

TROPICAL CYCLONE TC 03A FOR THE PERIOD 3RD JUNE TO 10TH JUNE, 1998

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Introduction:

This report gives the review of cyclonic storm formed over the East Arabian Sea, latitude 11.0 n and longitude 71 e on 4th June, 1998. Moving initially west-northwestward then northwards, it recurved northeastward and weakened after crossing the coast of India on 9th June, 1998.

In this case, the intensity of circulation was examined at different levels, from surface to upper level (200 hpa).

This system intensified into a severe cyclonic storm (WMO categories V as discussed in Appendix-I) on 7th June, 1998. The cyclonic circulation extended upto mid-troposphere and significant positive vorticity was observed at 850 hpa and 500 hpa through out the period. Climatic record shows that 12 cyclonic Storms which intensified into severe cyclonic storm formed in the Arabian Sea in the month of June, based on 99 years data (1891-1989) (Mandal 1991).

Average Tropical Cyclone conditions:

Brands (1944) examined the average conditions of the Tropical Cyclone formed in the Arabian Sea.

Source Region: The tropical cyclones develop over Ocean in low latitude and dissipate after they move over land. The tropical cyclone forms in the Arabian Sea, between latitude 5-20 degree N, near the laccardiv and Maldiv Islands.

Period: The Maximum frequency of tropical cyclone formation occurs in two periods i.e. One in April, May and June and the other in October and November. G.S.Mondel (1991) pointed out that 12 cyclonic storm, which intensified in to severe cyclonic storm, formed in the Arabian Sea in the month of June. Based on 99 years data (1891-1989). During this period, 5 years data were not available. The frequency of cyclonic storm in June is very small.

Latitude of Recurving: The tropical cyclone recurves between latitude 15 N and 20 degree N but generally. However, recurvation is not common. G.S. Mondel (1991) examined the tropical disturbance in the region between

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5N/55E and 35 N/105 E about 65% of the cyclone disturbance area of nonrecurving type and 35% are of recurving type.

Area of dissipation: it generally dissipates between Gulf of Cambay and Karachi.

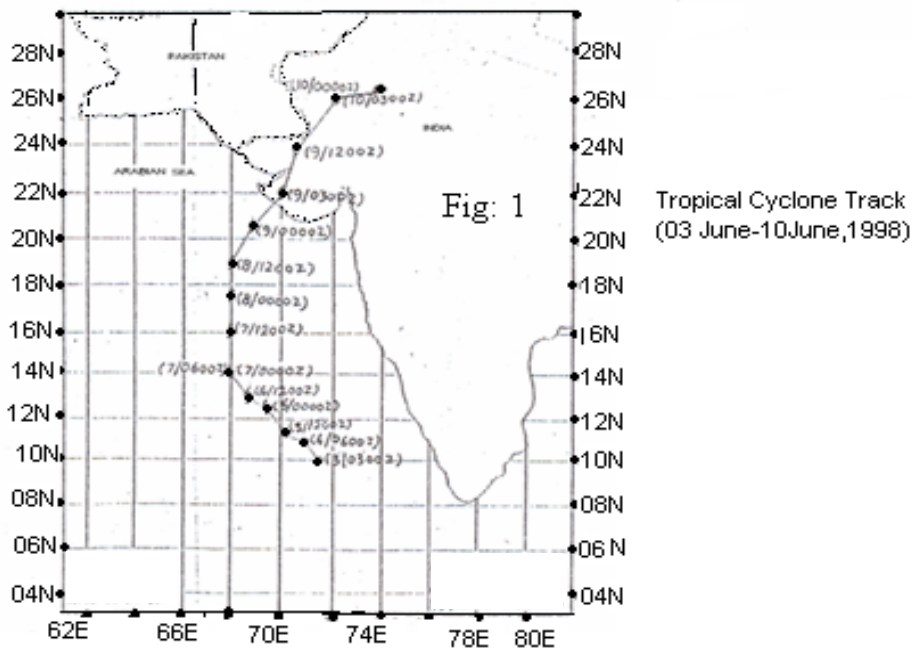
Diameter: diameter is about 270 – 720kms (150-400 nautical miles)

Paths: south of latitude 15 degree N. The path is WNW. Further North of Northwest or Northeast.

