainfall occurred in 63%, 58%, 67% and 75% El Nino years in the month of October, November, December and in NEM season respectively. Less than LTA rainfall occurred in 67%, 57%, 48% and 62% of La Nino years in the month of October, November, and December and in NEM season.

Out of the 15 El Nino years with positive anomaly of rainfall during the month of October, same positive anomaly was maintained in 10 years and positive anomaly changed into negative anomaly at the end of the season for the other 5 years. Out of 9 El Nino years with negative anomaly in the month of October, the same trend was found for a year and had changed into positive anomaly in rest of the 8 years. Out of 7 La Nina years with positive anomaly in the month of October, the anomaly had been maintained to the end of the season in 2 years and changed into negative in 5 years. Also out of 14 La Nina years with negative anomaly in the month of October, the same trend maintained to the end of the season in 8 years and changed to positive anomaly in 6 years.

4 Districtwise NEMR rainfall patterns

Tamil Nadu is divided into 29 administrative districts and out of this 13 districts cover Tamil Nadu coastal areas and rest are away from the coast. The districts in the western Tamil Nadu are close to Western Ghats and the rain gauge stations close to Western Ghats are on the windward side of the Western Ghats for northeasterly winds. Also the coastal districts are closer to the moisture source. Also there are individual mountain peaks. The average height of the districts, which are close to coast, is varying less as compared to the height in the western districts. These factors play an important role in the distribution of rainfall pattern of the concerned districts. Thus the spatial pattern of rainfall is pronounced based on relief, closeness to coast and the prevailing wind directions of the local areas.

4.1 Box plot analysis

To have a bird's eye view of the distribution of seasonal rainfall of 29 districts of Tamil Nadu, box plot (Figure 1) analysis is made. The Box plot or Box-and- Whisker plot is a widely used graphical tool introduced by Tukey (1977). It is a simple plot of five quartiles, representing the lower quartile, the median, the upper quartiles, the minimum and the maximum. The five elements of the plot essentially present a quick sketch of the distribution of the underlying data. The box in the middle of the diagram is bounded by the lower and the upper quartiles and the vertical extend of box within this extend represents the distribution of the central 50% of the data. The Whiskers beyond the box represent minimum and maximum extreme values on either side of this extend. The Box plot for the 4 subdivisions of Tamil Nadu as identified by IMD namely North Coastal Tamil Nadu, North Interior Tamil Nadu, South Coastal Tamil Nadu and South Interior Tamil Nadu are shown in figure 1. From the figures, it is seen that the median of seasonal rainfall of north coastal districts are higher than that of other districts. Also the vertical extent of the whiskers of the north coastal districts are higher than that of other districts which means that the seasonal rainfall of north coastal districts are highly variable. Also the median is not located at the centre of the box in all the plots but is located to the lower half of the box, which means that the rainfall distribution is not symmetrical but negatively or right skewed. Also the length of the upper whisker is more than the lower whisker in all plots which means that the range of the seasonal rainfall in the lower 25 % of the data are less than that of the upper 25% of the data. Therefore a simple interpretation is that less than expected rainfall is bound to occur with lesser variations but more than expected rainfall may occur in abundant quantities with larger variations and thus flood possibilities are more than to driest season possibilities.

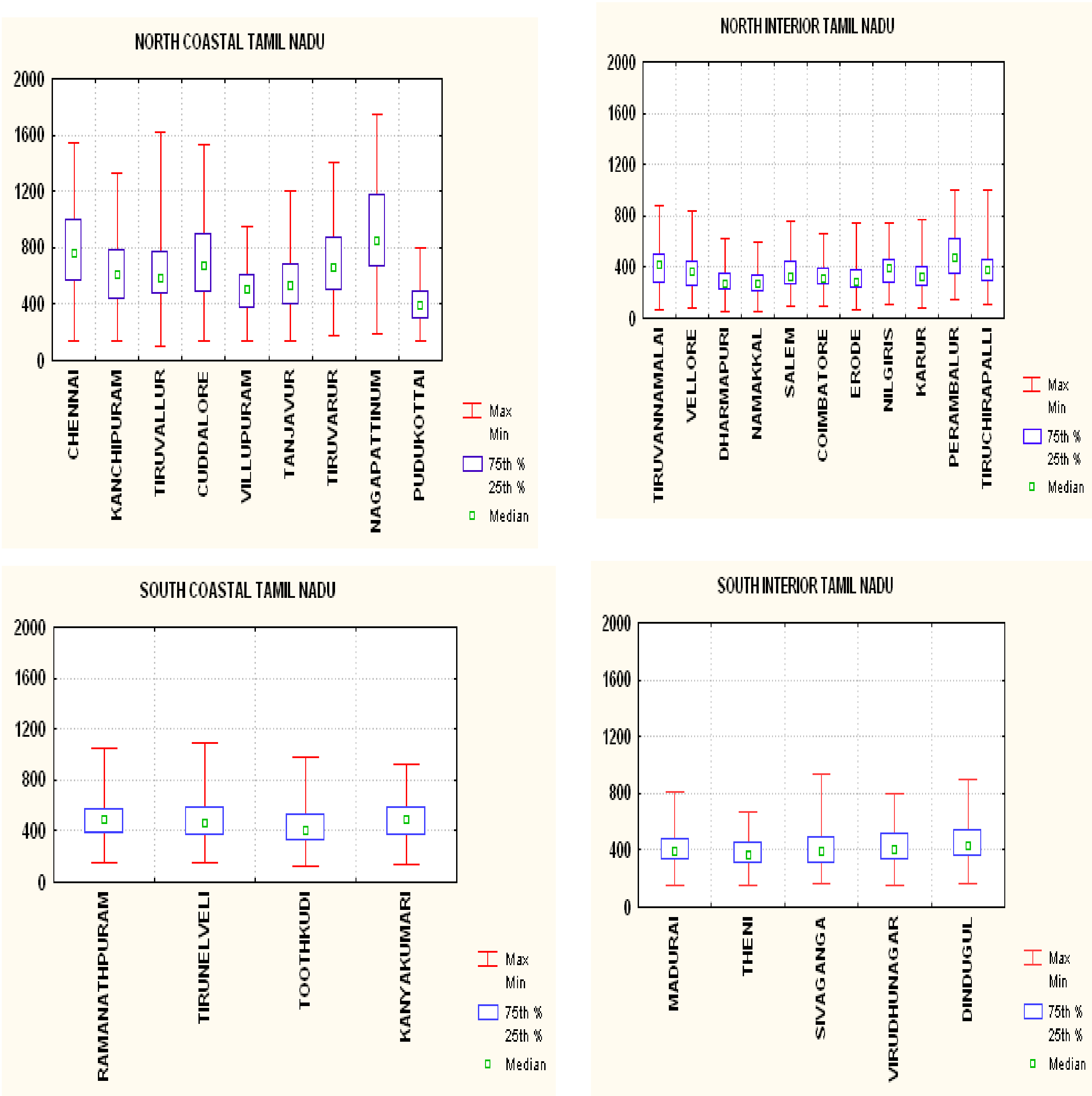


Figure 1. Box plot of seasonal rainfall of Tamil Nadu (mm): a) North coastal Tamil Nadu, b) North interior Tamil Nadu c) South coastal Tamil Nadu d) South interior Tamil Nadu (1896 – 2005)

