Analysis of Tropical Cyclone and its Impact on Coastal Areas

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Abstract - The present study is behavior of Nilam cyclone analyzed. Most of the tropical cyclones that occur in India is due to low depression over Bay of Bengal. Low depression over bay of bengal on 27 Oct 2012 with in couple of day's strength of cyclone reached its maximum indicating and precipitation 59mm of rainfall, high wind speeds 18m/s with gust speed 23m/s and squall. There is a difference of 5 hPa to 10 hPa from 27 Oct 2012 to 2 Nov 2012 due to which cyclone developed. Thus it concluded that improper alertness of disaster management also contributes the heavy loss of lives and damage of property and to Pro-active preparation for disaster mitigation which will include engineering, social and legal measures.

Key words: cyclone, Tropical, Disaster, Wind & Monsoon

I. INTRODUCTION

Tropical cyclone, also called typhoon or hurricane, an intense circular storm that originates over warm tropical oceans and is characterized by low atmospheric pressure, high winds, and heavy rain. Drawing energy from the sea surface and maintaining its strength as long as it remains over warm water, a tropical cyclone generates winds that exceed 119 km (74 miles) per hour. In extreme cases winds may exceed 240 km (150 miles) per hour, and gusts may surpass 320 km (200 miles) per hour. Accompanying these strong winds are torrential rains and a devastating phenomenon known as the storm surge, an elevation of the sea surface that can reach 6 metres (20 feet) above normal levels. Such a combination of high winds and water makes cyclones a serious hazard for coastal areas in tropical and subtropical areas of the world.

Tropical cyclones are one of the deadliest and costliest weather phenomena worldwide. As a killer, tropical cyclones are far ahead of many other natural disasters. Almost all these storms form within 25° latitude on both sides of the equator except over the 5 °N to 5 °S equatorial region. However, the genesis of tropical cyclones over the Indian seas is highly seasonal, with primary maximum inthe post-monsoon season (mid-September to December) and secondary maximum during the pre-monsoon season (June to September). The post-monsoon storms are more devastating in nature. As a storm intensifies from a loosely organized state, it passes through several stages. Based on pressure drop and maximum sustainable surface wind, the World Meteorological Organization (WMO) broadly classifies the tropical cyclones over the Indian Seas into seven categories and the same is provided in Table 1. These classifications are also used by the India Meteorological Department (IMD), New Delhi.The Bay of Bengal (BoB) is a potentially active region for the formation of tropical cyclones.The Bay of Bengal, located north of the Indian Ocean, is responsible for the formation of some of the strongest and deadliest tropical cyclones in the world. The basin is abbreviated BOB by the India Meteorological Department (IMD), the official Regional Specialized Meteorological Center of the basin. The Bay of Bengal's coast is shared among India, Bangladesh, Myanmar, Sri Lanka and western part of Thailand.

1.1 Theory

A warm core, non-frontal, synoptic scale system with cyclonically rotating winds characterized by a rapid decrease in pressure and increase in winds toward the center of the storm. Cyclones develop over tropical or subtropical waters and have a definite organized circulation (Fig.1).

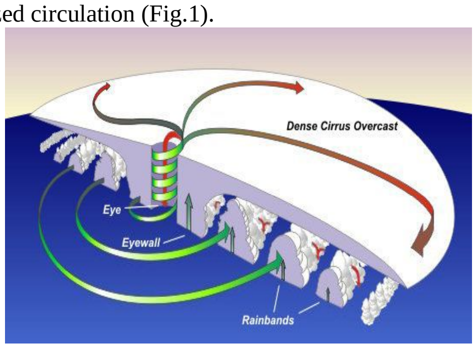


Fig 1. Tropical Cyclone Description

1.2 Tropical Cyclone Formation

- Warm Ocean waters (at least 80°F / 27°C).
- An atmosphere which cools fast with height (potentially unstable).
- Moist air near the mid-level of the troposphere (16,000 ft / 4,900 m).
- Generally a minimum distance of at least 300 miles (480 km) from the equator.
- A pre-existing near-surface disturbance.
- Little vertical wind shear between the surface andthe upper troposphere. (Vertical wind shear is the change in wind speed with height.)
- Outflow aloft/exhaust

Table 1. World Meteorological Organization (WMO) Classification of Tropical Cyclone

S.No	Category of System	Pressure Drop (hPa)	Maximum Wind Speed knot (kmph)
1	Low (L)	<1.43	< 17 (< 32)
2	Depression (D)	1.43-3.61	17 - 27 (32-50)
3	Deep Depression (DD)	3.91-5.40	28 - 33 (51-61)
4	Cyclonic Storm (CS)	5.73 – 10.95	34 – 47 (62-88)
5	Severe Cyclonic Storm (SCS)	11.43 – 19.68	48 – 63 (89 – 117)
6	Very Severe Cyclonic Storm (VSCS)	20-49	64 – 119 (118-220)
7	Super Cyclonic Storm (SUCS)	≥ 50	≥ 120 (≥ 221)

