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SOME ASPECTS OF DISSIPATION OF TROPICAL CYCLONES OVER NORTH INDIAN OCEAN DURING 1990-2004

1. Tropical cyclone intensity and movement forecasting still remains a challenging job for meteorologists around the globe though there has been significant improvement during the last few decades. The problem is further compounded as the genesis and movement of Tropical Cyclones (TCs) occur frequently over the oceanic regions where data is sparse. Meteorologists therefore rely on satellite monitoring of cyclonic storms, for their genesis, movement and intensity. Satellite techniques involve interpreting cloud patterns and cloud top temperature that are associated with structure, movement or sudden changes in the tracks of the storms. The intensity of a TC can be estimated to a great extent by the technique proposed by Dvorak (1973, 1975 and 1984), based on satellite cloud imageries.

The formation and intensification of a TC depend on various ocean-atmospheric conditions such as favourable

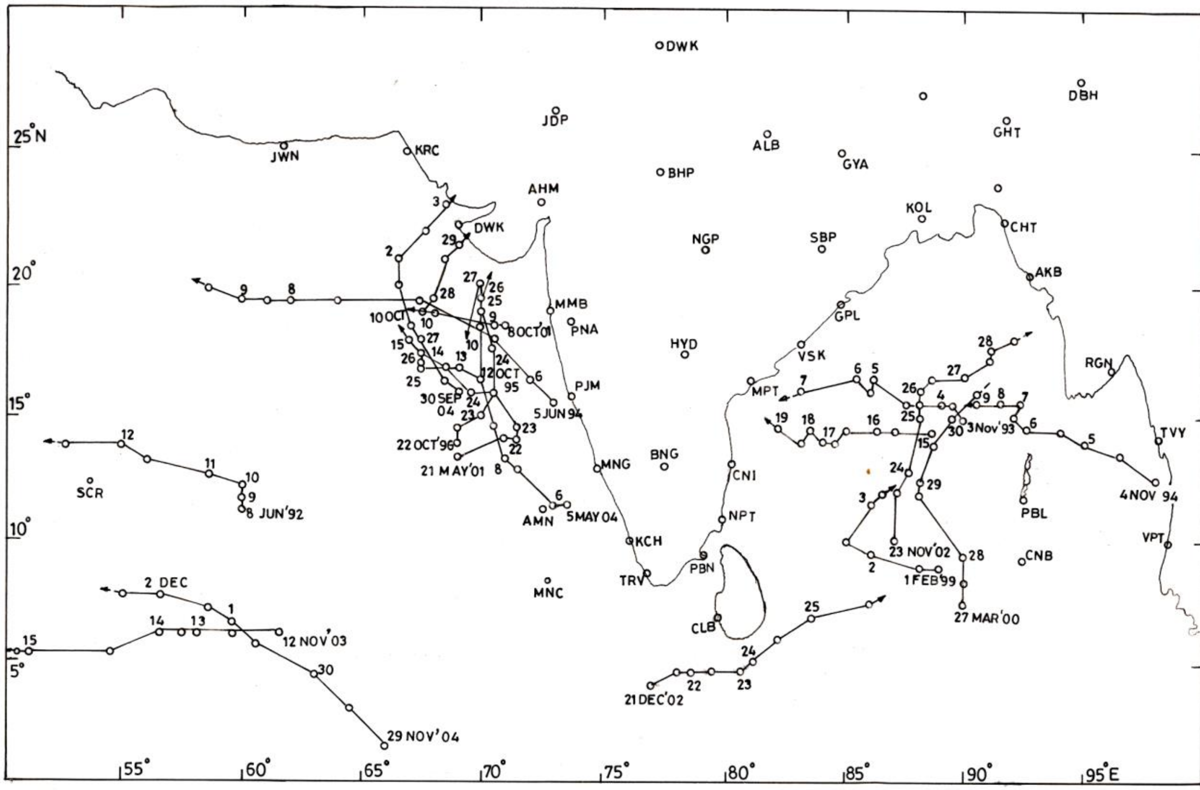

Fig. 1. Tracks of the cyclonic storms, dissipated over north Indian Ocean itself during 1990-2004

Sea Surface Temperature (SST), positive relative vorticity at lower level, moderate upper level divergence. It is also generally accepted that a small vertical wind shear is a favourable condition for an individual pre-existing disturbance to develop into a tropical cyclone (Anthes 1982 and Frank 1987). Low vertical wind shear contributes to accumulate moisture and help to decrease the cloud temperature in a vertical column above the incipient disturbance. By contrast, the presence of large vertical wind shear ventilates the column by advecting the warm core aloft away from the low-level circulation centre. Frank and Ritchie (2001) have suggested that a relatively weak shear (5 m/s) is greatly responsible for the intensification of a TC. Whereas a strong wind shear arrests the intensification and is one of the major causes for disorganization of TCs. Some observational studies suggested that shears of the order of 10 m/s are strong enough to immediately reduce the storm intensities (Zehr, 1992). Mandal *et al*. (1990) have studied some aspects related to weakening of Bay of Bengal cyclones in regard to SST and upper air westerlies. The present study is mainly confined to those systems, which formed over North Indian Ocean (NIO) and dissipated over the sea itself during the period 1990-2004 due to decreasing SST, increasing vertical wind shear and the resulting cloud pattern seen in satellite imageries.