	CHN	KNJ	TVL	CDL	VLP	TNJ	TRR	NGP	PDU	TVM	VLR	DRM	NMK	SLM	CMB	ERD	NLG	KRU	PRM	TRP	RMD	TNL	TTK	KYK	MDR	THN	SVG	VRD	DND
CHN																													
KNJ	0.80																												
TVL	0.84	0.84																											
CDL	0.46	0.59	0.58																										
VLP	0.52	0.68	0.61	0.80																									
TNJ	0.34	0.47	0.41	0.79	0.67																								
TRR	0.32	0.43	0.38	0.75	0.60	0.88																							
NGP	0.36	0.45	0.41	0.76	0.60	0.81	0.87																						
PDU	0.27	0.39	0.33	0.64	0.55	0.79	0.75	0.65																					
TVM	0.54	0.70	0.63	0.63	0.78	0.50	0.45	0.48	0.46																				
VLR	0.59	0.72	0.71	0.55	0.69	0.45	0.39	0.37	0.40	0.85																			
DRM	0.27	0.36	0.34	0.41	0.49	0.37	0.29	0.23	0.37	0.61	0.58																		
NMK	0.22	0.30	0.27	0.45	0.45	0.46	0.38	0.30	0.48	0.49	0.42	0.61																	
SLM	0.28	0.37	0.35	0.51	0.53	0.48	0.38	0.31	0.48	0.59	0.55	0.77	0.78																
CMB	0.21	0.26	0.24	0.31	0.29	0.30	0.24	0.19	0.37	0.35	0.33	0.40	0.48	0.53															
ERD	0.20	0.25	0.24	0.33	0.36	0.37	0.29	0.23	0.43	0.42	0.38	0.55	0.70	0.71	0.70														
NLG	0.21	0.26	0.27	0.29	0.29	0.29	0.23	0.15	0.33	0.39	0.40	0.47	0.55	0.56	0.60	0.61													
KRU	0.22	0.29	0.27	0.48	0.44	0.54	0.45	0.36	0.58	0.46	0.39	0.52	0.69	0.65	0.50	0.61	0.47												
PRM	0.34	0.45	0.41	0.76	0.67	0.82	0.70	0.65	0.67	0.58	0.53	0.49	0.56	0.62	0.36	0.44	0.35	0.58											
TRP	0.23	0.32	0.28	0.55	0.50	0.71	0.59	0.52	0.61	0.40	0.36	0.34	0.46	0.45	0.30	0.38	0.28	0.52	0.67										
RMD	0.21	0.26	0.22	0.44	0.32	0.54	0.55	0.46	0.58	0.27	0.22	0.17	0.26	0.27	0.34	0.31	0.23	0.37	0.44	0.37									
TNL	0.20	0.20	0.20	0.32	0.23	0.31	0.29	0.26	0.32	0.20	0.17	0.12	0.19	0.19	0.34	0.24	0.26	0.26	0.27	0.20	0.50								
TTK	0.18	0.20	0.20	0.29	0.21	0.29	0.31	0.26	0.32	0.20	0.18	0.11	0.16	0.16	0.30	0.20	0.22	0.23	0.22	0.19	0.58	0.71							
KYK	0.23	0.22	0.24	0.26	0.22	0.26	0.23	0.23	0.28	0.20	0.19	0.17	0.20	0.24	0.29	0.25	0.25	0.23	0.25	0.21	0.30	0.52	0.37						
MDR	0.22	0.26	0.23	0.34	0.34	0.36	0.32	0.24	0.47	0.34	0.29	0.32	0.41	0.40	0.49	0.48	0.34	0.48	0.39	0.31	0.52	0.39	0.37	0.31					
THN	0.16	0.20	0.19	0.27	0.23	0.26	0.22	0.16	0.33	0.25	0.23	0.23	0.31	0.31	0.51	0.38	0.35	0.36	0.29	0.20	0.39	0.43	0.34	0.31	0.56				
SVG	0.21	0.27	0.24	0.37	0.31	0.44	0.39	0.30	0.51	0.31	0.27	0.25	0.33	0.32	0.41	0.38	0.30	0.44	0.41	0.35	0.64	0.43	0.42	0.32	0.67	0.46			
VRD	0.19	0.22	0.21	0.27	0.24	0.27	0.23	0.18	0.35	0.27	0.24	0.20	0.26	0.27	0.45	0.33	0.29	0.35	0.28	0.20	0.50	0.49	0.50	0.27	0.61	0.58	0.57		
DND	0.28	0.34	0.31	0.46	0.42	0.51	0.44	0.36	0.56	0.41	0.36	0.34	0.48	0.45	0.55	0.52	0.42	0.59	0.49	0.39	0.58	0.43	0.41	0.31	0.63	0.59	0.62	0.56	

Legend: 0.8 or more; 0.70 - 079; 0.60 -069; 0.50- 0.59; less than 0.49

Table 3 Tamil Nadu Northeast monsoon rainfall during 1896 - 1996: Inter district correlations

4.2 Inter-relations between districts:

The correlation coefficients among the 29 districts are calculated and given in table 3. In the table, rows and columns are 29 districts (the abbreviated name is found in the axis). The value in each of the grid is the CC between corresponding district's daily rainfall. The value of CC, which is more than 0.5, is shaded in different colours and the colour scale is shown at the bottom of the table. From the figure it is found that (a) Chennai, Kanchipuram and Tiruvallur, (b) Nagapattinam, Thanjavur & Tiruvarur (Cauvery delta districts), and (c) Vellore and Thiruvannamalai form three different groups having inter district correlations of more than 0.8. They are characterised with more or less same daily rainfall patterns and can be treated as homogeneous regions in character in restricted sense. The three districts of north coastal Tamil Nadu viz., Tiruvallur, Kanchipuram, Chennai and the six districts of central coastal region, Thanjavur, Pudukottai, Cuddalore, Nagapattinam and Tiruvarur and Perambalur form two different groups having a high correlation of more than 0.7 (within the group). Also the groups (a) Madurai and Dindugul, Karur and (b) Namakkal, Salem and Namakkal, Dharmapuri and Salem, Vellore and (c) Tiruvannamalai, Cuddalore and Villupuram are having Inter district correlations of greater than or equal to 0.6. The groups comprising (a) the six districts of Villupuram, Thiruvannamalai, Vellore, Kanchipuram, Chennai and (b) the eight districts of Nagapattinam, Thanjavur, Tiruvarur, Pudukottai, Tiruchirapalli, Perambalur, Villupuram and Cuddalore and (c) the two districts of Toothugudi and Tirunelveli (d) the districts, Erode, Salem, Karur and Namakkal and (e) the districts Madurai, Sivaganga and Dindugul form five different groups having correlation greater than 0.5. They are not independent groups but are interconnected to each other. The correlation between northeastern districts with northwestern districts is low. It is found that the north interior districts Vellore, Dharmapuri, Namakkal, Salem and Tiruchirapalli are less correlated with daily rainfall of south coastal districts of Toothukudi and Tirunelveli.

