METEOROLOGICAL ASPECTS OF THE DECAY OF TROPICAL CYCLONE 01A IN NORTH ARABIAN SEA (MAY 05-11, 2004)

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Abstract:

In changing climate scenario, the intensity and frequency of extreme events is also changing. Extreme events are often the consequence of a combination of factors that may not individually be carrying such devastating socio-economic and environmental impacts.

The aim of work is to understand the dynamics of the SST and Wind fields in the development and decay of tropical cyclone 01A. Of particular interest is the impact of atmospheric forcing on the circulation patterns in open waters.

Satellite remote sensing data, in combination with other sources of information is used to analyze the cyclone structure during its course of development and found that on 9th May, 2004, upper level winds blew the storm apart and weakened it. SST fields around the cyclone dropped by 0.5-1.0°C on 9th May indicating the upwelling in the region. Combination of these factors resulted in the decay of cyclone in north Arabian Sea.

Introduction:

Tropical cyclones are the off-spring of ocean-atmosphere interaction, powered by heat from the sea, driven by the easterly trades and temperate westerlies, the high planetary winds and their own fierce energy (WMO Technical Note # 201). Cyclones are among the most devastating natural hazards. Their potential for wrecking havoc caused by their violent winds, torrential rainfall and associated storm surge, flash floods is aggravated by their severity, size, frequency of occurrence and the vulnerability of the vast coastal areas they affect. The impact of tropical cyclones is greater over coastal areas which bear the brunt of the strong surface winds and flooding from the rainfall and storm surge at the time of landfall.

Occurrence of tropical cyclone in the Arabian Sea is very rare; about 1.84 cyclones per year. No tropical storms develop during winter season (Jan-Mar). The peak season of cyclonic activity in Arabian Sea is the pre-monsoon season (Apr-Jun) and post monsoon season (Oct-Nov). The most active month is June during in which frequency of cyclones is 0.43 storms. Analysis of last 53 years data depicts that relatively more tropical storms developed in Arabian Sea during 1950-1975 period compared to 1976-2003 segment. 1950-2003 annual occurrences of

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cyclones show a negative trend in terms of the development of cyclonic storms in Arabian Sea as depicted by the following graph.

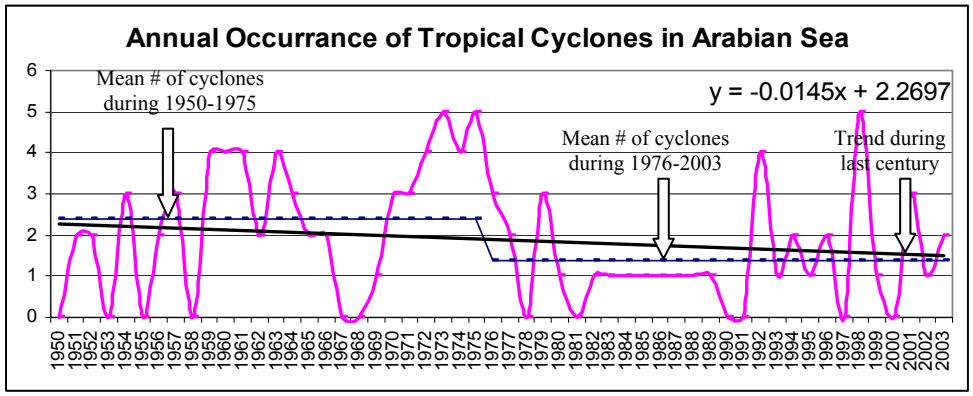


Fig. 1

Approach:

The primary observations for the analysis are based on satellite data from geostationary and polar orbiting satellites covering the Arabian Sea. Cloud pictures were mainly extracted from GMS-5 Satellite whereas SST, wind and precipitation data was extracted from TMI satellite.

Meteorological conditions in the Arabian Sea were studied on twelve hourly bases during 1st decade of May, 2004 and the development of the storm was correlated and documented accordingly.