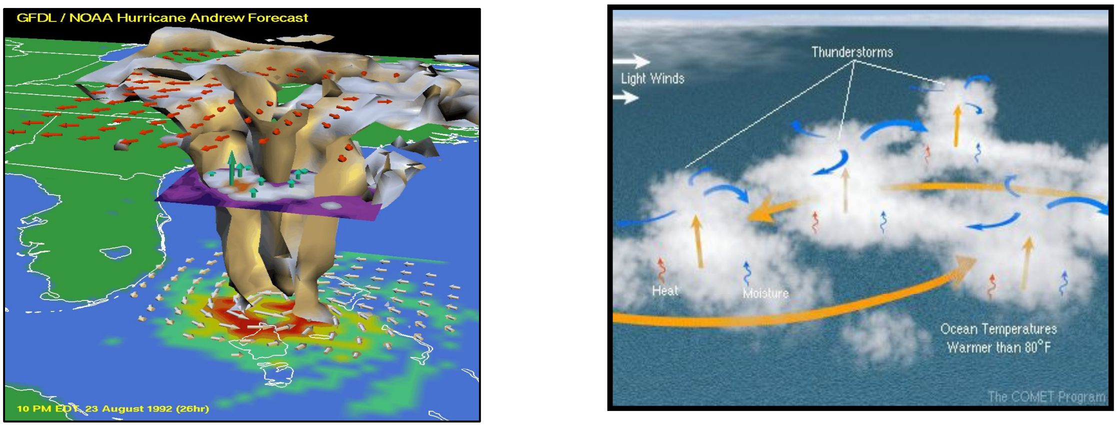


Fig 2. Favorable environmental conditions in tropical cyclone is shown in:

II. REVIEW STUDIES

Many scientists of today have been trying to quantify climate change and its relation with other environmental systems. Early investigators (e.g. Riehl, 1950, Kleinschmidt, 1951) established that mature tropical cyclones are maintained against frictional dissipation by enthalpy (heat) transfer from the ocean to the atmosphere.It has been shown (e.g. Emanuel, 1989) that tropical cyclones cannot arise spontaneously but must be set off by some independent process or processes. Understanding those processes is an important endeavor known as the “genesis problem” in the science of tropical cyclones. Arguably one of the most heavily dependent upon weather system is the monsoon seasons Southeast Asia. In Southeast Asia the link between global warming and the seasonal atmospheric flow during the monsoon seasons shows varying degree of fuzziness. A large majority of the Indian cyclones typically form over the head of the Bay of Bengal, move northwestward, andhave a life cycle of 3–6 days and a length scale of about1000–2000 km (Mooley 1973; Mooley and Shukla 1987; Krishnamurti et al. 1975; Godbole 1977; Sikka 1977).

The pattern of Indian cyclones is investigated to understand their effect and impact on rainfall distribution and vulnerability during the southwest and northeast monsoon season. In recent years, the erratic and unpredictable nature of the monsoons have caused extensive financial loss, damage to lives and property and also the destruction of the environment and farmlands. This consequently leads to food insecurity issues. It has thus, become a priority to predict and understand monsoon rainfall patterns in many Asian countries (Reuter et al., 2012).The India Meteorological Department (IMD) classifies LPS as lows, depressions,and so forth, based on peak surface wind speeds estimated from maps of surface pressure (Raghavan and Rajesh2003; Sikka 2006),. Reported trends in LPS include an increase in the number of severe cyclonic storms over the north IndianOcean (Webster et al. 2005); however, these severe cyclonic storms generally appear in the pre and post-monsoon seasons. A decreasing trend in the frequency of depressions and cyclonic storms since 1970 has also been noted (Kumar and Dash 2001; Sikka 2006, and references therein), which is puzzling in view of the increasing trend in ERE.

Using a long data set of gridded rainfall and statistics of low pressure systems over India, the impact of LPSs on precipitation pattern has been studied by Krishnamurthy and Ajaymohan 2010 in detail.It is shown that the rainfall composite pattern of LPS days represents the most dominant pattern of precipitation variability. During LPS days, the monsoon trough and the low-level horizontal winds are strengthened, and central India and north west Indian receive copious rainfall. Moreover, the orographic rainfall over the Western Ghats is also strengthened duringLPS days. The southeast India and northeast India receive more rainfall during non-LPS days.Raindrop size distributions (RSD) with PARticle SIze VELocity (PARSIVEL) disdrometer deployed at semi-arid region kadapa city in Andhra Pradesh during JAL and NILAM cyclone by Amrutha et. al., 2014. Study showed that small and mid drops below 2mm diameters have higher concentrations in JAL and NILAM Cyclones. During Nilam cyclone estimated sea level pressures over Bay of Bengal is studied using OSCAT by Purnachand et. al., 2014. Estimated pressures are compared with moored buoy observations and inferred that the pressure differences are closer to in-situ observations than those which are examined with University of Washington Planetary Boundary Layer (UWPBL) numerical model estimations.