4.3 Variability within the districts

The mean monthly and seasonal rainfall of all available 173 stations in Tamil Nadu is studied and the minimum and maximum rainfall recorded in Tamil Nadu is tabulated in table 4. In October, the lowest mean rainfall of 107.3mm was recorded at Cheramandevi in Tirunelveli district and the highest rainfall of 291.2 mm was recorded at Chennai (Nungambakkam).

Month/ season	Minimum rainfall		Maximum rainfall	
	Amount (mm)	Station	Amount (mm)	Station
October	107.3	Cheramandevi	291.2	Nungumbakkam
November	67.7	Thalli	468.0	Vedaranyam
December	16.4	Thalli	261.7	Vedaranyam
NE monsoon season	241.8	Hosur	1001.7	Vedaranyam

Table 4 Minimum and maximum rainfall in Tamil Nadu during NEMS (from 1896 to 1996): Stations and Rainfall

In November and December, the lowest rainfall of 67.7 and 16.4 mm were recorded at Thalli in Dharmapuri district. Hosur in Dharmapuri district has recorded the lowest rainfall of 241.9 mm during NE monsoon season. Vedaranyam, a coastal station in Nagapattinam district has recorded the highest mean rainfall in the month of November and December and in the NE monsoon season.

5. Trend and periodicity in monthly and seasonal rainfall

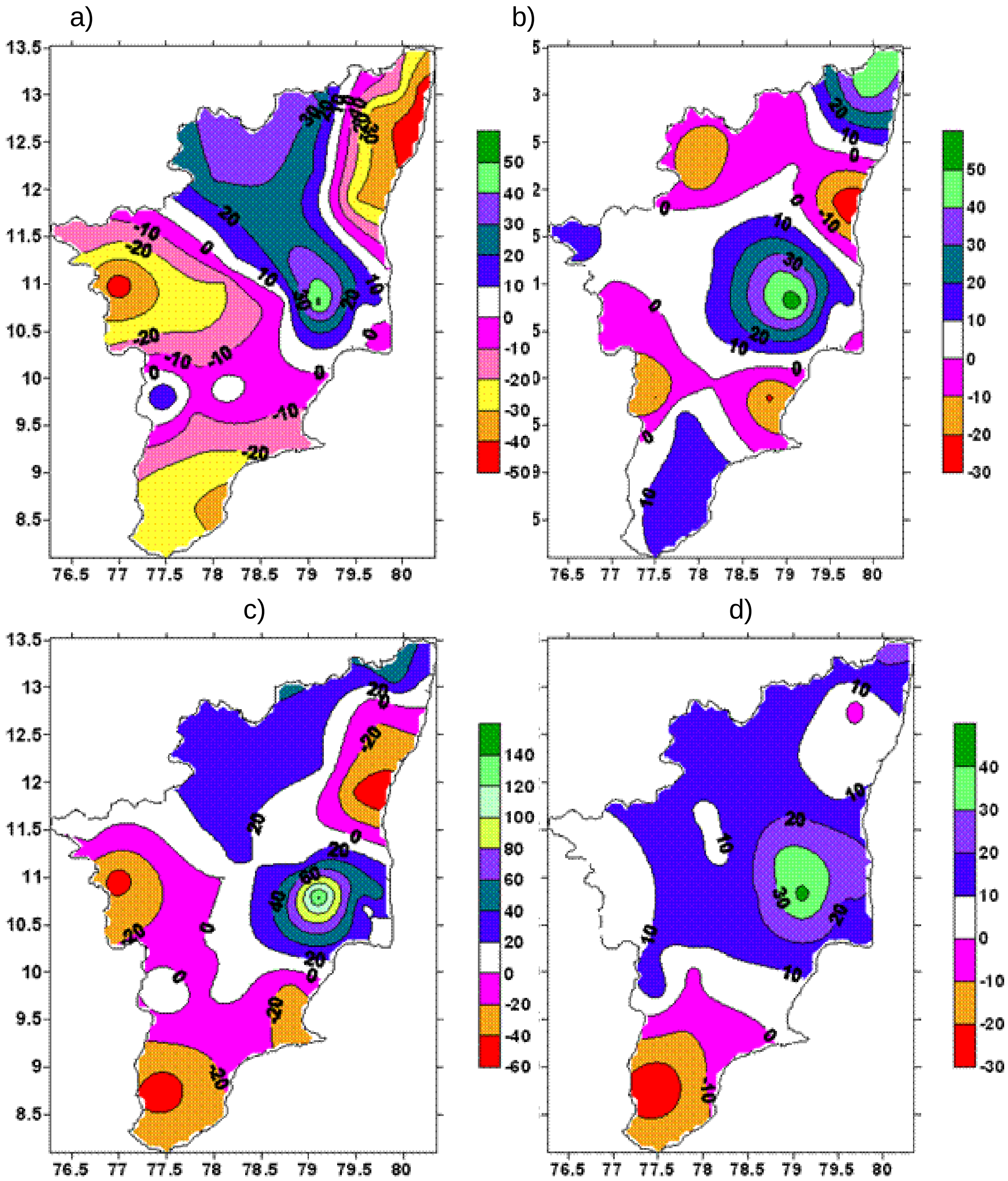
In October, a decreasing tendency of 3.9 mm in 10 years in the rainfall of TN is noticed. But there is an increasing tendency of 6.2 mm, 9.9 mm, 7.5 mm per 100 years is seen in the rainfall of Tamil Nadu in the months of November, December and NE monsoon season respectively. Table 5 shows the number of districts having increasing or decreasing tendency of rainfall in the months of October, November, December and NE monsoon season. About 66 % districts showed a decreasing tendency in the rainfall of October and more than half the number of districts showed an increasing tendency in the rainfall trends of November, December and NE monsoon season. Based on Mann- Kendall test, the trend is checked for significance. It is found that the trend in the rainfall of all districts in the month of October, November, December and NEMS are not significant Figure 2.(a) shows the tendency of rainfall in the October month. There is a decreasing tendency in south and western Tamil Nadu and northeast Tamil Nadu. An increasing tendency is seen in east central and NW parts of Tamil Nadu. Maximum increasing tendency is found in Perambalur, Thanjavur and Dharmapuri districts.

	Number of districts			
	Oct	Nov	Dec	Season
Increasing tendency	10	19	23	17
Decreasing tendency	19	10	6	12

Table 5. Frequency of districts that are having increasing / decreasing tendency of rains in NEMS for the period 1896- 1996.

Fig. 2(b) shows the tendency in the rainfall of November. From the figure, extreme northeast, southern part of TN and central parts of TN show an increasing trend. Coastal parts of Tamil Nadu (Villupuram, Cuddalore districts), NW Tamil Nadu, west and SW parts show decreasing tendency in the rainfall of November month. Fig. 2 (c) shows the tendency of total rainfall in the month of December. Major parts of TN except south and NE Tamil Nadu show an increasing tendency in the monthly total rainfall of December. Fig. 2(d) shows the tendency of total rainfall in the NE monsoon season. Southern and western Tamil Nadu except small pocket of Theni district shows decreasing tendency.

Spectrum analysis was done to see the periodicity in the rainfall of Tamil Nadu. The periodicity of 2.08 years is seen in rainfall of October, December and NEM season and periodicity of 2.38 years is seen in the rainfall of November. It is observed that a long term 11.1-year cycle is also seen in the rainfall of October.



