SIGNAL OF DISSIPATION OF A VERY SEVERE TROPICAL CYCLONE THROUGH AMVS OVER THE INDIAN REGION

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ABSTRACT

In this study, prime importance of satellite derived AMVs is highlighted for improving the forecast of disastrous atmospheric systems over the Indian region. Satellite data obtained from various national and international satellites such as NOAA, DMSP, IRS-P4, METEOSAT and INSAT are utilized for analyzing all the stages of very severe tropical cyclone formed over the Arabian Sea during 21 to 28 May 2001. Especially, cloud motion vectors (CMVs) and water vapour wind vectors (WVWVs) obtained from METEOSAT-5 are used in objective analysis (OI Scheme) of the wind field at 850 and 200 hPa for monitoring dynamical changes in respect of vorticity, convergence and divergence associated with complete life cycle of tropical cyclone. This computation was made using improved CMVs and WVWVs obtained from regression relationship developed between satellite-derived winds of METEOSAT-5 and radiosonde winds of Minicoy and Port Blair island stations over the Indian region. Cyclonic vorticity at 850 hPa computed with input of improved winds was found to be properly maintained throughout the life period of tropical cyclone whereas anticyclonic vorticity at 200 hPa did not show proper consistency. Instead of continuous development of anticyclonic vorticity at 200 hPa, suddenly cyclonic vorticity started generating and intensifying near the center of tropical cyclone from 26 May onwards. This reverse development gave a signal of dissipation of tropical cyclone 2-3 days before it's hitting the west coast of India. Practically, it hit the west coast of India (Gujrath coast) on 29 May in the form of only low-pressure area. Supporting consistency in dissipation of tropical cyclone was also noticed from the data of other satellites.

1. INTRODUCTION

Global observations of atmospheric winds are very important for atmospheric studies and operational weather forecasting. This is especially true at low latitudes, where the wind field cannot be inferred from the mass field and upper air-soundings from conventional network are sparse. Observations of wind flow over the oceanic areas are important prerequisite for accurate weather forecasts by numerical weather prediction (NWP) models. Vast oceans – the Arabian Sea, the Bay of Bengal and Indian Ocean, surround India. Lack of conventional wind data in these areas causes error in weather forecasts. Therefore, it is worthwhile evaluating the impact of satellite-derived winds on objective analysis of wind field for getting proper depiction of different atmospheric systems over the Indian region.

Here, first, utility of satellite-derived AMVs for improvement in forecast over the Indian region is highlighted in brief. Archiving of satellite derived wind data from INSAT imagery commenced during 1984 at MDUC (Meteorological Data Utilization Centre), New Delhi using automated technique (Kelkar and Khanna, 1986). With subsequent increase in areal coverage of CMVs, interactive quality control procedures were introduced. Some of the earlier investigators carried out impact studies of different observing systems during

FGGE period; these observations included satellite-derived observations of winds. Bengtsson et al. (1982) concluded that satellite-derived wind data have significant impact on forecasts in the tropics and are more significant for southern hemispheric circulations than for those in the northern hemisphere. However, Rajamani et al. (1982) showed that aircraft/ship data have a bigger positive impact in the analysis than satellite-derived wind data. Utilizing conventional and non-conventional MONEX-79 data over the Indian region these results were brought out. They also suggested that this could be due to the satellite-derived wind data not being exactly at 850-hPa level, where the analysis was made. Joshi et al. (1987) suggested that the use of satellite-derived wind data at few intermediate levels would lead for the better forecast over the Indian region. Mahajan et al. (1992a) established an empirical relationship between satellite-derived winds obtained from GOES satellite and conventional winds reported by the research ships at different pressure levels. They showed that satellite-derived wind data could be used for the construction of vertical wind profile over the Indian Ocean. In their further study (Mahajan et al. 1992b), they used these winds in objective analysis of the wind field and showed that constructed winds are of potential use for depicting major circulation features over the seas surrounding India. Later, for utilization of INSAT winds they developed (Mahajan et al. 1995) another regression relationship between INSAT winds and the radiosonde winds of island stations over the Indian seas. They used modified INSAT CMVs as an input in objective analyis of the wind field and showed that they are of potential use in depicting better monsoon circulation features over the Indian region. However, the same empirical relationship may not hold good for the winds derived from METEOSAT-5 satellite. Therefore, in this study, another relationship is used which was already developed between METEOSAT-5 winds (CMVs & WVWVs) and radiosonde winds of island stations i.e. Minicoy and Portblair over the Arabian Sea and the Bay of Bengal (Mahajan, 2002). Potential utility of AMVs for receiving signal of weakening of very severe tropical cyclone through dynamical changes is brought out. Simultaneously, variations in geophysical parameters and modulation in convective activity obtained from IRS-P4 and INSAT satellites are highlighted for the complete life period of tropical cyclone (21 to 28 May, 2001) over the Arabian Sea.