III. Objective

The Present paper is an effort to understand weather phenomenon during NILAM cyclone in Chennai coastal region. Response of tropical cyclones to changing climate should be aided by a better understanding of the factors that control their rate of generation, their intensification, and their demise, as well as related phenomena such as flood and storm surges. Development and testing of comprehensive theories for these and other aspects of tropical cyclones is of fundamental scientific interest, and also is needed to help us predict how climate change might affect tropical cyclones and their effects on society.

3.1 Study Area

Chennai is the capital city of the Indian state of Tamil Nadu. Located on the Coromandel Coast of the Bay of Bengal, Chennai has a tropical wet and dry climate The city lies on the thermal equator and is also on the coast, which prevents extreme variation in seasonal temperature. The hottest part of the year is late May to early June, known locally as Agni Nakshatram ("fire star") or as Kathiri Veyyil, with maximum temperatures around 35–40 °C (95–104 °F). The coolest part of the year is January, with minimum temperatures around 15–22 °C (59–72 °F). The lowest temperature recorded is 13.8 °C (56.8 °F) and the highest recorded temperature is 45 °C (113 °F). The average annual rainfall is about 140 cm (55 in). The city gets most of its seasonal rainfall from the north–east monsoon winds, from mid–October to mid–December. Cyclones in the Bay of Bengal sometimes hit the city. According to the report of Ramakrishna 2006, highest annual rainfall recorded is 257 cm (101 in) in 2005. Prevailing winds in Chennai are usually southwesterly between April and October ("NASA climate data visualized" Dec 2012) and north-easterly during the rest of the year. Historically, Chennai has relied on annual monsoon rains to replenish water reservoirs, as no major rivers flow through the area. Chennai has a water table at 2 metres for 60 percent of the year (Ayyappan 2012).

In the present paper effect of Nilam cyclone on Chennai coastal city is studied. It has originated from the area of low pressure over Bay of Bengal on October 28, 2012 the system began as a weak depression 550 km (340 mi) northeast of Trincomalee, Sri Lanka. Over the following few days, the depression gradually intensified into a deep depression, and subsequently a Cyclonic Storm by October 30. It made landfall near Mahabalipuram on October 31 as a strong Cyclonic Storm with peak winds of 85 km/h (50 mph).In Chennai's Marina Beach, strong winds pushed piles of sand ashore and seawater reached nearly a 100 m (330 ft) inland [From Wikepedia].

3.2 Data

Weather data is taken from internet from weather underground website is used and sounding data is taken from Wyoming University website.

IV. Results and Discussion

In the present paper, study of tropical cyclone occurred in coastal area is made to analyze the damage that occurs in coastal areas during cyclones in pre and post monsoon seasons. Several studies have examined the stronger LPS in the context of environmental factors believed to govern the frequency of LPS formation. It has been found that, although increasing BoB SST should favor LPS formation, other trends, including decreasing cyclonic low-level vorticity, increasing vertical wind shear, and decreasing midtropospheric moisture, appear to be acting oppositely (Rajeevan et al. 2000; Mandke and Bhide 2003; Dash et al. 2004; Pattanaik 2005; Pattanaik and Rajeevan 2007). Some of these changes are consistent with an observed southward shift in the low-level jet that supplies south Asian monsoon rainfall with moisture generated over the southern Indian Ocean and Arabian Sea (Joseph and Simon 2005). A strong connection has also been noted between the frequency of monsoon season BoB storms and the strength of the upper-level tropical easterly jet over southern India (Rao et al. 2004).

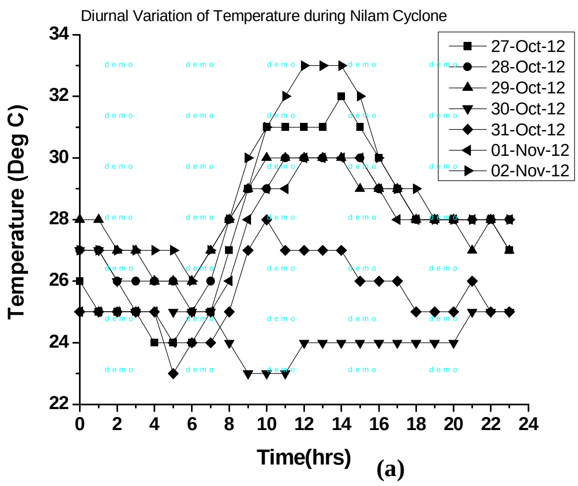
This study is made to analyze the behavior of tropical cyclone Nilam that occurred in Bay of Bengal from 27 Oct 2012 to 2 Nov 2012. On 28 Oct 2012 low pressure developed over Bay of Bengal and it became weak depression in the northeast of Srilanka. After couple of days the depression gradually intensified into a deep depression and subsequently turned into cyclonic storm by 30 Oct 2012 and it made landfall near Mahabalipuram on 31 Oct 2012. The cyclone track is shown in Fig 3.