2. In this study 17 cases of TCs have been considered, which formed over NIO and dissipated over sea itself during 1990-2004. Out of these 17 storms there was 1 Very Severe Cyclonic Storm (VSCS), 6 Severe Cyclonic Storms (SCSs) and 10 Cyclonic Storms (CSs). The tracks of these systems are presented in Fig. 1. Data used in this study are based on the report of the Regional Specialized Meteorological Centre (RSMC), New Delhi. Three hourly intensity data used on, INSAT as well as METEOSAT-5 satellite imageries are used in the study. Infrared IR satellite imagery of 0300 UTC of 25 October, 1996 shows the cloud mass over the land in northeastern side, where as the system centre is still located in the sea (Fig. 2). In Meteosat imagery of 0200 UTC of 29 March, 2000 (Fig. 3), the cloud mass is elongated towards northeastern sector, which indicates disconnection of the moisture feed to the system. The National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) 2.5° × 2.5° reanalysis winds at 850 hPa and 200 hPa levels have been used to calculate the vertical Mean Wind Shear (MWS). SST data have been taken from NCEP reanalyzed dataset at different grid points of the sea surface of the cyclone field the average over this area is defines as the Mean Sea Surface temperature (MSST) for the day. Graphs of MWS and MSST are presented in Figs. 4 & 5.

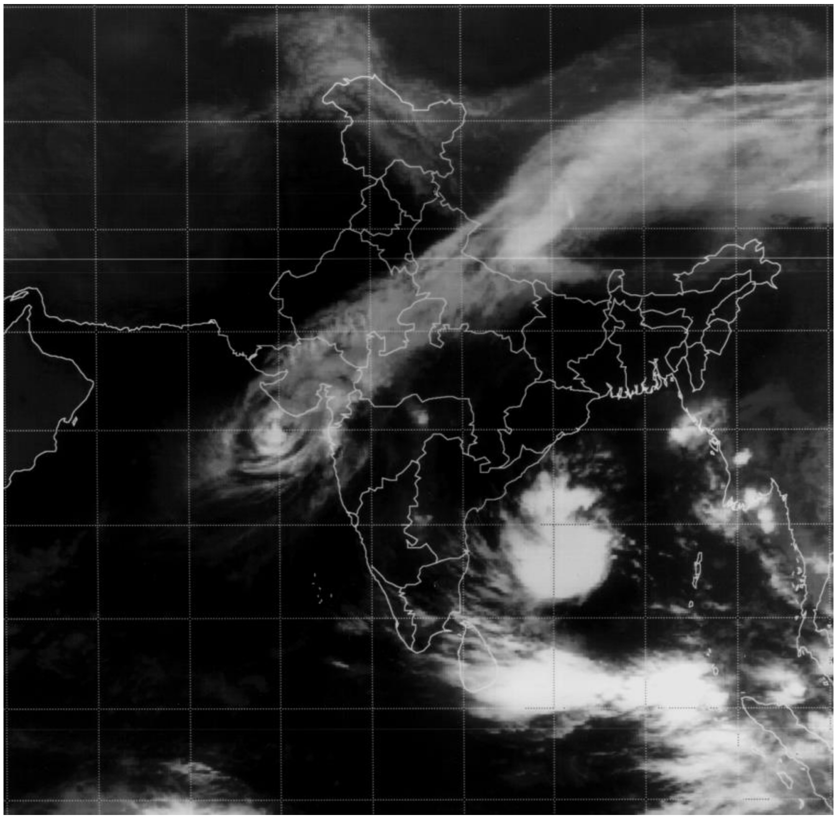

Fig. 2. Satellite imagery of 0300 UTC (IR) of 25 October 1996 shows the centre of the system is still over the sea