Speed: the average speed of the tropical storm is 7-18kms/hr.

Synoptic History of TC 03A:

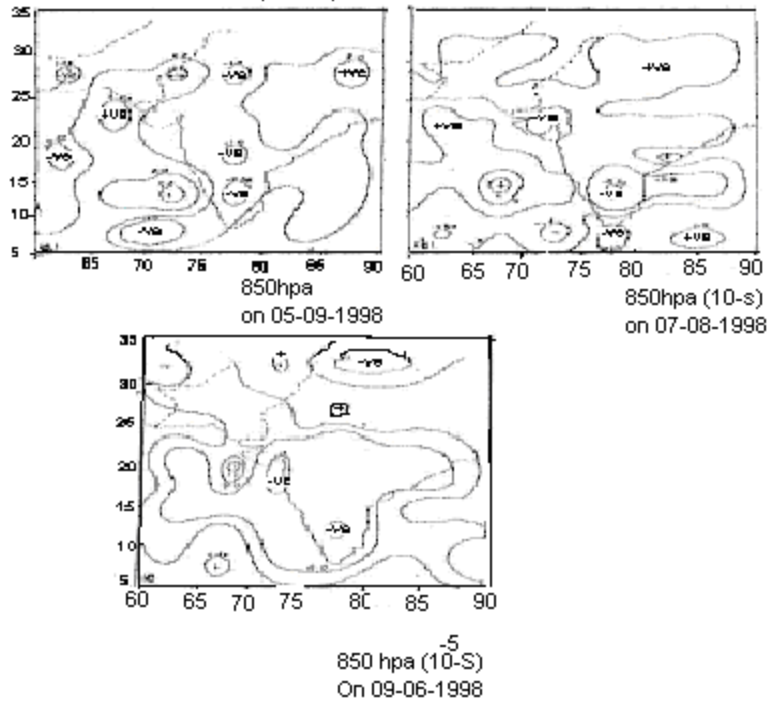
- Data:** The surface and upper air data from the tropical Storm area was not available between (5 N/55E and 35N/105 E). therefore it is difficult to compare properly the various important parameters, such as, vorticity, divergence, vertical velocity etc. However, on the basis of available synoptic data and satellite imagery it is discussed as given below.
- Synoptic Situation:-** on June 4, 1998 one strong tropical disturbance developed in the East Arabian Sea. This disturbance at 11.0° N/71E intensified into tropical cyclone. There after it moved Northwest-ward,



Northward and North Eastward (fig.1). On the basis of available data the vorticity is calculated at different levels. Fig-II shows vorticity field for 5th, 7th and 9th June. The cyclone retains full intensity for about three days as it slowly tracks northeastward into India where it finally begins to decay. On 10th it is pulled up as a low, by the westerly wave near Delhi.

Tropical Cyclogenesis is a continuous process. At the beginning of this process a tropical cyclone does not exist. During this time, the beginning tropical cyclone acquires a low level meso-scale circulation and associated organized convection. On 1st & 2nd June cloud's cluster were present in the Arabian Sea around (8 N/72 e). on 3rd June meso-scale circulation and cloud cluster were present at 10 N and 71.5 E. This system, created from easterly wave, intensified in the lower latitudes of Arabian Sea. On 4th June, 1998 the low became well established and on the upper level at 300 hPa strong divergence was present (not shown here). This strong divergence, accompanied with latent heat released, intensified the said system.