Fig 3. Map plotting the track and intensity of the storm according to the Saffir–Simpson hurricane wind scale

4.1 Diurnal variation of meteorological parameters

Nilam cyclone is developed over Bay of Bengal on 28 Oct 2012. Diurnal variation of meteorological parameters during cyclone period i.e., from 27 Oct 2012 to 2 Nov 2012 is shown in Fig 4. Throughout the cyclone period after sunrise from 6am temperatures started increasing as shown in Fig 4(a) due to increase in solar radiation until 15:00 hrs and after that temperatures decreased due to decrease in solar radiation with respect to time. The temperatures are observed constant throughout night. From 27 Oct 2012 to 31 Oct 2012 there is a fall in temperature from 1oC to 3oC due to cyclone effect. On 30 Oct 2012 and 31 Oct 2012 there is temperature drop of 4 oC to 5 oC compare to other days thus indicating intensity of cyclone. In the same way relative humidity is maximum during nights and less during day time as seen in Fig 4(b). 90% to 100% relative humidty is observed on 30 Oct 2012 & 31 Oct 2012. Diurnal variation of wind speed is shown in Fig 4(c). Maximum wind speeds 8-18 m/s are observed in daytime compared to night times 2 – 7m/s. Calm winds are observed throughout night except on 31 Oct 2012. Maximum wind speed 18 m/s is observed on 31 Oct 2012. Low Pressures are observed during the cyclone period. There is a difference of 5 hPa to 10 hPa from 27 Oct 2012 to 2 Nov 2012. This shows that the intensity of cyclone is observed on 31 Oct 2012 as low temperatures, high wind speeds and low pressures are observed. On 1 Nov 2012 the intensity of cyclone gradually reduced and made landfall on 2 Nov 2012.

Fig 5(a) shows maximum and minimum temperatures observed from 27 Oct 2012 to 02 Nov 2012. There is a difference of 2 oC to 8 oC in a day and maximum wind speed 18 m/s is observed as shown in Fig 5(b) on 31 Oct 2012 which also indicates maximum intensity of cyclone. During this period squall and gusty wind speed 23m/s is also observed on 31 Oct 12. Throughout the cyclone speed max relative humidity is above 90% to 100% as shown in Fig 5(c). Low pressures are observed during cyclone period 999hPa to 1009hPa. On 31 Oct 2012 low pressure of 999hPa is observed.



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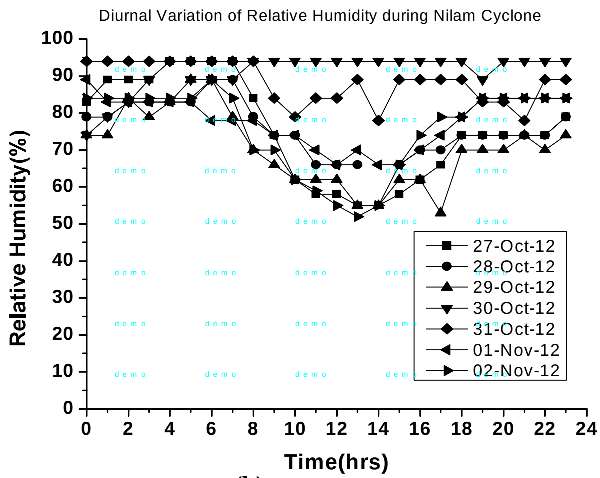

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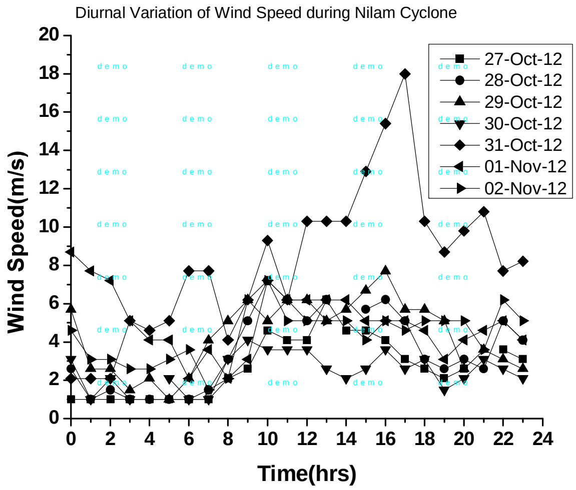

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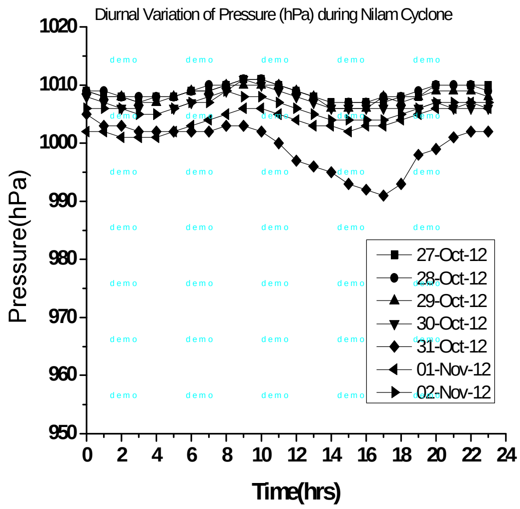

