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Research Article

MULTI-SPECTRAL ANALYSIS OF THE VORTEX DURING (16-21) DECEMBER 2005

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ABSTRACT
The multi-spectral satellite imagery and Doppler Weather Radar (DWR) analysis plays an important role in forecasting to determine the movement and intensity of the vortex. In this present study, the upper air forecasting charts produced by regional specialized meteorological centre (RSMC) New Delhi have been utilized for analyzing the vertical extent of the vortex formed over Bay of Bengal during 16-21 December, 2C05. The simulated widespread rainfall distributions during the storm from mesoscale numerical models have also been graphically analyzed.

Keywords: *Low Pressure Area, Numerical Model, Mesoscale and Convective Rain Bands*

INTRODUCTION
It is well known fact that the East coast of India is very prone to natural disasters (like, tropical cyclones and floods etc) during Northeast monsoon season (October -December). Based on observational analysis. Gray (1968) suggested six parameters of atmospheric and oceanic conditions for genesis of tropical storms. These are sea surface temperature (SST), relative vorticity in lower levels, vertical wind shear, vertical stability, coriolis force and relative humidity in the lower and middle troposphere. The vertical wind shear for both monsoon depression and tropical cyclones (October to December for an area 7.5 N – 17.5 N, 80 E- 95.0 E is lower for the period 1970- 1974) of higher frequency than for the period 1989-1993 of lower frequency (Kalney *et al.,* 1996). The conventional way for the intensity of tropical disturbances, using satellite imagery data (Dvorak, 1984 & Kalsi, *et al.*, 2002) for operational purposes have been used in intensity analysis of the vortex over Bay during 16-21 December, 2005. The fifth generation mesoscale model (MM5) convective precipitation scheme discussed by Cotton and Anthes (1993) for different convective environment of precipitation clouds will be different at different locations. The wide-spread distribution of rainfall simulated by Grell (1994) scheme has been used in this present vortex study. Rainfall estimation based on the reflectivity data of Chennai and neighborhood (165 km radius) which is based on $Z= 267\ R^{1.345}$ is works reasonably well in all the seasons. This Z-R relationship is defined already by well-known Marshal -Palmer (1948) equation ($Z==aR^{b}$) in which 'R' represents the rainfall intensity and a and b are constants. This gives the surface rainfall intensity (mm/hr) over the area. Its variation over the area indicates the system intensity and its movement, towards or away from the station.

MATERIALS AND METHODS
DATA
The Kalpana-1 satellite imageries data used for the present study at Infrared (10.5µ -12.5µ), Visible (0.55µ - 0.75µ) and Water vapour (5.1µ- 7.lµ) bands is taken from satellite division of India Meteorological Department Lodi Road New Delhi. Some of the Meteosat -5 satellite images of Dundee satellite receiving station available at web site: www. sat.dundee.ac.uk/pdus/pdus.html, are utilized to fill the gap of continuity in the analysis. The daily operational Eta and MM5 model forecast charts available at National Centre for Medium Range Weather Prediction Forecast (NCMRWF) web site:

www.ncmrwfgov.in, have also been utilized in this study. The model analysis charts at different pressure levels are taken from India Meteorological Department (IMD) web site (www.imd.ernet.in).