TMI SSTs data near Tropical Cyclones:

The TRMM Microwave Imager (TMI) has produced passive microwave observations at 10.7, 19.4, 21.3, 37.0, and 85.5 GHz since December 1997. Orbiting at 35° inclination from the equator, TRMM provides sampling throughout the diurnal cycle. Remote Sensing Systems has developed a Sea Surface Temperature (SST) algorithm, relying primarily on the 10.7 GHz channel. Physical parameters in the retrieval algorithm were adjusted to minimize cross-talk errors due to wind speed, wind direction, atmospheric water vapor, and cloud water. Accordingly the performance of its algorithm has been found relatively more accurate compared to Reynolds and AVHRR SST products.

Chronology of Cyclone 01A:

As the spring heat wave broken out during first week of May across the subcontinent, Sea Surface Temperatures of Arabian Sea and adjoining north Indian Ocean became 1°C above than normal. Tropical waves started developing and enhanced convective activity was observed in satellite cloud imageries during early days of May.

The optimum interpolation analysis showed the presence of a low pressure over Arabian Sea on 3rd May. The winds had become easterly and North easterly. Simultaneously, a high pressure was built up over south west of Arabian Sea near Gulf of Oman. The high pressure enforced this cyclonic storm to develop near the Indian coast..

On 4th May:

SST along 10°N reached above 32°C in Arabian Sea and Bay of Bengal. High temperatures resulted in pressure fall over the Central Arabian Sea. The cyclonic circulations were observed up to 700mb on 4th May. Satellite and surface data showed that; the wind speed was over 50kts at tropospheric level but surprisingly it was just 20kts to 30kts at 200mb.

The low level winds continued to be easterly and southeasterly over southern India and southeastern Arabian Sea with wind speed 20 to 30 kts.

The vertical wind shear between 850mb and 700mb was only 1.5*10-3 per sec, which was small and favorable for cyclogenesis.

Also the forward motion of the wave completed the closure on the northern side of a broad low-level center, and a tropical depression was formed. It was located at 11.7°N & 72°E at 0600Z.

5th May 2004:

As the depression moved in northeasterly direction, carioles force together with high pressure aloft supported the development of cyclonic activity. Winds registered by TMI sensor were above 35 knots. As such the depression was declared as tropical cyclone TC-01A at 0600 on 5th May, 2004. Its location was 11.3°N and 73°E; about 1400KM south of Karachi-Pakistan.

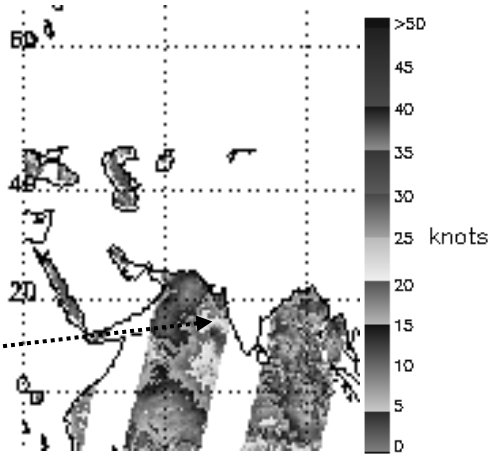


Fig. 2

6th May, 2004:

Despite the fact that the eye of cyclone was not developed, warmer than average SSTs over central Arabian Sea, low vertical wind shear and enhanced convective activity provided sufficient energy to the storm for further development. Wind speeds increased to 45 kts. The system was located at 12.5°N, 73°E at 0600Z.

The cyclone moved to & fro along 72°E longitude most of the day with dominant backward track and was located at 11.2°N, 71.5°E. The central pressure remained nearly same(994 hpa).