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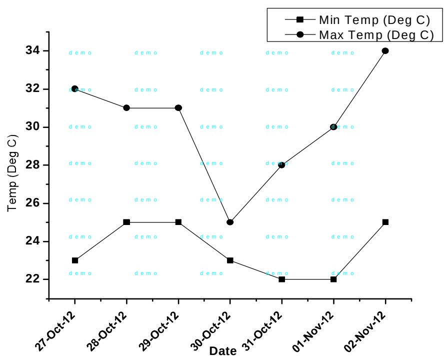
Fig 4: Diurnal variation of meteorological parameters during Nilam Cyclone (27-Oct-2012 to 02-Nov-2012



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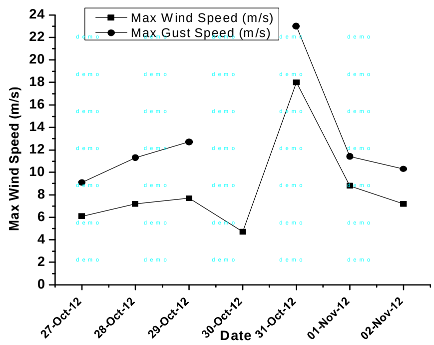

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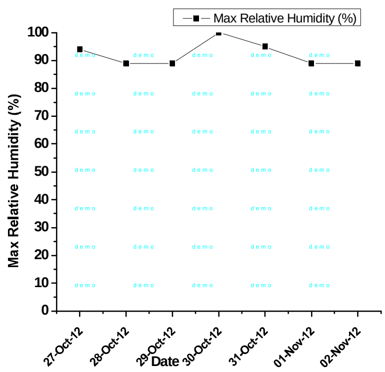

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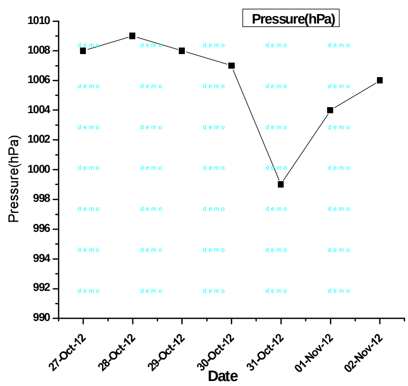

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Fig 5. Maximum and Minimum values of meteorological parameters during Nilam Cyclone (27-Oct-2012 to 02-Nov-2012