RESULTS AND DISCUSSION

ANALYSIS

a. Synoptic/satellite Analysis

Present study is to explain the behavior of the vortex formed over southeast (SE) Bay of Bengal using K ALP ANA -1 and Meteosat -5 cloud imageries with mid & upper troposphere moisture distribution analysis depicted in Water vapour satellite imageries. Initially, a curved band which was filled with convective clouds along its entire length on 16 December/ 0300 UTC, has associated with intense to very intense convection concentrated into depression and observed to have centre near 8.0 °N/ 85.0 E and strength T1.5 as estimated by Dvorak Technique (Fig. 1). By 17 December /0600 UTC curved band grew organization as seen by the increasing curvature and moisture content of the cloud band and it is almost circular in shape (Fig. 2). This pattern is similar to central dense overcast (CDO) type. The convective cloud mass, now almost closer to the centre of the vortex below low clouds to the west (Fig. 3). The distance between the centre of the vortex and dense overcast was estimated to be more than 0.75° and therefore the intensity of the vortex was estimated to T2.0. The system then moved north-northeastward and the vortex had band type of pattern, later it concentrated into shear type of pattern. In the water vapour imagery of 18 December/0530 UTC (Fig 4) shows more spatial distribution of water vapour over the area, due to this the cloud pattern is no longer circular type and moisture extended to upper troposphere. Whereas the distance between the centre, which of course was not very distinct due to poor appearance of non convective clouds in Infra red (IR) imagery and dense overcast to the north (Fig. 5) 18 December /05 UTC. The clouds kept their organization in 'shear type' pattern with vortex centre nearly more than 0.50 to the northeast of the dense overcast. The intensity was operationally given as T2.0 on 18 December /0600 UTC seeing the centre of the vortex below low clouds. The water vapour distribution shown in (Fig. 7) also indicates E-NE propagation of moisture. It is due to the fact that the composition of vortex as regards clouds did not change appreciably except that convective dense overcast shifted from west to north of vortex centre (Fig. 6). The intensity of the vortex estimated operationally T2.0 with centre near 11.3 °N/ 82.4 °E at 1800 UTC of 19 December 2005 (Table 1). The vortex was not further intensified and weakening gradually from T 2.5 to T1.5/ C.I. 2.0. at 20 December /1200 UTC. The 'shear type' pattern was indicative of strong vertical wind shear over the vortex region and rapid intensification was not favoured. The deformed moisture distribution is shown in Fig. 8. The increasing distance was almost 0.75° between the dense overcast and vortex centre 11.8 N/83.6 E. at 20 December/1800 UTC was pointing to further disorganization of structure. Thereafter it remained stationary till 21 December 70300 UTC and later dissolved over there as low level circulation.

b. Doppler Weather Radar (DWR) and Model Analysis

Doppler weather radar (DWR) at Chennai derived Max (z) reflectivity spectrum in E-W (X- dir) and N-S (Y -dir) orientation on 17 -19th December 2005 shows the pattern of convective rain bands. Their colour coding indicates the convection overlying the area. The surface rainfall intensity on 17th December is SE and NE oriented and widely distributed in 100-300 km area (~ 14.2 mm/hour at 0900 UTC) from the Chennai station. On 18th and 19th December this distribution is confined in a lesser area around 100-200 km area only. PPI (V) determines the radial velocity distribution and it has both positive and negative values of velocities, negative velocity shows that the disturbance is approaching towards the station whereas the positive values shows that it is moving away. On 18th and 19th December, 2005 PPI (V) velocity spectra it is clear that the system is away from the Chennai station in comparison to 17th December, 2005 [Figs. 12 (a to j)]. The MM5 and Eta model simulated rainfall comparison shows that Eta model rainfall intensity is under estimated in comparison to MM5 simulated rainfall. On 18th to 20th December 2005 the spatial distribution of rainfall by all the three models are almost the same. On 18th to

20th December 2005 the area predicted is approximately 06 N to 17 N and 80 E to 95 E. But the rainfall

Table -1: Position and Intensity of the Vortex during 16-21 December 2005.

Date	Time (UTC)	Centre Position	Intensity (T .No)
16-12-2005	0300	8.0 N/85.0 E	T1.5
17-12-2005	0000	8.2 N/84.2 E	T2.0
	0300	8.2 N/84.2 E	T2.0
	0600	8.2 N/83.8 E	T2.0
	1200	8.3 N/83.3 E	T2.0
	1800	8.6N/83.1E	T2.0
18-12-2005	0000	9.0 N/83.0 E	T2.0
	0600	103 N/82.7 E	T1.5
	1200	10.7N/82.5E	T2.0
	1800	10.9N/82.5E	T2.0
19-12-2005	0000	10.9N/82.5E	T2.0
	0300	11.0N/82.5E	T2.0
	0600	11.2N/82.4E	T2.0
	1200	11.3N/82.4E	T2.0
	1800	11.3N/82.4E	T2.0
20-12-2005	0000	11.6N/82.8E	T2.0
	0300	11.5N/82.8E	T2.0
	0600	11.6N/83.5E	T2.0
	0900	11.6N/83.6E	T2.0
	1200	11.8N/83.6E	T1.5/C.I2.0
	1800	11.8N/83.6E	T1.5/C.I2.0
21-12-2005	0300	Low level cir.	