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DR. JOANNE SIMPSON (1923-2010) - A LEGACY

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March 23 is the day celebrated as World Meteorological Day since 1950, but way back in 1923, on this day there was a little baby girl who came into the world at Boston, Massachusetts, USA without a trace of the fact that she will go on to leave her footprints in the annals of the history of meteorology as the ***first ever woman meteorologist to receive a Ph.D in Meteorology.*** She is Dr. Joanne Simpson, a world-renowned atmospheric scientist whose accomplishments in the field of Tropical Meteorology speak volumes about her valuable contributions. I wonder if the number 23 has anything to do with women meteorologists whom I revere and admire, but it is a fact that another eminent scientist in Meteorology and Instrumentation in India, Miss Anna Mani, was also born on 23 Aug in 1918.

Dr. Joanne Simpson

As a woman meteorologist, I think it is my bounden responsibility to pay a special tribute to Dr. Joanne Simpson who passed away, after a brief illness, on 4 March 2010, at the age of 87, in Washington, USA. She is an inspiration to us who despite odds, by sheer dint of her persistence and hard work, achieved many laurels which few men of her times could accomplish. Joanne Simpson came from humble beginnings and did not have an ideal childhood. Like all great people who come up and shine as stars due to the forbearance they develop amidst life's trials and tribulations, she eventually became a renowned meteorologist who developed the first scientific model of clouds.

Joanne developed interest in clouds and weather when, as a child, she first learnt to sail. Later on, she took a course in Astrophysics in the University of Chicago and when she was training as a student pilot she studied a paper in meteorology. She was fascinated with the subject and her breakthrough came when she met Carl Gustaf Rossby (An unparalleled and greatest meteorologist) who had arrived in University of Chicago to set up an Institute for Meteorology.

The rest, as they say, is history. She joined as a teacher-in-training for the aviation cadets, in the Meteorology Programme of the Second World War. After the war ended, when she wanted to pursue doctoral work in clouds, Carl Rossby told her that no one else was very interested in the topic, so it was a good subject “for a little girl to study.’’ Herbert Riehl (another great meteorologist) agreed to be her advisor, and she began working on cloud research at the University of Chicago. After she received her doctorate in 1949, she and Riehl wrote several landmark papers about hurricanes and tropical meteorology.

In 1951, she became a research meteorologist at the Woods Hole Oceanographic Institute in Massachusetts, USA, where with the help of a slide rule, she constructed some of the first mathematical models of clouds. Joanne Simpson’s career spanned for over six decades, from field research aboard an aircraft in the Tropical Pacific to her work with satellite data at NASA Goddard Space Flight Centre in Greenbelt, where she was the Chief Scientist for Meteorology. She made many significant discoveries, led research projects and influenced generations of scientists. She discovered what keeps hurricanes whirling forward and revealed what drives the atmospheric currents in the tropics.

In her own words, her most important professional achievement came near the end of her long career, when NASA in 1986 asked her to lead the science study for the proposed **Tropical Rainfall Measuring Mission (TRMM)**. The joint mission with the Japanese Space Agency has been instrumental in helping meteorologists to learn how hurricanes evolve in the Atlantic, how dust and smoke can drastically influence rainfall and how to estimate latent heat released by tropical cloud systems.

Now, women are making their mark in all walks of lives and seem to have broken the proverbial glass ceiling. It is comparatively a better scenario where a woman is treated on par with a man when she takes efforts to prove that she is a woman of substance. But during the days of Joanne Simpson, it was never an easy job. She was quoted as saying: "I have experienced three different classes of gender related problems in my lifetime. The first is discrimination simply from being a woman. The second comprises difficulties from being a married woman. The third arises from being a mother" and yet... she didn't let it stop her from achieving in her lifetime all the things she achieved as a wife, as a mother and emerge as a pearl among tropical meteorologists. She was candid about the number of obstacles she had to overcome. She was a simple and at the same time a tough and focused meteorologist who knew what she wanted and yet had a heart of gold.

"Any comparison between the way it was when I started and the way it is now is like comparing the covered wagon with a jet plane. But this doesn't mean that women don't still have obstacles to overcome," Dr. Joanne told the Christian Science Monitor in 1989. It is noteworthy to mention here that Miss Anna Mani (1918-2001), Indian Meteorologist who breached gender barriers in science and who never received a doctoral degree, despite her achievements, repudiated the sense of victimhood throughout her career. She once said, "My being a woman had…..no bearing on what I chose do with my life. What is this hoopla about women and science?".

Dr. Simpson, who was the first female President of the American Meteorological Society, received its highest honour, the Carl-Gustav Rossby Research Medal, in 1983. In 2002, she was awarded the prestigious International Meteorological Organisation Prize. She was the first woman to receive the award. Bob Simpson, her husband, was Director of the U.S. National Hurricane Centre. To a generation of meteorologists, his name is synonymous with hurricanes. He is the Simpson in the "**Saffir-Simpson scale**" which is used world over to assess the intensity of hurricanes in USA. One more feather in his cap is to be called as Dr. Joanne's husband.

The empowerment of women has been one of the greatest social changes of our times. While there is reason to celebrate the rise of woman in all her avatars, there is still a long way to go, especially in the field of science. Scientists like Dr. Joanne Simpson are beacons to aspiring women meteorologists and I consider the following lines of John Henry Newman befitting to end this tribute to a brave lady who never feared to challenge convention. "**Lead Kindly Light, Lead Thou me on, I loved to choose and see my path but now lead Thou me on**".

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GENESIS AND INTENSIFICATION OF CYCLONE NISHA

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The Cyclone 'Nisha' which crossed Tamil Nadu coast on 27th November 2008 created significant impact on Tamil Nadu and the adjoining places of Tamil Nadu. The system produced extremely heavy rainfall over Nagapattinam, Thanjavur, Thiruvarur districts. Vedaranyam, Adiramapatnam, Karaikal, Thanjavur and Mannargudi received about 30 cm rainfall. The heaviest rainfall being 42 cm at Vedaranyam (Nagapattinam district) and 66cm at Orathanadu (Thanjavur District) on 26th & 27th respectively. Most of the dams & lakes in the above areas like Veeranam, Madurantakam etc reached their full capacity.

Rain continued to pound delta districts on 25, 26 & 27th continuously disrupting normal life and causing widespread inundation of paddy crops. The core delta districts of Nagapattinam, Thiruvarur, and Thanjavur bore the brunt. Standing Samba and Thaladi crops and paddy fields in delta districts, particularly in Thiruvarur, Thiruvaiyaru, Thiruvidaimarudur and Orathanadu blocks were submerged. Nearly 1 lakh hectares of samba & 25,000 hectares of thaladi were affected and To avoid confusion over several systems that may form at the same time, Here the favourable conditions for the genesis and intensification of 'Nisha' cyclone are studied and presented.