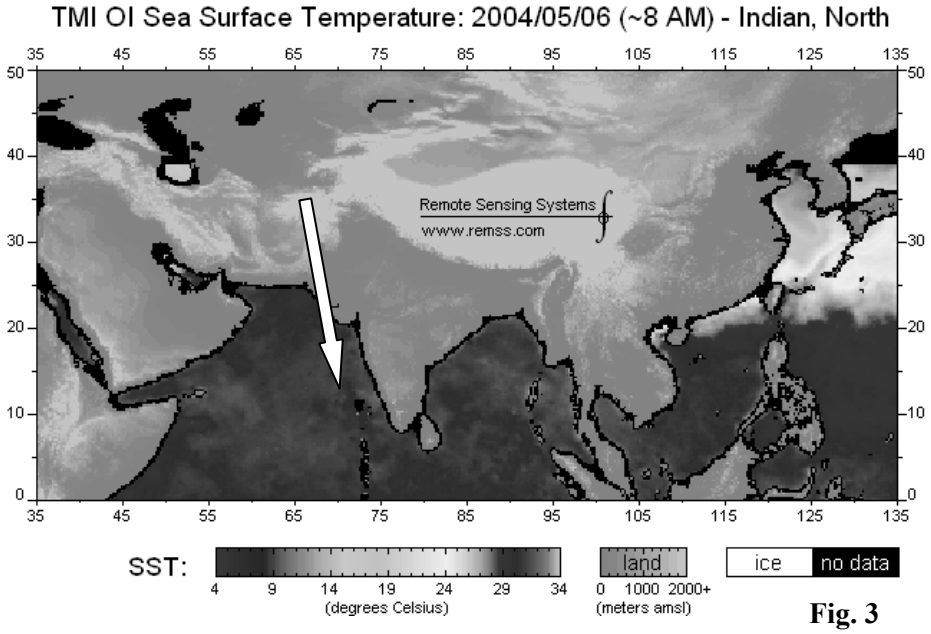
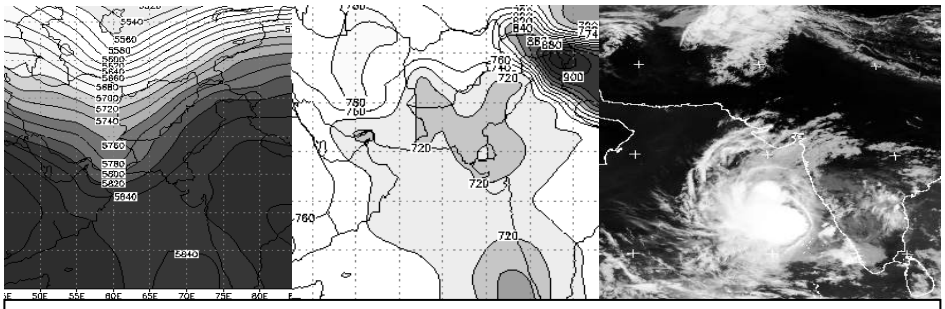


Fig. 3

7th May, 2004:

The cyclone started organizing in more structured format and as it gained energy from high rate of evaporation due to favourable SST. Falling pressure tendency was recorded at the centre of cyclone. Satellite picture also depicted the intensification of cyclone in the afternoon.



Analysis at 500hpa (Left) indicating the dipping of westerly wave down to 25°N Lat. Analysis at 925hpa (Centre) indicates the coupling of cyclonic circulation to seasonal low over southern parts of Pakistan. The satellite imagery of 1000GMT(right) indicates well organized cyclonic storm at Lat. 12.4°N, Long 71.5°E.

Fig. 4

Animated multi-spectral Satellite imagery indicated an organized area of convection over low level cyclonic circulation. Development of system was duly supported by weak vertical wind shear and good diffluence aloft. The westerly wave started affecting upper parts of country and westerly trough became sufficient deep. Accordingly southerly wind component became strong and the cyclone moved in northerly direction. In the afternoon at 1200GMT, the cyclone was 12.5°N and 71.6°E.

8th May, 2004:

Relatively dry air from north and fast movement due to effect of westerly wave slightly weakened the cyclone. The cyclone lay centered at 0600GMT near Lat. 13.5 °N / Lon. 71.0°E, about 1300 km south of Karachi and 685 km south of Mumbai. In the afternoon, fast moving westerly wave tracked northeastward and its influence to cyclone diminished. The cyclonic storm moved to & fro and started to re-intensify and its central pressure dropped to 992hpa. At 2100GMT the cyclone lay centered at Lat. 14.1°N/ Long. 73.0°E, about 1200 km south of Karachi. The TC 01A has moved in NNE'ly direction in last 8 hrs. Animated multi-spectral satellite imagery at 2100GMT indicated well organized area of convection over low level cyclonic circulation.