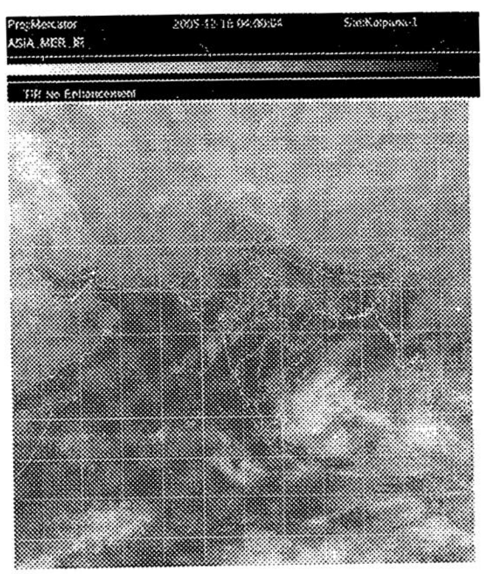


Fig. 1: Kalpana – 1 Infrared (IR) 04 UTC indicating curved band of convective cloud Mass (16 December, 2005)

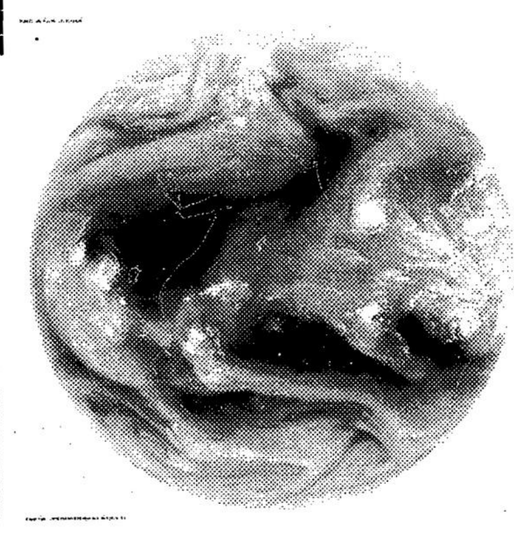


Fig. 2: Meteosat-5 Water Vapour (WV) 0530 UTC indicating low and middle level troposphere moisture (17 December, 2005)

amount predicted approximately 50cm, 160 cm, 130 cm and 100 cm from 17th to 20th December respectively (MM5 operational model at NCMRWF). But this amount comes approximately 45, 140, 100 and 80 cm (The operational IMD MM5 model analysis). This 24 hours forecasted rainfall analysis gives an idea of wide spread distribution of rainfall. The 24 hours forecasted rainfall by Eta model shows very less intensity for all the above four days as 18, 21, 18 & 13 cm respectively. These types of case studies are important because, the genesis and development of such type of vortices are primarily based on the release of latent heat of condensation and its cooperative interaction with the convective systems. The

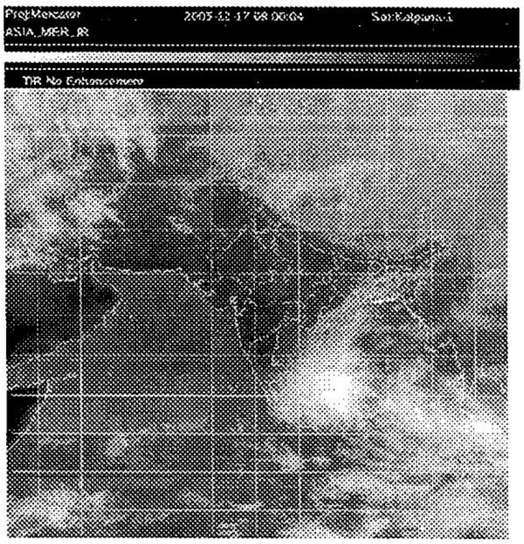


Fig 3: KALPANA-1 IR, 09 UTC indicating central dense overcast (CDO) type pattern and almost circular in shape (17 December,2005)