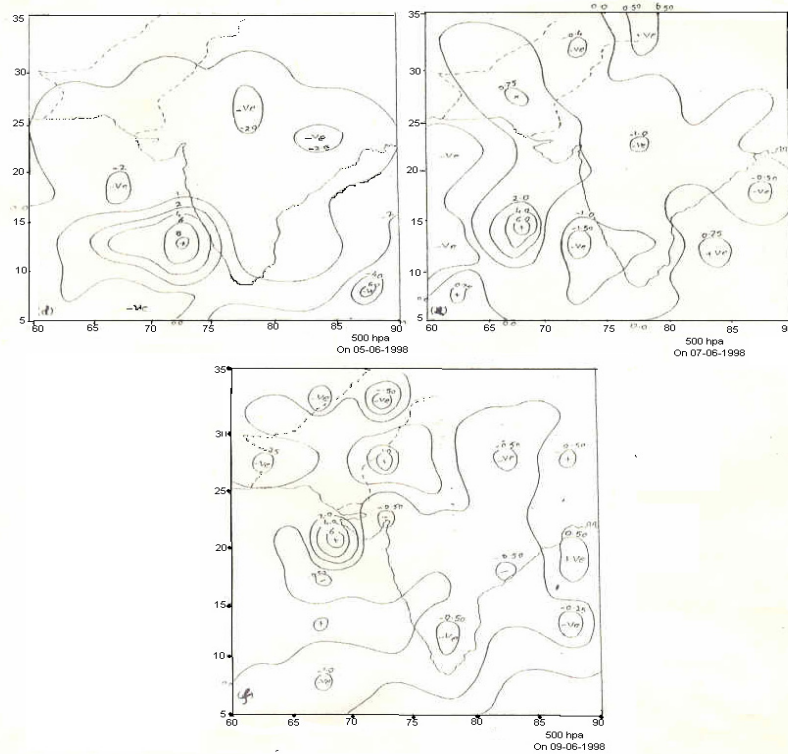
Figure II-Vorticity field for 5, 7 and 9 June, 1998 at 850 hpa (10-5-S)



The following day, it became a depression. Due to upper air conditions it developed into tropical storm. The cyclonic storm over southeast of Arabian Sea moved northwestward and intensified further (center at 12.5 N/69 E) on 6th June, 1998. The maximum estimated surface wind was 55 knots around its center. The cyclonic circulations extended upto 400 hpa.

By 7th June, 1998 it further intensified into a severe cyclonic storm. The movement was still approximately northward. Its center was at 14 N and 68 E. The maximum sustained wind was estimated as 65 knots, around the center of the system. If further intensified into a severe cyclone with a core of Hurricane wind and named TC03A. The Pakistan Meteorological Department (PMD) was watching closely its developments. On 8th June Pakistan Meteorological Department set up an emergency cell to monitor the tropical cyclone. The first advisory for tropical cyclone was issued on 8th, June at 1100 Pakistan Standard Time (PST). Which read as "A severe tropical cyclone located at 18 N/68 E about 700 km south of Karachi (Pakistan). The movement estimated surface wind was about 90 Knots". The cyclonic circulation extended upto 400 hpa tilting northwards with height. The imagery (No. AA) indicated the intensive convective clouds with faint eye.

Figure II Vorticity Field for the day 5,7 and 9 June, 1998 at 500 Hpa (10-05-S)



The following day cyclone recurved, reached at maximum intensity and moved in northeast direction, with an average speed of 39 kms/hour. The surface pressure of Indian station W.M.O. No (42734) dropped 12.8 hpa in 24 hours. Cyclone was located at 21 N/69 e ABOUT 350KMS OF KARACHI (Pakistan) and 70km southwest of India, (Gujrat State). The center pressure of cyclone was 970 hpa with maximum surface wind 95 knots.

The cyclonic circulation extended upto 400 hpa. The TC03A hit the (42830) porbandar (India) between 0700 and 0800 PST of 09/06/98. the NOAA (APT) indicate the convective clouds over northeast and east central Arabian Sea. Figure III-03A shown convection associated with TC03A as it moved northeastward into India. On 10th June 1998 the cyclonic storm moved north eastward direction and weakened into depression over Rajistan.

During the period 5th June, 1998 to 10th June 1998 the anticyclone axis at 200 hpa shifted from latitude 17 N to 22 N. The TCO03A recurved through the axis of the subtropical anticyclone at 200 hpa, and adopted the most frequently occurring pattern.