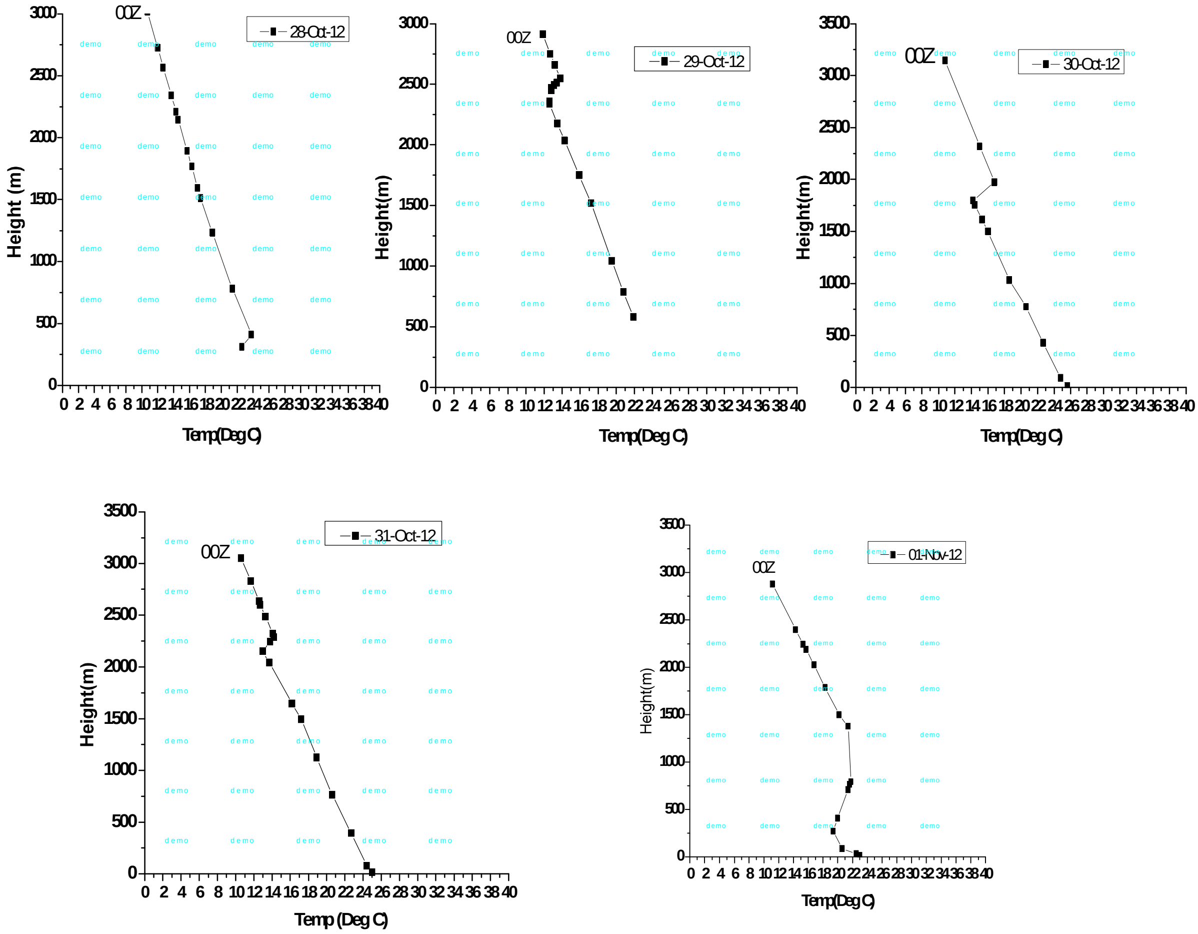

Fig 6. Temperature profiles during Nilam Cyclone (28-Nov-2012 to 01-Nov-2012)

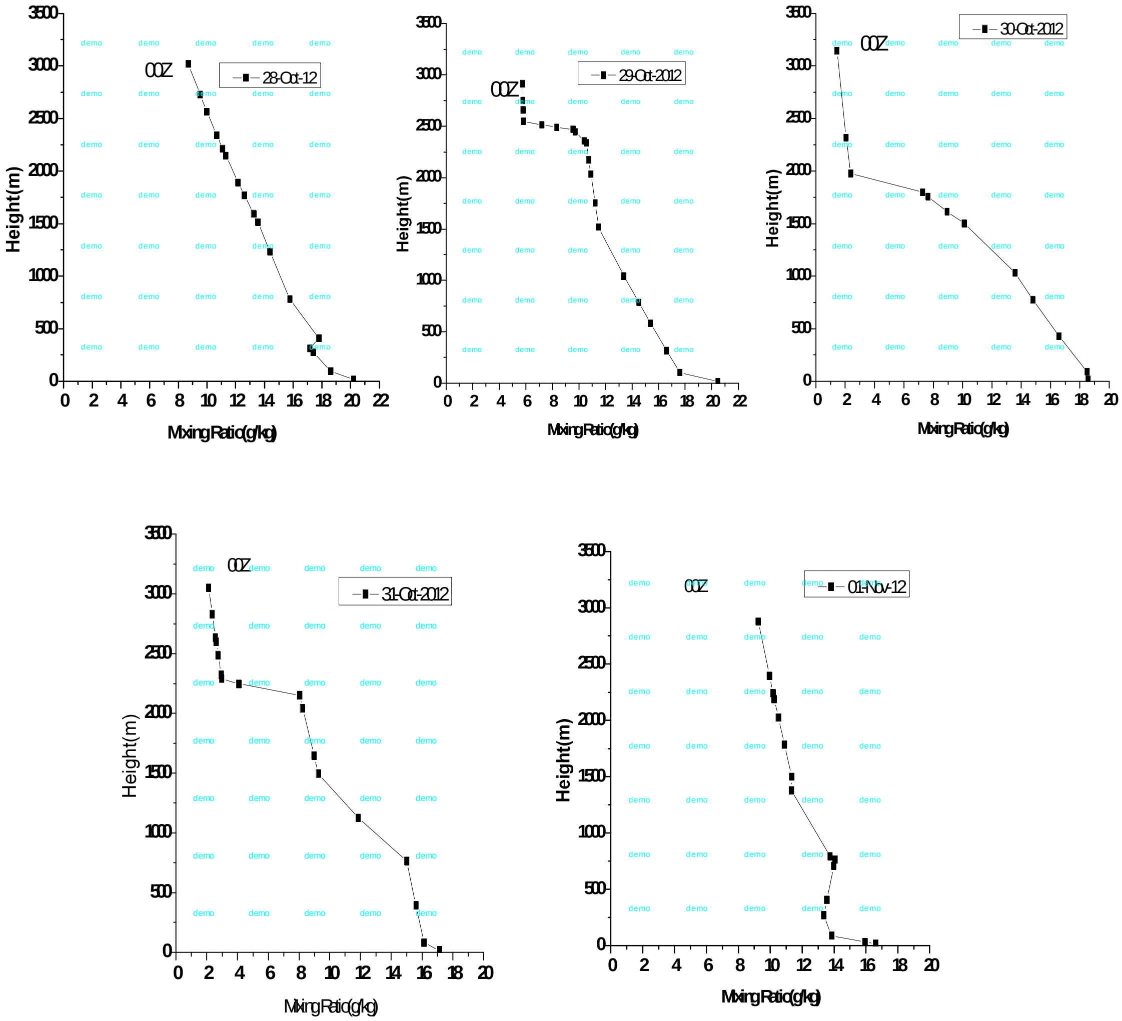

Fig 7.Mixing Ratio profiles during Nilam Cyclone (28-Nov-2012 to 01-Nov-2012)