2. DATA

CMVs (800-950 hPa) and WVWVs (100-250 hPa) obtained from METEOSAT-5 are utilized for computing dynamical changes in lower and upper troposphere especially at 850 and 200 hPa for the life period of tropical cyclone. INSAT (Fig.1) and NOAA satellite imageries at synoptic and asynoptic observations are used for finding variations in convective activity in the region of tropical cyclone. IRS-P4 MSMR grid mode data are utilized for the computation of sea surface temperature, sea surface winds, integrated water vapour and cloud liquid water content. Radiosonde data of Minicoy and Port Blair island stations are used for the year 2000 for its comparison with satellite derived winds of METEOSAT-5 satellite. NCEP daily wind field analysis at 850 and 200 hPa is used for the period 21 to 28 for performing modified analysis with input of satellite derived winds in objective analysis (OI) of wind field.

3. METHODOLOGY

CMVs (800-950 hPa) and WVWVs (100-250 hPa) are noted at the locations of radiosonde stations of Minicoy and Portblair over the Arabian Sea and the Bay of Bengal for the year 2000. There were few occasions when CMVs and WVWVs were not exactly available over the location of island station. In such cases mean wind in a 5º square keeping the island station at the center is used as a representative wind. This procedure is adopted because autocorrelation coefficients of satellite derived wind vectors remain highly significant within a 5º square (Wylie and Hinton, 1981). In order to generate satellite-derived winds at 850 and 200 hPa, above recorded winds of CMVs and WVWVs are compared with radiosonde winds at 850 & 200 hPa of Minicoy and Portblair island stations. Considering satellite derived wind as independent variable, linear regression equations are developed for both u and v wind components. These equations are statistically tested for their significance. Table 1 gives number of observations recorded, regression equations, the values of correlation coefficients and standard deviation for 850 and 200 hPa.

IRS-P4 MSMR data for both descending and ascending nodes are combined for each day and plotted on the chart. The SST values are available only at 150 X 150 km grid resolution. Moreover, wind speeds are more accurate for this resolution as compared to 75 X 75 km resolution (Ali et al., 2000). Therefore, in the present study, the data of 150 X 150 km resolution are used for uniformity. All the geophysical parameters such as sea surface wind speed, sea surface temperature, integrated water vapour and cloud liquid water content are plotted for above cyclone to comprehend variations of geophysical parameters associated with modulation of convective activity during various stages of development and dissipation of tropical cyclone. The following table shows statistical relationship between satellite derived winds and conventional winds.