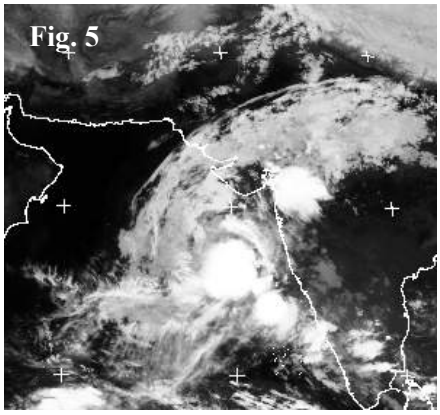


Fig. 5

9th May 2004:

Tropical Cyclone 01A continued to spin over the Arabian Sea. As of Sunday morning, the storm was centered about 1100 KM south of Karachi, Pakistan. Maximum sustained winds with the storm were about 40 knots, and movement was towards the northwest at 15 Knots. The cyclone had been stronger, but upper level winds had blown the storm apart and weakened it. Multispectral and water vapour imageries depicted a decrease in convection. Low to mid-level ridge over India was strong enough to force the cyclone to track northward. This track had kept the storm over waters and away from land.

Fast movement and weak to moderate vertical wind shear at 200 mb contributed in weakening tendency of cyclonic storm.

10th May 2004:

The southwesterly wind shear increased during early hours and the cyclone was tilted in northerly direction due to strong upper air winds. Main convective activity was taking place about 0.2° north of the centre of cyclone. At 0000GMT, the centre was near Lat. 16.80°N/ Long. 70.0°E, about 1000 km southeast of Karachi. The TC 01A had moved in NNW'ly direction during last 10 hrs.

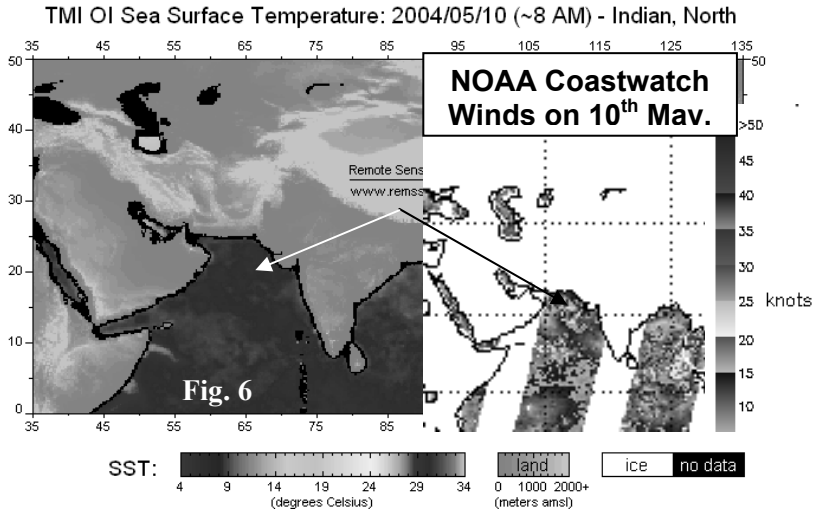


Fig. 6

SST over the north Arabian Sea, showed decreasing trend due to upwelling. Rate of cooling of SST depicts vigorous upwelling activity in the area. Animated multi-spectral satellite imagery at 1200GMT showed that the cyclone was blown apart due to unfavorable conditions for further development of cyclone. The Tropical Cyclone continued to move in the North-Northwesterly direction at a speed of 10 knots with maximum sustained winds of 30 knots as monitored by TMI sensor. The system was now located near Lat19.0Nº, Long70.0Eº, about 600km South of Karachi. This system traveled 400km with the speed of 10kts (18km/hr) during last 22hours.

The dissipation of tropical cyclone (01A) was continued and this was converted into a depression on 10th May at 1200GMT. Finally the system was observed near Lat 22.1Nº and Long 67.2Eº. Further this system weakened into a low-pressure area on 11th May 2004.

Track of Cyclone 01A, 2004:

The cyclone didn't follow a go-forward track during its life cycle. It showed to & fro motion on 5th and 8th May, 2004 and intensified during such situation. Detailed track of the cyclone is shown in fig 3.