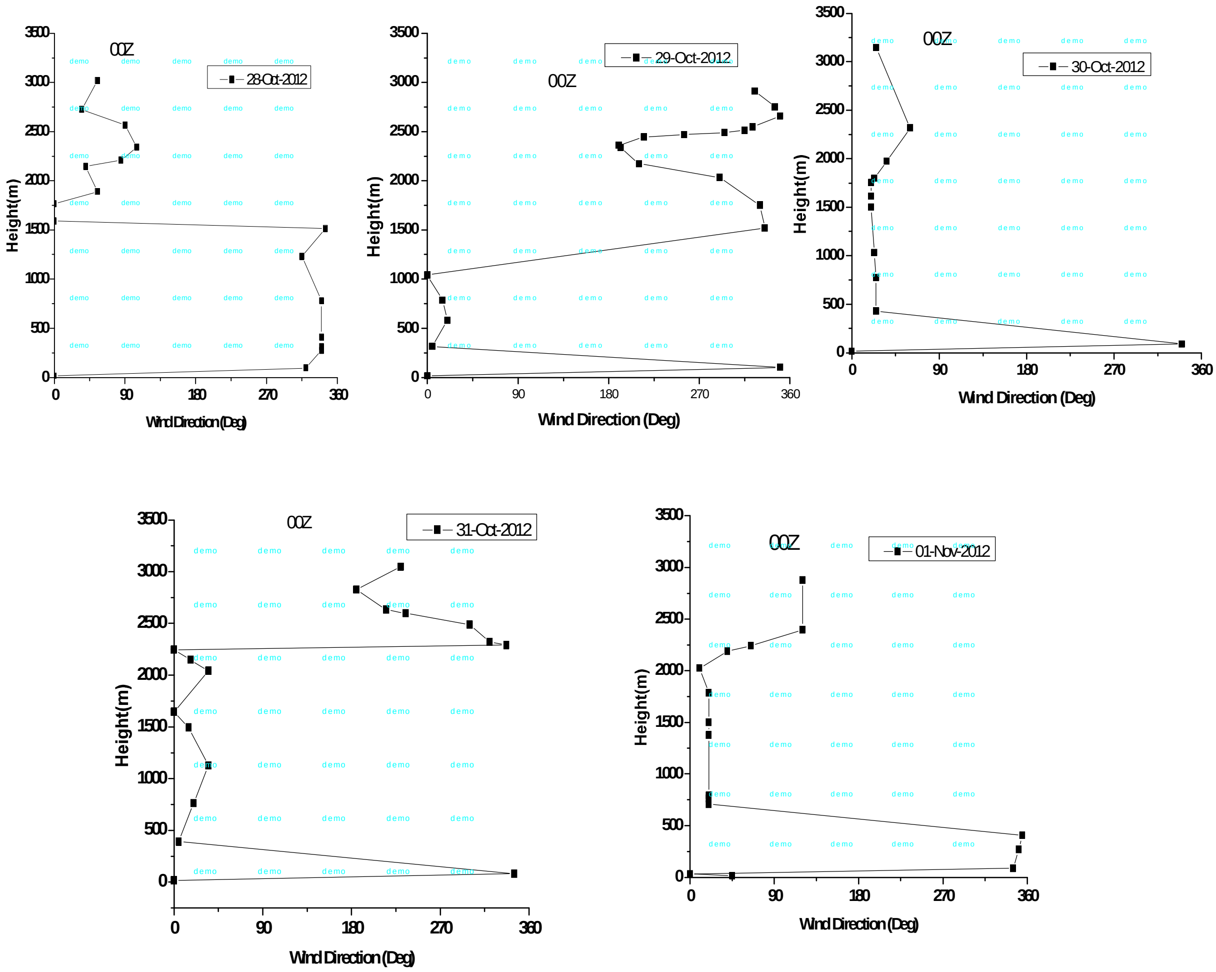

Fig 8. Wind profiles during Nilam Cyclone (28-Nov-2012 to 01-Nov-2012)

Table 2. Precipitation during Nilam Cyclone (27-Oct-2012 to 02-Nov-2012)

Date	Average Precipitation	Actual Precipitation
28-Oct-2012	13.6mm	Haze & Scattered Clouds
29-Oct-2012	13.6mm	Rain / drizzling
30-Oct-2012	13.6mm	59mm (Rain Thunderstorm)
31-Oct-2012	13.7mm	9mm (Rain Thunderstorm)
01-Nov-2012	13.3mm	Drizzling

The precipitation received during Nilam cyclone in Chennai is shown in Table 2. On the onset of cyclone i.e., on 28-Oct-2012 haze and scattered clouds are seen and next day started with light drizzling followed by rain and thunderstorm with 59mm and 9mm in the next couple of days indicating strength of cyclone in Chennai. An average precipitation is recorded as 13.3mm to 13.7mm rainfall during Nilam cyclone period. Table 3 defines the wind direction throughout the day during Nilam cyclone. After the onset of cyclone the winds are observed as Northerly and Northeasterly throughout the day indicating the movement of cyclone track towards north easterly. On 01 Nov 2012 the winds are moving southerly most of the time.