1. Brief history of Nisha

A Low pressure area (LOPAR) formed over Southwest Bay of Bengal off SriLanka coast and became well marked low pressure area on 24th evening. On 25th at 0300 UTC, the low pressure area lay over SriLanka at 1400 UTC and it concentrated into a Depression near latitude 81.0 °E and further intensified into a Deep depression at 1200 UTC at the same location. Moving in a Northwesterly direction, it was lying at 1800 UTC near latitude 9.5 °N and Longitude 80.5 °E. It further moved in a north westerly direction and further intensified into a cyclonic storm and lay centered at 0300 UTC of 26th near Latitude 10.5°N and Longitude 80.0°E. Moving slowly in a Northerly direction, it was located at 1500 UTC near Latitude 11.0 °N and Longitude 80.0°E. It remained practically stationary and crossed coast near North of Karaikal between 0000 and 0100 UTC of 27th November 2008. The system after crossing the coast maintained the intensity as cyclonic storm and lay centered at 0300 UTC about 50 Kms northwest of Karaikal. Moved in a north-westerly direction it weakened into a deep depression at 0900

UTC and further weakened into Depression at 1200 UTC and lay centered about 50 Kms Southeast of Dharmapuri and weakened gradually.

It took just 24 hrs for a well-marked low pressure area to intensify into a cyclonic storm. On 25th 0300 UTC the low lay over north SriLanka, by 0900 UTC it became Depression, by 1200 UTC Deep Depression and on 26th 0300 UTC, it has intensified in to cyclonic storm. The track of Nisha is given in figure 1

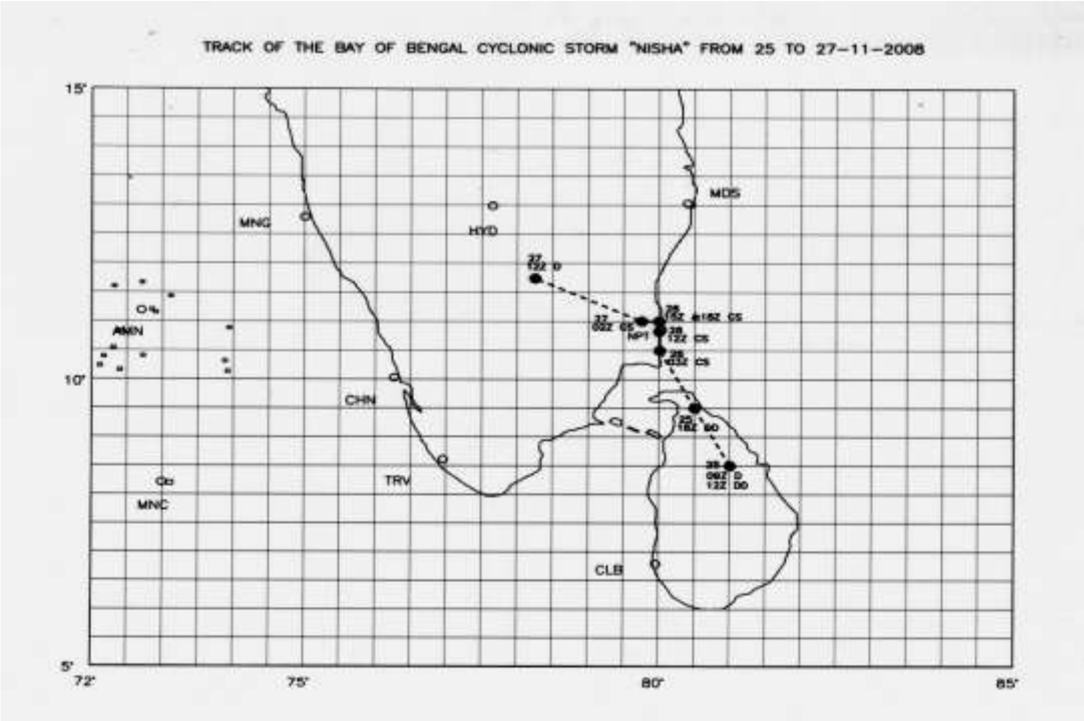


Figure 1 Track of cyclone 'Nisha'

2 Genesis and intensification, movement

Table 1 gives the location of the system, intensity of the system and the movement of the system. The system was as depression at 1430 IST of 25.11.2008 and intensified into a deep depression during the period 1730 IST of 25.11.2008 to 0530IST of 26.11.2008 and intensified further into a cyclonic storm from 1130 IST of 25.11.2008 to 0230 IST of 26.11.2008. It crossed the coast near Karaikal between 0630 IST and 0730 IST of 26.11.2008. The system was stationary between 1430 to 1730 IST of 24.11.2009, moved northwards from 1730 IST to 2030 IST, and tracked northwestwards from 2030 IST to 0530 IST, and moved northwards from 0530 to 1130 IST. On 25.11.2009, the cyclone was stationary from 1130 IST to 1730 IST and tracked northwards up to 0230 IST of 26.11.2008. Then the system moved westwards and crossed the coast.

Date	Time	System	Latitude	Longitude	Direction of motion	Speed of motion (m.p.s)
25.11.08	1430	Depression	8.5N	81.0E	000	00
25.11.08	1730	Deep depression	8.5N	81.0E	360	05
25.11.08	2030	Deep depression	9.0N	81.0E	315	07
25.11.08	2330	Deep depression	9.5N	80.5E	315	07
26.11.08	0530	Deep depression	10.0N	80.0E	360	05
26.11.08	1130	Cyclonic storm (Nisha)	10.5N	80.0E	000	00
26.11.08	1430	Cyclonic storm	10.5N	80.0E	000	000
26.11.08	1730	Cyclonic storm	10.8N	80.0E	360	03
26.11.08	2030	Cyclonic storm	11.0N	80.0E	360	02
27.11.08	0230	Cyclonic storm	11.0N	80.0E	270	05
27.11.08	0530	Cyclonic storm	North of Karaikal			
27.11.08	0830	Cyclonic storm	North west of Karaikal			
27.11.08	1430	Cyclonic storm	100Km east of Dharmapuri			
27.11.08	1730	Cyclonic Storm	50Kmsouth- east of Dharmapuri			
28.11.08	0530	Cyclonic storm	50Kmsouth- east of Dharmapuri			

Table.1 Position and direction of motion of 'Nisha'

3. Favourable conditions for Intensification

The favourable conditions of the atmosphere are studied and presented here.

3.1 Sea surface temperature (SST)

The first basic condition for a disturbance to attain cyclonic storm intensity is that the sea surface temperature must be greater than 26°C. Figures 2.1 and 2.2 displays SST distribution over the area between 70°E to 120°E and equator to 30°N for 24th, 25th, 26th and 27th November 2008. From the figures it can be seen that the SST over the Area, where the system was located, was above 27°C. Hence the sea surface temperature over the Nisha cyclone region was favourable for intensification

3.2 Low level relative humidity

Relative Humidity is the measure of moisture in the atmosphere and it is expressed in percentage. The second basic condition for any system to intensify in to a cyclonic storm is that low level relative humidity must be greater than 50%. Figure 3.1 and 3.2 depicts the RH distribution over the area from 75 to 100°E and from equator to 30°N at the surface and 1.5 km above mean sea level (a.m.s.l) on 24.11.2008, 25.11.2008 and 26.11.2008 . From the figures , it can be seen that the relative humidity over the cyclone area are more than 50% and hence relative humidity also favours the system to intensify as cyclonic storm.