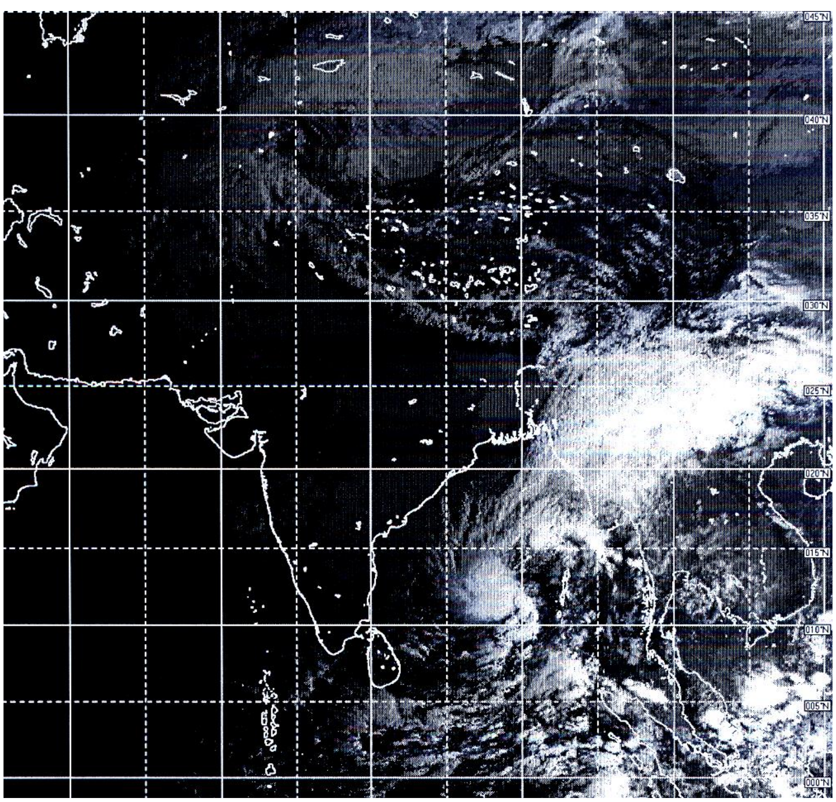

Fig. 3. Meteosat imagery of 0200 UTC (VIS) of 29 March 2000 shows convective cloud mass elongated and moved northeastwards

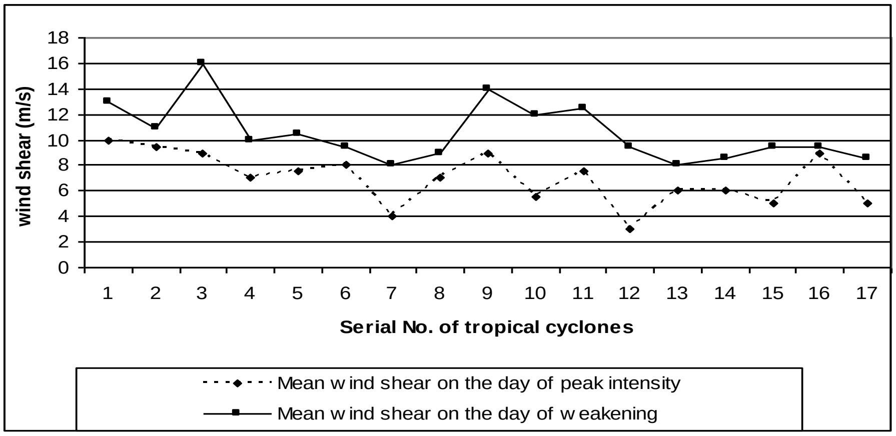

Fig. 4. Mean wind shear (m/s) on the day of peak intensity and the day when the storm starts the weakening

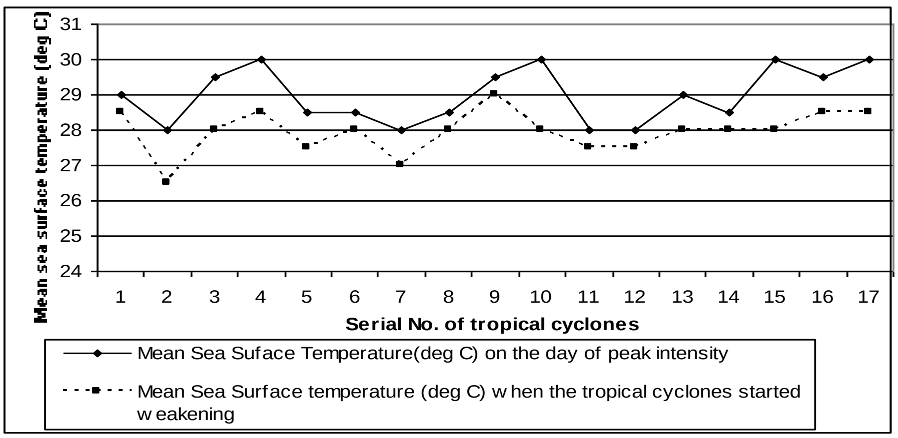

Fig. 5. Mean sea surface temperature (°C) on the day of peak intensity and the day when the tropical cyclone starts weakening

3. During the period 1990-2004 a total of 46 cyclonic storms has formed over NIO, 29 crossed the coast and 17 out of 46, *i.e.*, 37% dissipated over the sea itself as shown in (Fig. 1).