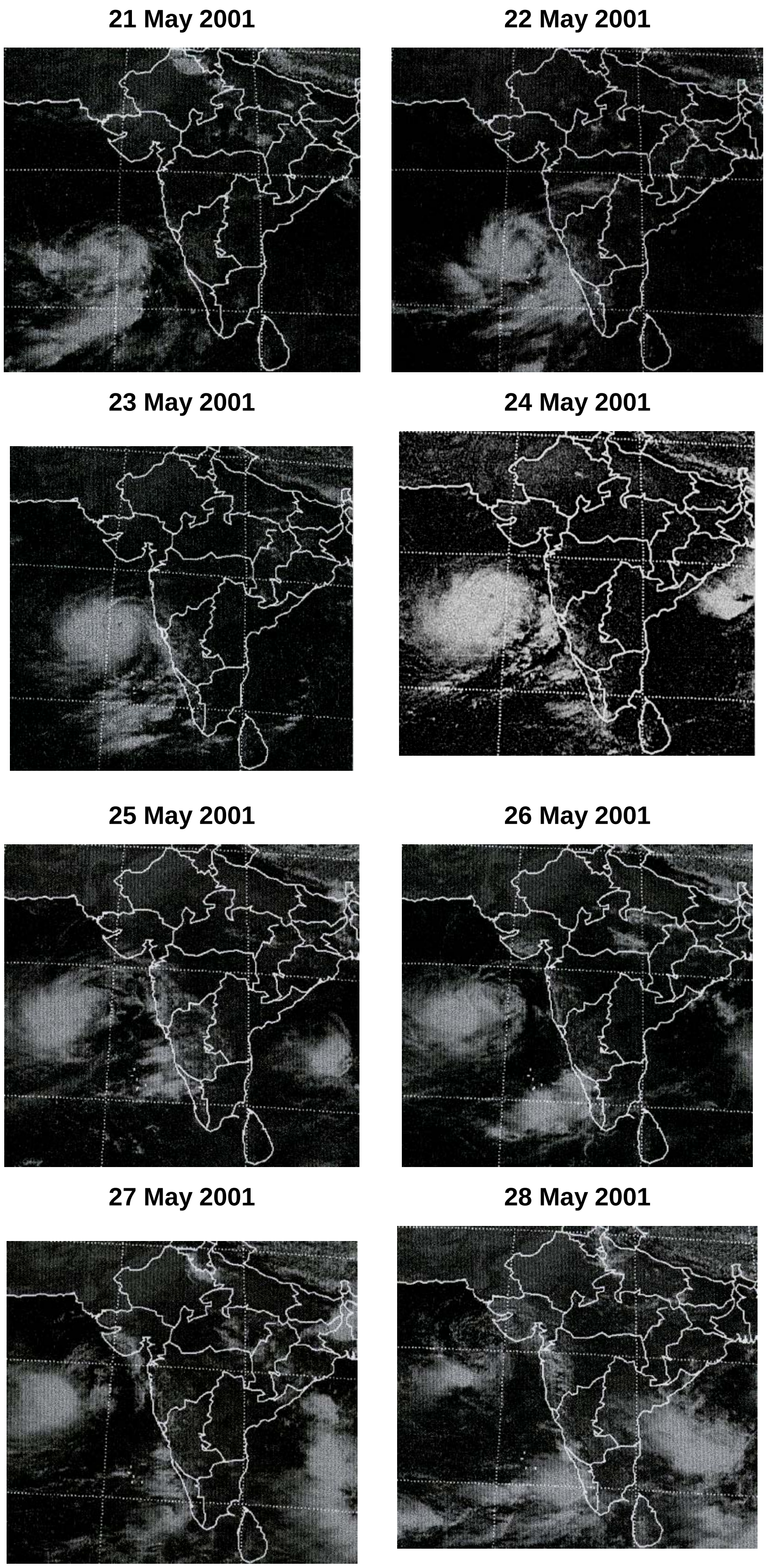

Figure 1: INSAT imageries of tropical cyclone during 21-28 May 2001.

Level (hPa)	N	Regression relation	r	SD
850	105	Yu(850) = 3.51 + 0.976 X1	0.79	4.11
850	105	Yv(850) = -1.76 + 0.95 X2	0.74	3.59
200	160	Yu(200) = -3.71 + 0.83 X3	0.53	8.51
200	160	Yu(200) = 1.23 + 0.76 X4	0.48	7.62

Table 1: Statistical relationship between conventional and satellite winds.