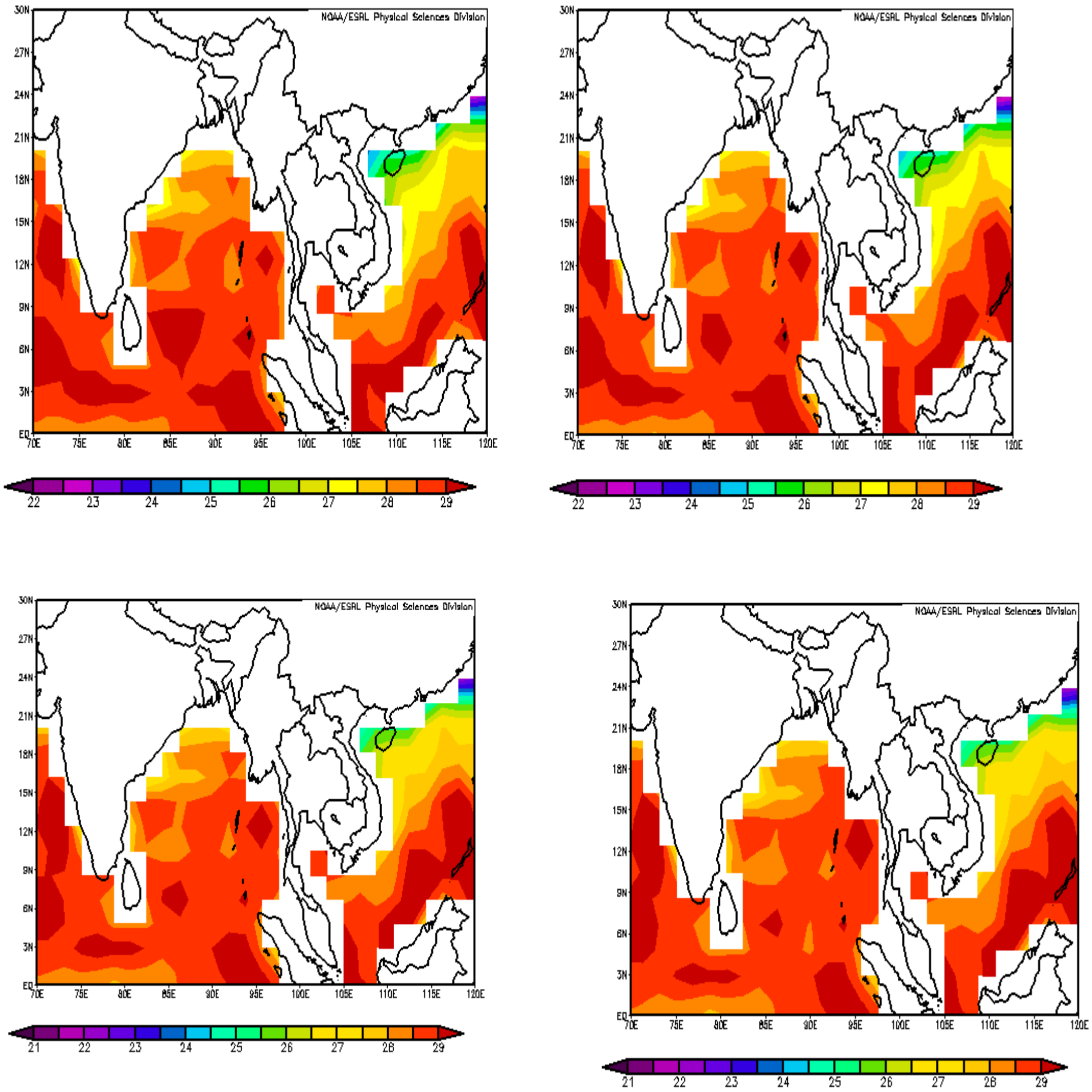
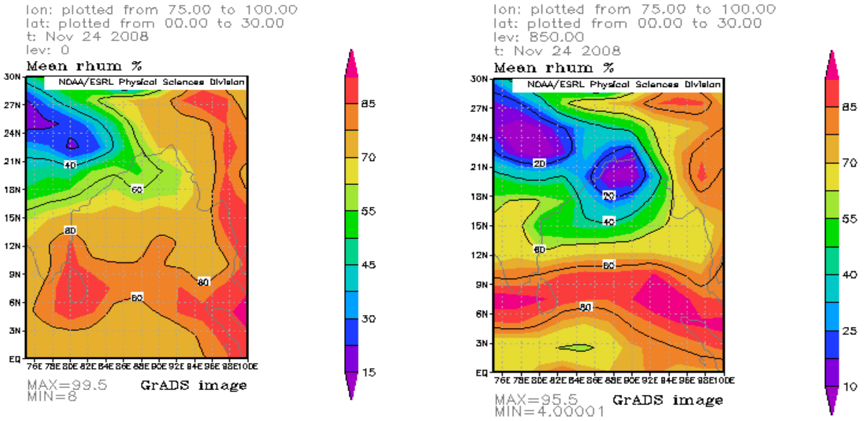


Figure 2.1 Pattern of Sea Surface Temperature in °C on 24,25th,26th and 25th November 2008



Surface **850 hPa**

Figure 3.1 Relative humidity distribution at surface and 850hPa(1.5 km a.m.s.l) at 0530 of 24.11.2009