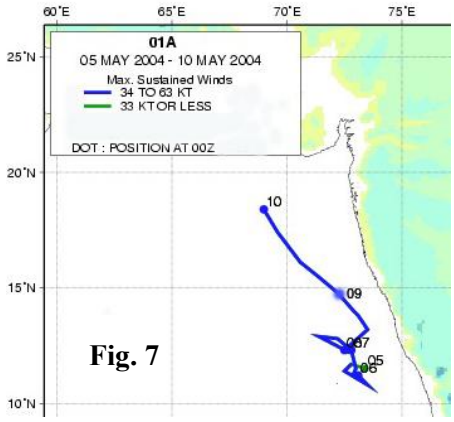


Fig. 7

Weather Realized:

Under the influence of cyclonic storm 01A, rainfall with isolated heavy falls over Karalla, coastal Karnataka, India was observed. Maximum significant wave height on 10th May morning along Indian coast was 16 feet.

In association with this system moderate to heavy rainfall was reported from station in GAO and coastal areas of Maharashtar and Gujarat including some of the interior districts. This resulted into normal to excess rainfall along the west coast during the passage of tropical cyclone.

Under the influence of this dissipating system, scattered rain/thundershower was also reported in coastal areas of South East Sindh - Pakistan

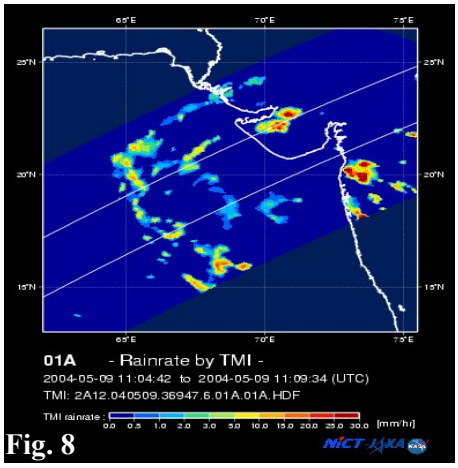


Fig. 8

Damage:

Six people died in the southern India but no damage to life and property was reported from Pakistan.

Conclusion:

Normally the cyclonic storms continue to develop/intensify as soon as it continue to spin over waters and its dissipation starts after land fall. However this cyclone dissipated over waters. Decay of the cyclone 01A was mainly governed by

- Relatively sharp decreasing tendency of SST in the area
- Light to moderate southwesterly wind shear
- Fast movement of the system due to strong heating inland.

Also upper air strong winds played an important role in deforming and weakening of cyclone 01A.

References:

Dvorak, V. F., 1975: Tropical cyclone intensity analysis and forecasting from satellite imagery. Mon. Wea. Rev., 103, 420- 430.

Glass, M. and G. W. Felde, 1990: Tropical storm structure analysis using SSM/I and OLS data. 5th Intl. Conf. on Interactive and Information Processing Systems for Meteorology, Oceanography and Hydrology, Anaheim, CA, Amer. Meteor. Soc, Boston, MA., 432-437.

H. Thompson, 1979: Climatological characteristics of rapidly intensifying typhoons. Mon. Wea. Rev., 107, 1022-1034.

USAF, 1974: Tropical Cyclone Position and Intensity Analysis Using Satellite Data. IWWP 105-10 Hq. 1st Weather Wing. (MAC), APO, San Francisco. 96 pp.

http://www.pakmet.com/upload/AVN/Files/tc_pmd_warn.html

1984: Tropical cyclone intensity analysis using satellite data. NOAA Tech. Report NESDIS 11, U.S. Dept. of Commerce, National Oceanic and Atmospheric Admin., National Environmental Satellite Data, and Information Service. Washington D.C. 47 pp.

WMO Technical Note # 201; Agrometeorology related to extreme events

NOAA satellites and information; visualized products. http://www.nnvl.noaa.gov/
Dunnavan, G. M., 1981: Forecasting Intense Tropical Cyclone Using 700 mb Equivalent Potential Temperature and Central Sea-level Pressure. NAVOCEANOCOMCEN/JTWC Tech. Note 81-1, 12 pp.

Bureau of Meteorology, Australia, SST anomaly analysis. http://www.bom.gov.au/

Indian Ocean Climatology;
https://metoc.npmoc.navy.mil/climo/io/io_files/frame.htm