Where u(850) and v(850) are estimated winds for u and v components at 850 hPa. u(200) and v(200) are estimated winds for u and v components at 200 hPa. X1 and X2 are u and v components of CMVs at 850 hPa. X3 and X4 are u and v components of WVWVs at 200 hPa. N is number of observations when synchronization of satellite and radiosonde winds was available. Above regression equations developed for both u and v components have been used to modify the wind fields of METEOSAT-5 during the life period of the tropical cyclone. This process was made for two important standard pressure levels i.e. at 850 and 200 hPa where, generally we get maximum low level convergence and maximum upper tropospheric divergence. NCEP daily wind field analysis during life period of tropical cyclone i.e. 21-28 May 2001 is used for performing objective analysis (OI) of the wind field at 850 and 200 hPa by including modified winds of METEOSAT-5 satellite. Actually, all satellite-derived winds at 850 and 200 hPa are corrected by above regression equations developed for these two levels. These modified winds are used in objective analysis of the wind field for the complete life period of tropical cyclone over the Arabian Sea. Later, using these improved objectively analyzed wind fields; vorticity fields at 850 and 200 hPa were computed. Main emphasis is given to monitor the vorticity fields especially in the region of tropical cyclone. It is then compared with the cloudiness pattern obtained by INSAT, METEOSAT-5 and NOAA satellites. T numbers obtained from these cloudiness patterns are also compared with the vorticity fields at 850 and 200 hPa. TRMM-derived daily rainfall is used to know the major rainfall activity in the thick convective areas for the complete life cycle of the tropical cyclone.

As it is well known that during pre-monsoon and post-monsoon seasons, genesis of tropical cyclone is supported by transport of large amount of moisture over the Arabian Sea and the Bay of Bengal. Hence, accurate analyses of moisture fields over these areas play an important role in understanding the mechanism and the dynamics of development of intense atmospheric systems. Satellite data, however, make it feasible to study the distribution of moisture and cloud liquid water content over large and remote oceanic areas because of their wide spatial and temporal coverage. Here, in this study IRS-P4 MSMR derived all geophysical parameters are used for finding their variations during genesis, development, mature stage and dissipation of tropical cyclone over the Arabian Sea for the period 21-28 May 2001.

4. RESULTS AND DISCUSSION

The following are the major results of the study

- IRS-P4-derived surface wind speed increased in the region surrounding center of tropical cyclone for the period 21 to 26 May and then drastically decreased on 27 and 28 May giving signatures that some lull is likely to occur in the further development of tropical cyclone (Fig. 2).
- Cyclonic vorticity surrounding the center of the storm at 850 hPa was well established and it was varying from 3 to 5×10^{-5}/s during 23 to 28 May 2001 (Fig. 3).
- Anticyclonic vorticity of the storm at 200 hPa started increasing from 21 May and reached substantial high (-4×10^{-5}/s) on 24 May 2001 (Fig. 4).
- Neither cyclonic nor anticyclonic vorticity was developed at 200 hPa in the region of tropical cyclone on 25th and 26th May 2001.
- Adverse development i.e. enhancement of cyclonic vorticity in larger area surrounding center of cyclone at 200 hPa was recorded on 27 to 28 May 2001.