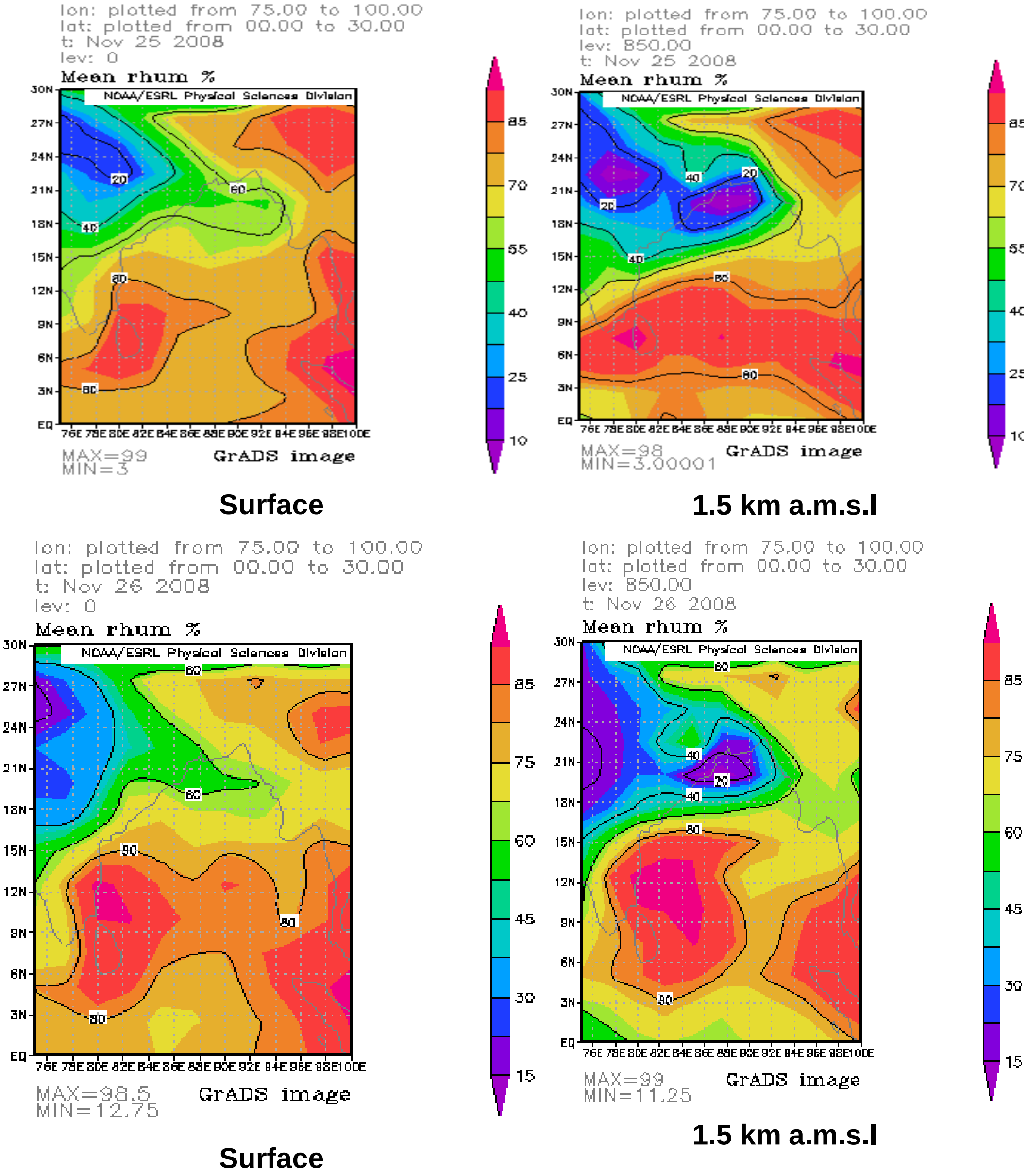


Figure 3.2 Relative humidity distribution at surface and 850hPa(1.5 km a.m.s.l) a
0530 of 25.11.2009 and 26.11.2009

3.3 Vertical wind shear.

Vertical wind shear of less than 10 m/s (20 kt, 22 mph) between the surface and the tropopause is favourable for a system to intensify into a tropical cyclone development. Strong wind shear can “blow” the tropical cyclone apart, as it displaces the midlevel warm core from the surface circulation and dries out the midlevel of the troposphere halting development. Figure 3.3 shows the vertical wind shear patterns over the area from 65-100°E and from equator to 30°N on 24.11.2008 to 27.11.2008. From the figures it can be seen that the vertical wind shear over cyclone area is less than 10 m.p.s. This implies that the vertical wind shear is also favoring the system to intensify into a cyclonic storm

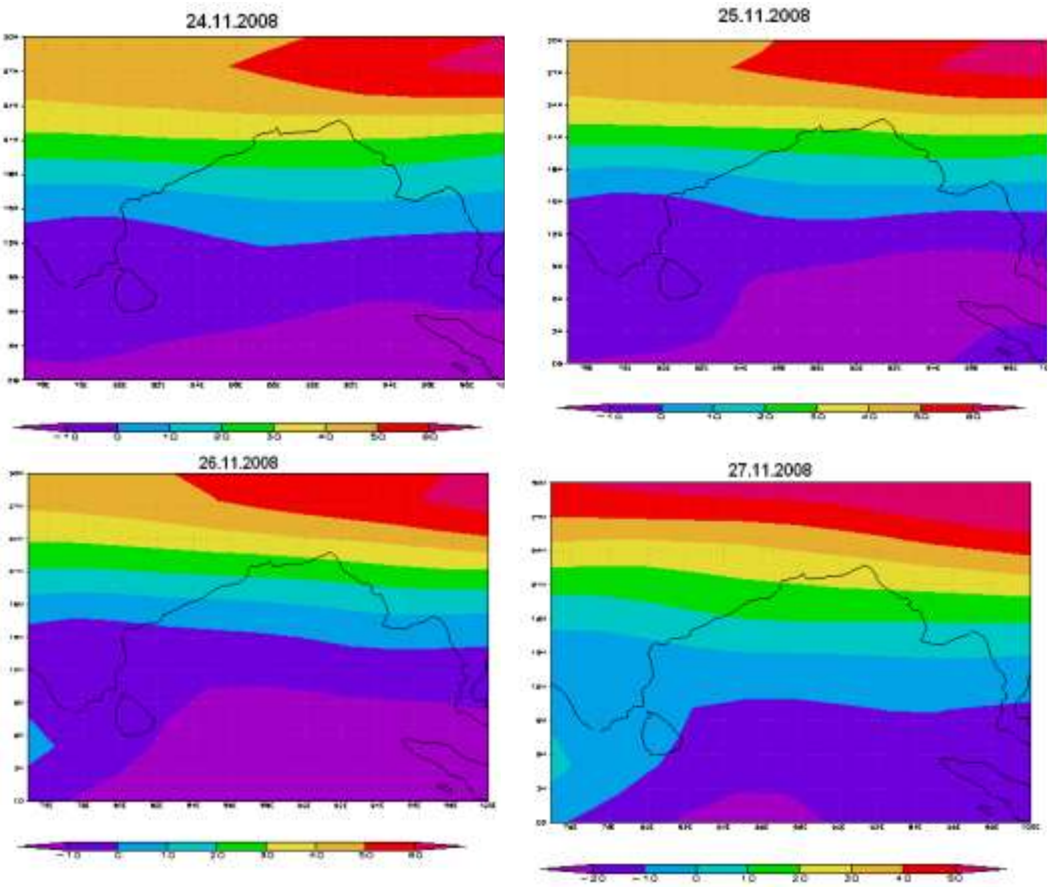


Figure 3.3 Vertical wind shear of zonal winds between 200 hPa and 925 hPa on 24,25,26 and 27th November 2008

3.4 Other conditions

The fourth condition is that 'tropical cyclones generally need to form more than 555 kilometres (345 mi) or 5 degrees of latitude away from the equator, allowing the Coriolis effect to deflect winds blowing towards the low pressure centre and creating a circulation". Lastly, a formative tropical cyclone needs a pre-existing system of disturbed weather, although without a circulation no cyclonic development will take place. Since the low pressure area over Sri Lanka was located north of 5°N on 24.11.2008, it intensified into a cyclonic storm 'Nisha'. Hence all the conditions are favourable for the formation and intensification of system into a cyclonic storm.

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ONCE IN A BLUE MOON

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The year 2010 started with a lot of media hype about the year beginning with a blue moon. One of the students who visited Regional Meteorological Centre around that time asked me “Whether moon will be blue on that day?”. I told him that it may not and explained him that a second moon in a calendar month is generally known as a ‘blue moon’. But when he asked again why a phrase like ‘once in a blue moon’ has a different meaning, I could not answer.

The modern definition of a blue moon is the common name given to the second full moon in a month. Since a full moon occurs every 29 ½ days, if there is a full moon on the 1st or 2nd day of a month, there is a good chance there will be a second full or blue moon that month. In 1999, there were two blue moons very close together, one on January 31st (after the full moon on Jan. 2nd) and the other on March 31st (after the full moon on March 2nd). There was another in November 2001, but not again until July 2004. There was a blue moon in May 2007 (and one in June 2007 for those in Europe and Asia), and December 2009. The next one will be August 2012, then July 2015. And we won't see two blue moons in one year again until 2018.