To identify the reason for the weakening of the 17 storms, satellite imageries of the storms were studied is shown in Figs. 2 & 3. The storms which weakened could be classified broadly into following two categories, (a) Due to strong wind shear the system appears as shear pattern, in which the cloud system centre remains away from the associated convective cloud mass and (b) Increase in cloud top temperature due to disorganization of the CDO, it can be understood that the cloud height decreased due to decrease in vertical velocity.

It is well established that warmer sea water can support strengthening of cyclones. TCs intensity does not have direct relation to MSST, but depends on the whole temperature profile of the sea water temperature, below the sea surface upto the considerable depth, except some occasion it indicates relation with TCs intensity. The appropriate measure of its thermo dynamical environment gives an idea of the potential of intensity. Synoptic scale atmospheric interaction is also responsible for causing variation in the intensity of TCs. A general consensus is that apart from small vertical shear of the environment wind, a lateral eddy input of angular momentum is also favourable to TCs intensification. Besides an environment of strong vertical wind shear, appearance of stratocumulus clouds and southward moving cirrus in satellite imagery on the periphery of TC give an idea of weakening of a system. Kelkar (1997) concluded that cyclonically curved bands forming in or entering the upstream area are unfavourable for further development of tropical cyclones.

MWS was noticed to be 3.0-10.0 m/s during the life span of each of these systems. But when systems started weakening MWS was of the order of 8.0-23.0 m/s over

Arabian Sea and 7.0-17.0 m/s over Bay of Bengal (Fig. 4). It is observed that MWS is comparatively higher on the day of ongoing weakening process than at the peak intensity day in all the cases.

Fig. 5 shows the variation of MSST for each of the individual TC on the day of its peak intensity and the day when the system started weakening. It was noticed that during the weakening phase of all these TCs, the SST was of the order of 27.5-28.5 °C over the TC region in Arabian Sea and was of the order of 26.5-28.0 °C over Bay of Bengal. The MSST was slightly higher and was of the order of 28.0-30.0 °C when each of these TCs attained its peak intensity in both the basins.

To asses the impact of MWS and MSST on the intensity of individual TC, the following two cases have been described.

A cyclonic storm formed on 22 October, 1996 over southeast Arabian Sea and subsequently moved in a northerly direction. It was a Centre Dense Overcast (CDO) pattern, without banding features. When it reached about 20.0° N, convective clouds moved away northeastwards, due to strong westerlies penetrating in the northern sector of the storm. Moderate to strong wind shear in the cirrus cloud outflow layer was indicated by the transverse drifts in the cirrus bands. In the next 6-9 hours the cloud mass spread and elongated upto the Himalayan region (Fig. 2). However the system centre still persisted over sea and subsequently weakened and dissipated over the same area. On the day of its peak intensity MWS varied from 4.5 -10.0 m/s and MSST was 28.5 °C. When the system started weakening on 25 October 1996, MWS was of the order of 9.0-14.0 m/s and MSST was around 27.5 °C (Figs. 3 & 4).

The cyclonic storm during 27-30 March, 2000 attained the intensity of T3.0 at 292100 UTC; it was analyzed as CDO pattern. Size of the irregular CDO was nearly 3.0°, with band features (Fig. 3). As the system reached about 15.0° N, it came under the influence of strong westerlies, convective cloud mass associated with the cyclone, separated from the system center and moved away in northeastwards direction. Cloud Top Temperature (CTT) of the CDO at 290600 UTC, 300300 UTC and 301200 UTC were –70.0 °C, -60.0 °C and – 40.0 °C respectively. Gradual increase in CCT indicates the weak vertical motion in the core of the system. MWS on the day of peak intensity was about 6.5 m/s and SST 29.5 °C. On 30 March 2000, when the system starting weakening it was 8.5 m/s and 27.5 °C (Figs. 3 & 4).

4. A total of 46 tropical cyclones formed over NIO during the period 1990-2004, out of which 46, *i.e*., 17 (37%) dissipated over the sea itself, 9 (52.94%) dissipated over Arabian Sea and remaining 8 (47.06%) over Bay of Bengal. During the peak intensity day of these systems the wind shear was of order of 6-10 m/s and the sea surface temperature was of the order of 28.0-30.0 °C. In all these 17 cases, the systems showed signature of weakening when wind shears were greater by 3.0-6.0 m/s and sea surface temperature were less by 1.0-2.0 °C than their respective values on the day of peak intensity of individual cyclonic storm. The increase in cloud top temperature of the center dense overcast is also an indication of weakening of a tropical cyclone.

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