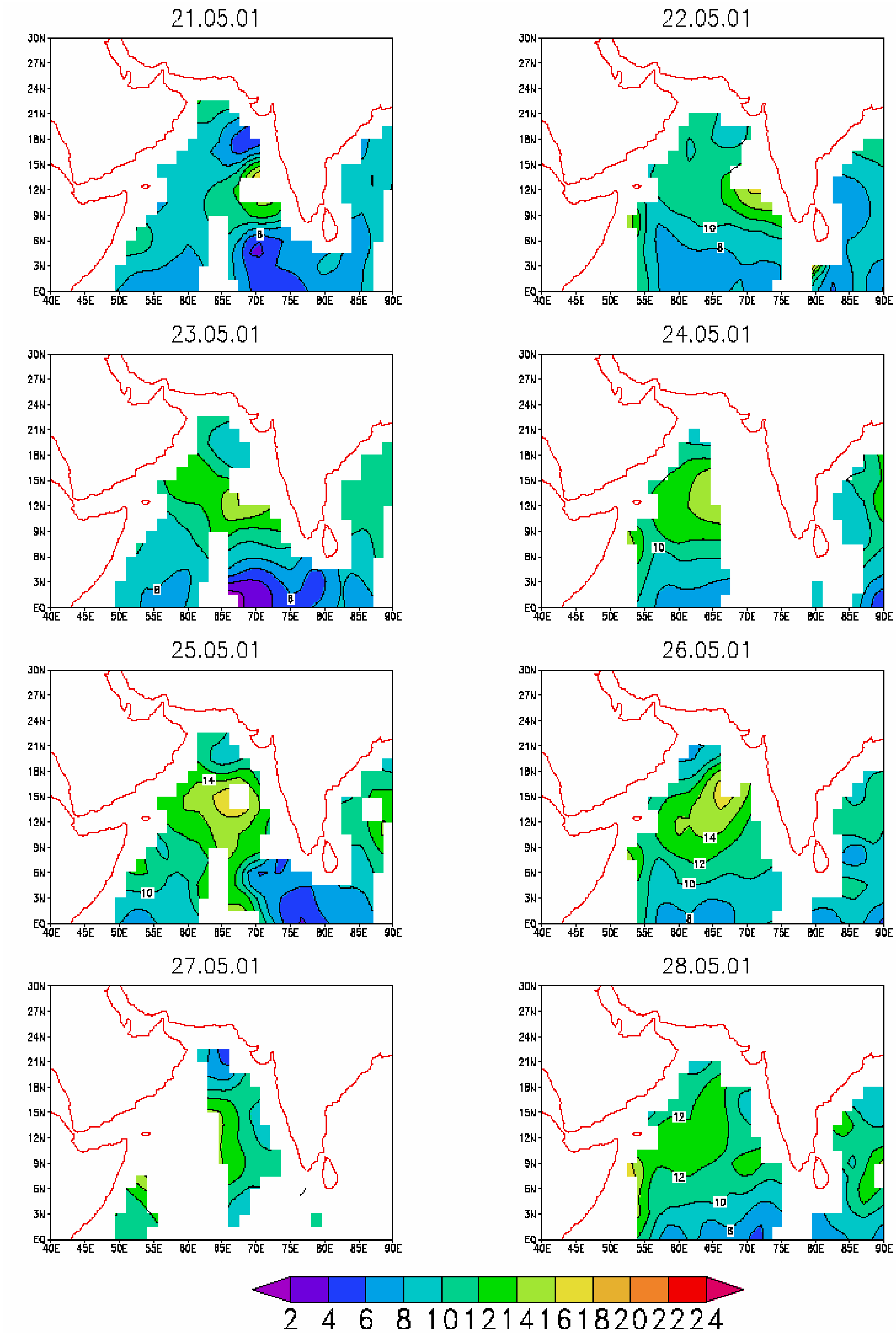

Figure 2: IRS-P4 MSMR sea surface wind speeds (m/s) during 21-28 May 2001.