More traditionally, a blue moon was referred to as the **4th full moon in a season.** That is, each of the 4 seasons of the year has 3 months, and will usually have 3 full moons. Each of these 12 moons has a name like "Harvest Moon," "Hunter's Moon" and the like. But when a season occurs that contains 4 full moons, there is no name for this occasional moon and it was given the name, **"Blue Moon."**

Philip Hiscock of Memorial University of Newfoundland(MUN), Canada Folklore 7 Language archive has done considerable research on the meaning of the phrase. The phrase "blue moon" has been around a long time, well over 400 years, but during that time its meaning has shifted. Six different meanings have been carried by the term, and at least four of them are still current today.

The earliest reference to a blue moon is as an example of obvious absurdity about which there could be no argument. Four hundred years ago, if someone said, "He would argue the moon was blue," the average sixteenth century man would take it the way we understand, "He'd argue that black is white." This understanding of a blue moon being absurd (the first meaning) led eventually to a second meaning, that of "never."

But there are examples of the moon actually turning blue. That's the third meaning--the moon visually appearing blue. When the Indonesian volcano Krakatoa exploded in 1883, its dust turned sunsets green and the moon blue all around the world for the best part of two years. In 1927 a late monsoon in India set up conditions for a blue moon. And the moon in Newfoundland, Canada turned blue in 1951 when huge forest fires in Alberta threw smoke particles up into the sky. Even by the mid-nineteenth century it was clear that although visually blue moons were rare, they did happen from time to time. So the phrase "once in a blue moon" came about. It meant then exactly what it means today--that an event was fairly infrequent, but not quite regular enough to pinpoint. That's meaning number four, and today it is still the main one.

There are six English songs which use "blue moon" as a symbol of sadness and loneliness. In half of them the poor crooner's moon turns to gold when he gets his love at the end of the song. That is the meaning number five. Any one hearing the records of old Elvis Presley or Bill Monroe can listen the phrase blue moon in the songs meaning sadness. Finally, in the 1980s, came the most recent meaning of blue moon--the second full moon in a month.

With the volcano Eyjafjallajökull in Iceland pumping ash plumes in the atmosphere we may perhaps hear about a blue moon soon.

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ASSESSING THE YIELD LOSS OF FOOD CROPS UNDER CROP WEATHER RELATIONSHIP FOR INDIA

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1. Introduction

Assessing the yield loss under crop weather relationship is much needed in the present day for marketing weather-based crop insurance products by different crop insurance companies in India. Further in the event of climate change, though it is possible to predict yield for temperature rise through crop models, real estimation under field conditions is pivotal for taking viable farm decisions especially for food crops. This area lacks research information, but however, based on available literature, the insurance companies in India go with their product to help the farmers for reducing their crop weather risks. Venkataraman (1992) presented excellent information on weather relation of crops in their book on crops and weather but quantification was not given deliberately. But after that period, no honest efforts were undertaken by scientists. However National Centre for Medium Range Weather Forecast (NCMRWF) through its well-defined project across India documented crop economical losses for medium range weather forecast information.

The present need is to quantify the economical losses of crops to happen at different crop stages of its growth especially for food crops to different weather elements. The generated information would be very useful to take policy decisions for providing food security for India since the agricultural production depends on the performance of monsoon weather.

2. Climate and weather risks

Under Indian condition weather risks are most competitive as compared to climate risks. Further climate risks could be seen only with the introduction of new crops to India from other countries and also it is anticipated that under climate change scenario five climates under consideration get either reversed or forwarded as given below and for that necessary crop planning is required to reduce the climate risks.

Arid ↔ Semi Arid ↔ Sub humid (dry / wet) ↔ Humid ↔ Per humid

In the case of weather risks the following must be considered to reduce the risks.

- Weather sensitive nature of the crops
- Weather sensitive stages of the crops
- Weather sensitive farm operations
- Unseasonal appearance of extreme weather parameters
- Soil types and its physiographic pattern

3. Seasonal risks

Both inter seasonal and intra seasonal crop risks could be seen in *Kharif* and *Rabi* seasons and they are listed here under:

3.1. Inter-seasonal Risks (crops more than >120 days in duration and Fruit shrubs and Trees)

- Synergistic and antagonist impact of the seasons on the long duration crops and fruit trees with varying degrees of risks
- Under irrigated condition the inter seasonal risk would be lesser as compared to dry land situation
- The yield loss would be relatively lesser under intra seasonal risks as compared to inter seasonal risks

3.2. Intra-seasonal Risks (Crops < 120 days in duration)

The intra seasonal risks mainly depend on the nature of weather elements and crops raised.

3.2.1 Nature of weather elements

- Time of occurrence (crop stages)
- Intensity of the occurrence
- Magnitude of the occurrence
- Duration of the occurrence
- Unseasonal appearance of extreme weather parameters
- Their interaction with soil types and its physiographic pattern

3.2.2. Nature of crops

- Weather sensitive nature of the crops
- Weather sensitive stages of the crops
- Weather sensitive farm operations to be undertaken
- Further the intra seasonal risks are of varying with the seasonal performance of the weather and they are;
- Pre-season weather variability affects the timely preparatory-operation for all the crops under dry land / rain fed situation

- Sowing season weather variability causes sowing more than once in addition to delayed sowing
- Mid season weather variability imbalances the reproductive stage of the crops raised
- Terminal season weather variability will affect harvest of crops like groundnut in the absence of rainfall and sometimes because of heavy rainfall the quality of food crops and grains gets reduced.

Crop	Stage	Weather	Intensity and duration	Yield loss(%)
1. Rice	50%Flo-wering	Rainfall	>150mm for 3-5 days	40 to 50
	50%Flo-wering	Cloudiness	>6 okta continously for 3 to 5 days	40
	Post flowering	Radiation	<500 cal/day for 20 days	50
	Harvest	Cyclone weather	3 to 4 days	80
	50%Flo-wering	T . Min	< 18°C and continued for 7 days	50
	50 %flowering	T.Max	> 32°C and continued for 7 days	50
2. Ground nut	40 DAS	Dry spell	> 12 days	60
	Pod development	Soil temp	< 18°C for 10 days	60
	Harvest	Rainfall	<10 mm	50
3. Banana	7 to 10 months(bearing	Rain	> 90 mm for 3 days	40
	7 to 10 months(bearing	Wind	> 60 km for 2 days	60
	7 to 10 months(bearing	Rain and wind	> 90 mm for 3 days and > 60 km for 2 days	80
4. Soy bean	Flowering	T.Min	> 25°C for a week	90
5.Maize	Tasseling and silking	Wind	Rain> 60 mm and T.max > 32°C	50
6. Sorghum	Physiological maturity	Rain	> 60 mm for 3 days	60

Table 1. Estimated economical yield loss(%) for different field crops

4. Crop economical losses

Based on the experiences of the author in field research, interaction with farmers and knowledge gained, attempt has been made to quantify the yield loss of different crops and given in Table1 and this requires refinement through further research.

5. Conclusion

Intensive information generation is required in this field for planning and implementing development projects

Reference

Venkataraman, 1992, Weather relations of crops, 302-457, In Crops and Weather (Edts.Venkataraman and Krishnan), ICAR,New-Delhi,p.586.

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