Table 3. Wind Direction during Nilam Cyclone (27-Oct-2012 to 02-Nov-2012)

WIND DIRECTION DURING NILAM CYCLONE							
Time (IST)	**27-Oct-12**	**28-Oct-12**	**29-Oct-12**	**30-Oct-12**	**31-Oct-12**	**1-Nov-12**	**2-Nov-12**
0	Calm	NNE	NNE	NNE	NNW	South	South
1	Calm	Calm	North	Calm	NW	SSE	South
2	Calm	North	North	NW	NNW	South	South
3	Calm	Calm	North	Calm	NE	SSE	South
4	Calm	Calm	NW		NNE	SSE	South
5	Calm	Calm	NNW	NW	NNE	South	South
6	Calm	Calm	NNE	Calm	NE	South	SSW
7	Calm	NW	North	Calm	NE	South	South
8	NNW	North	NNE	North	North	South	SW
9	North	NNE	NE	NE	NNE	South	SSW
10	NE	NNE	NE	North	NNE	South	South
11	NE	NNE	NE	NNW	NNE	South	South
12	NNE	NNE	NE	North	NE	South	SSW
13	NE	NNE	NNE	NNW	NE	South	SW
14	NE		NNE	NW	ENE	South	SSW
15	NNE	NNE	NNE	North	ENE	South	SE
16	NNE	NNE	NNE	NNW	ENE	South	SSE
17	NNE	NNE	NE	North	ENE	South	South
18	NNE	NNE	NNE	NNE	SSE	SSE	SSE
19	NNE	NNE	NNE	North	South	South	SSE
20	NNE	North	NNE	NNW	SSE	South	SSE
21		NNE	NNE	North	SSE	SSE	SSE
22	NNE	NNE	NNE	NNW	South	SSE	SSE
23	NNE	NNE	NNE	NNW	South	South	SSE

4.2 Vertical Profiles of Meteorological Parameters

The vertical profiles of meteorological parameters during Nilam Cyclone at 5.30 hrs are shown in Fig 6 From temperature profile in Fig 6 shows that the temperature is decreasing with respect to height until 200m to 500m in an average. Above this the temperature is increasing indicating the mixing height and is observed stable for a few hundred meters and again same scenarios is observed during cyclone period. The mixing ratio is defined as the ratio of the mass of water vapor to the mass of dry air and is expressed in grams per gram or grams per kilogram. It differs from specific humidity only in related to the mass of dry air to the total dry air plus water vapor. It is very numerically equal to specific humidity, but it is always slightly greater. The mixing ratio has the same characteristic properties as the specific humidity. It is conserved for atmospheric processes involving a change in temperature. It is non conservative for changes involving a gain or loss of water vapor. The vertical profiles of mixing ratio are shown in Fig 7. Inside the boundary layer the mixing ratio is decreasing with respect to height. High mixing ratio values are observed at surface level and started decreasing up to 100m to 700m above that height it remained constant. Mainly the mixing ratio is due to difference in surface heating in the city and thus turbulence is developed which leads to mixing ratio values. Winds observed in Fig 8 are southerly to south westerly on 28-Oct-2012 and after onset of cyclone the winds moved to southerly to north easterly with respect to height until 01-Nov-2012. Above 2000 m the winds are south westerly during cyclone period.

V. CONCLUSION

Analysis of Nilam tropical cyclone developed in Bay of Bengal (BoB) from 27 Oct 2012 to 2 Nov 2012. On 28 Oct 2012 low pressure developed over Bay of Bengal and after couple of days the depression gradually intensified into a deep depression and subsequently turned into cyclonic storm in the southeastern coast by 30 Oct 2012 and it made landfall near Mahabalipuram on 31 Oct 2012. Nilam cyclone is developed over Bay of Bengal on 28 Oct 2012. The tropical cyclone, which evoked fears of large-scale destruction, weakened as it travelled northwest. It caused significant damage to infrastructure, plantations and live stock along Tamilnadu's eastern coast. Thus it is concluded that the decrease of alertness in disaster management that often occurs after a few years' lull in occurrence of cyclones, known as the "fading memory syndrome," also contributes to increases in loss of lives and property damage. This distinction between meteorological and socio-economic causes for the increased impact is important to avoid a tendency for political and administrative decision makers to blame natural causes. They have to take these realities into account, not just in developing a vigilant disaster management system, but in land-use planning, development of coastal districts, and insurance measures. Pro-active preparedness for disaster mitigation which will include engineering, social and legal measures.

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