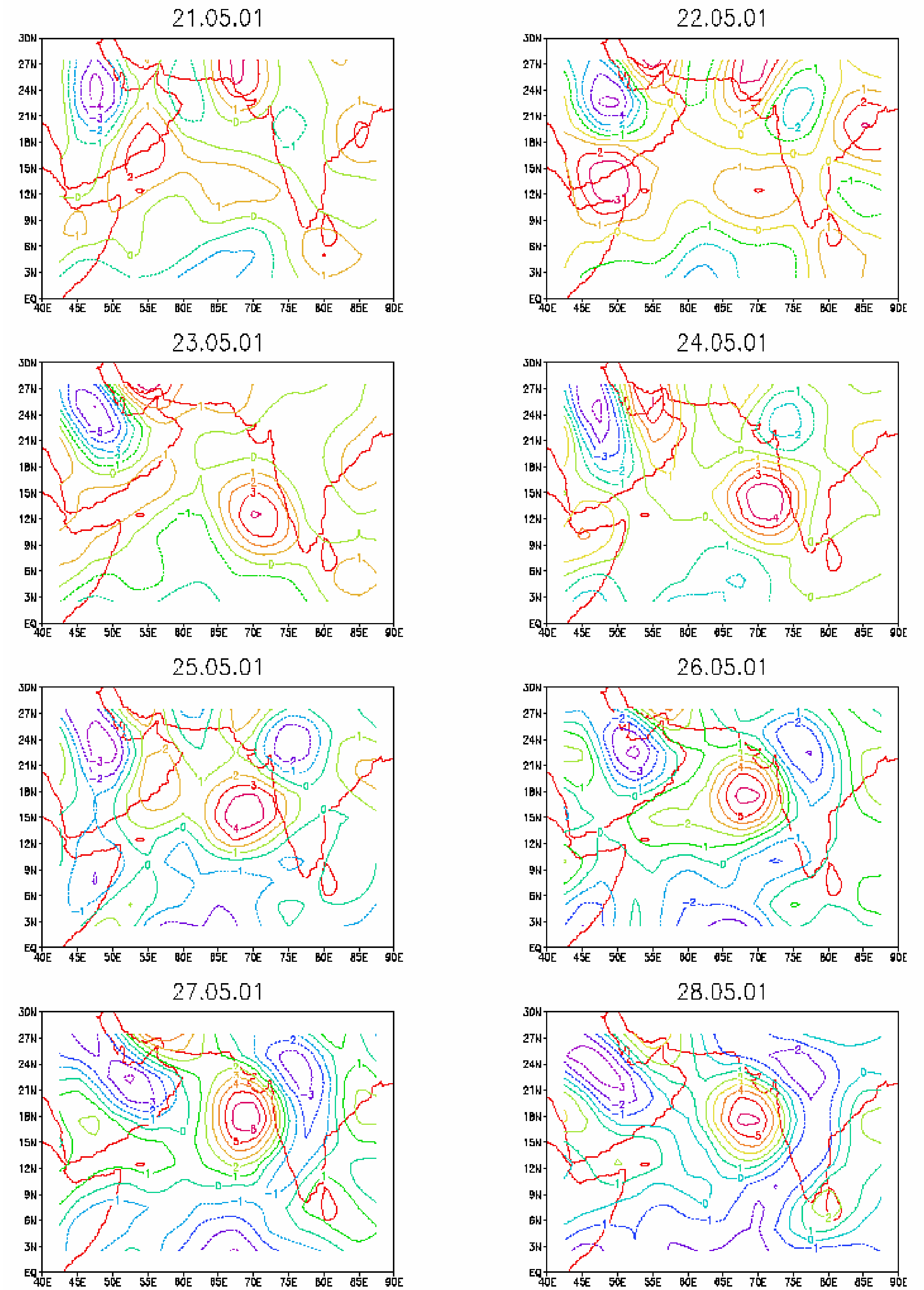

Figure 3: Vorticity (10^{-5}/sec) analyses at 850 hPa during 21-28 May 2001.