3. **Tropical Cyclone Maximum Wind and Minimum Pressure.** The area where the recurvature occurs, the average maximum intensity tends to occur just prior to recurvature. This is confirmed by the finding of Richle (1972).

The maximum wind in tropical cyclone is related to a number of convergence (LLCC), High level Circulation Divergences (HLCD), Topographic Factors, vertical wind shear etc. Holland (1987). The minimum center pressure of cyclone was recorded 970 hpa, with maximum surface wind 95knots (as discussed in appendix-II).

4. **Warning/Forecast:-** Pakistan Meteorological Department set up an emergency center to monitor the tropical cyclone (TC03A) on 8th June, 1998. the Pakistan Meteorological Department passed the information regarding the tropical cyclone (TC03A) to the public time to time through press and PTV/Radio. The first advisory for the TC03A was issued on 8th June, 1998 at 1100 PST. It was forecast that TC03A will move northerly direction and later on it will recurve to north east direction. The second advisory was issued at 2200 PST. The forecast was that TC03A would cross over land some where north Sindh border Gujrat coast in the morning. The TC03A crossed over Land Sindh border with India near Gujrat and hit station WMO (42830) Porbandar on 9th June, 1998 in the morning. The result was received according to Pakistan Meteorological Department warning center's expectation.

5. **Track/Intensity:-** A well marked low pressure area developed over southeast Arabian Sea on 4th June 1998 Convection associated with low level circulation, an estimated minimum sea level pressure of 1002 hpa, Tropical disturbance which developed into tropical cyclone continued to intensified. Available Devorak intensity estimates peak at 90 knots (45m/sec) around 9th June, 1998. The minimum sea level pressure estimated of 970 hpa. The track of tropical cyclone (TC03A) is shown in figure-1. the tropical cyclone weakened to tropical system (depression) intensity as it moved in land and moved northeastward.
6. **Tropical Storm Speed:-** The Tropical Storm moved northwest-ward with an average speed 5 to 10 km/hour in the beginning (formative and immature stage). Then it moved north with a constant speed 14km/hour in the mature stage. At the end stage, it moved northeastward. The speed suddenly increased and reached 39km/h. when tropical storm hit the porbandar in the morning, then tropical storm started decaying and speed increased.
7. **Casualties/Damages or Impact:-**Death toll is 1128 and losses of US\$ 300 millions according to press report.

Conclusions:

It is concluded that the positive vorticity indicate the intensity of the system. If this positive vorticity is present upto mid-troposphere or above. The system is strengthened.

The cyclone is recurved through the axis of strong anticyclone at 200 hpa (17 N latitude) and adopting the standard pattern.

Acknowledgements:

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Appendix-I

(Classification of cyclone disturbance)

Classification of cyclone disturbance for the Bay of Bengal and Arabian Sea region for the exchange of messages among the panel countries are given below:-

<u>Weather System</u>	<u>Maximum Wind Speed</u>
1. low	Wind speed less than 17kt (31km/h)
2. Depression	Wind speed between 17 & 33kts (31 & 61km/h)
3. Tropical Cyclone storm	Wind speed between 34 & 47 kts (62 & 88km/h)
4. Severe cyclonic storm.	Wind speed between 48 ^ 63 kts (89 & 117km/h)
5. Sever Cyclone Storm with a core of Hurricane	Windspeed 64kts (118km/h or more)

Appendix-II

The center pressure and maximum wind in the Tropical Cyclone are inter related. The available data over the North Indian Ocean is conformed by the fletcher's formula in form;

$$V_{max} = 16 (p_o - p_c)^{1/2}$$

Where V_{max} = Maximum wind in circulation

P_o = Value of outer most closed isobar (in hpa)

P_c = Center pressure (in hpa)

Instead of the actual value of the outer most closed isobar a constant value $p_o = 1010\text{mb}$ (in hpa) can also be used with fairly good result.

For the Indian Ocean area the value of the constant taken as 14.0 provides better result than 16.