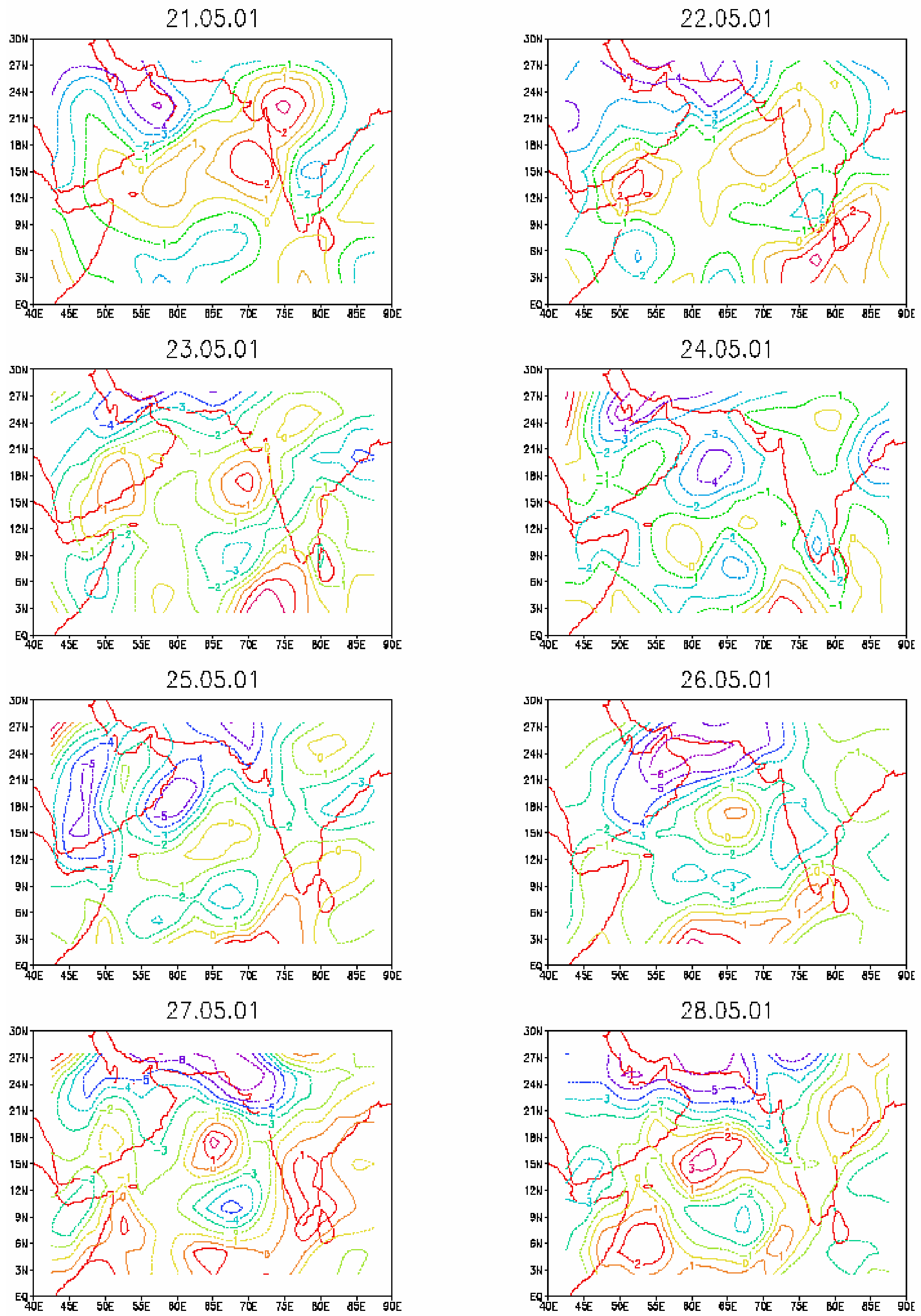

Figure 4: Vorticity (10^{-5}/sec) analyses at 200 hPa during 21-28 May 2001.

IRS-P4 MSMR derived geophysical parameters during the development of different stages of the tropical cyclone (21-28 May) had given the indication that it was likely to intensify into super cyclonic storm. But, instead of developing into super cyclonic storm it started dissipating from very severe cyclonic storm to well marked low pressure area from 27 May to 29 May 2001. Cyclonic vorticity at 850 hPa in the region of tropical cyclone started increasing from 22 May onwards and it was gradually more in the following days up to 28 May. It gradually developed from 3 to 5 x 10^{-5}/s during 23 to 28 May 2001.

This was the positive sign for the development of tropical cyclone into its peak intensity. But it did not develop into super cyclonic storm. Vorticity field at 200 hPa was thoroughly examined in order to understand non-development of the super cyclonic storm. Area of very small anticyclonic vorticity was further developed in to more anticyclonic vorticity (-4 x 10^{-5}/s) in the region of tropical cyclone during 21 to 24 May 2001. This generated eye, central dense overcast region and banding features of very severe cyclonic storm on 24th May. Later, neither cyclonic nor anticyclonic vorticity area at 200 hPa was developed in the region of tropical cyclone surrounding eye on 25th and 26th May. Further, more intense cyclonic vorticity area was developed on 27th and 28th May giving a signal of dissipation of tropical cyclone. In association with these reverse developments at 200 hPa tropical cyclone dissipated in to depression on On 28th May, further it dissipated into well-marked low-pressure area on 29th May and hit the coast of Gujrath without any disastrous event.

5. CONCLUSION

In this study, apart from proper variations of geophysical parameters and satellite imageries, the improved analysis of vorticity, convergence and divergence of the wind field based on input of modified CMVs and WVWVs in objective analysis of the wind field at 850 and 200 hPa gave a signal of dissipation of very severe tropical cyclone into well marked low pressure area 2-3 days before its hitting the west coast of India.

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