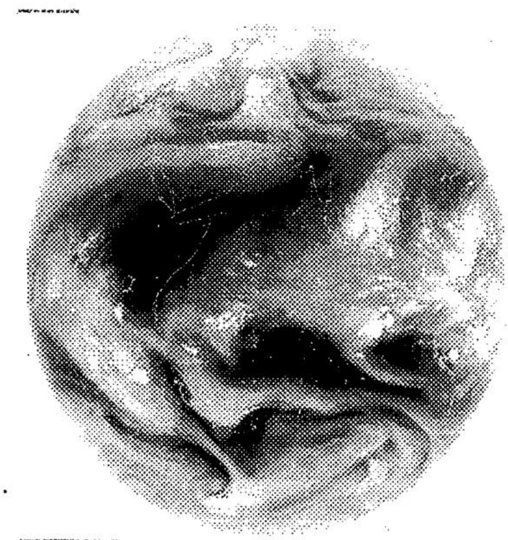
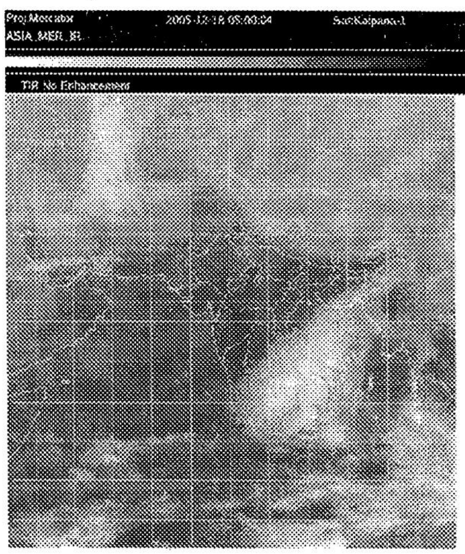


Fig 4: Meteosat -5 'WV' 18 December/ 0530 UTC 'shear type' pattern.



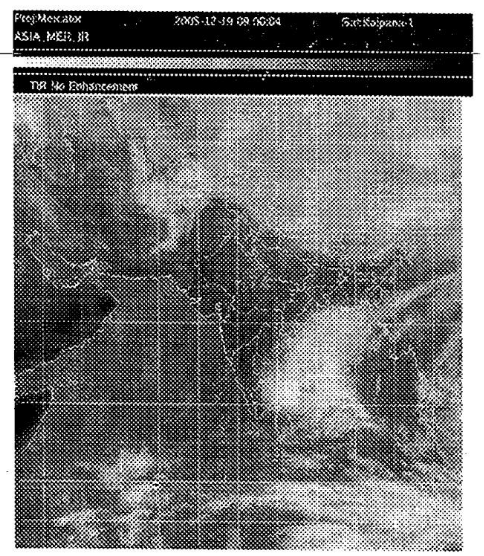


Fig 5: IR imagery of KALPANA-1 satellite, 18 December/0500 UTC, 'shear type'.

Fig 6: IR imagery of KALPANA-1 satellite 19 December/0900 UTC, 'shear type' model simulated rainfall results are shown graphically in the [Fig 9, 10 &11 (a to d)]. The upper level wind analysis in support of the genesis and intensification of the system are shown in the [Fig 13 (a to f). This shows that the well-marked depression over Bay extended up to middle and upper troposphere. This system remained almost stationary in upper levels also for two days, 18th and 19th December 2005. These forecasting analysis charts produced by RSMC (New Delhi) have significantly improved the knowledge of intensification and weakening of the system. This in turn improves the forecasting accuracy of intensity and track prediction.

pattern remains almost stationary.
(convection decreases)

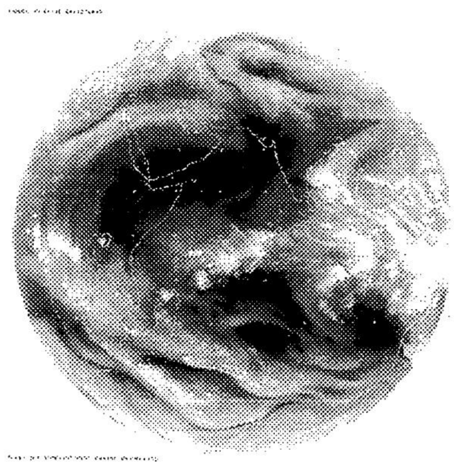


Fig 7: Meteosat -5 'WV' imagery on 20 December/0830 UTC showing 'E-NE' propagation of moisture

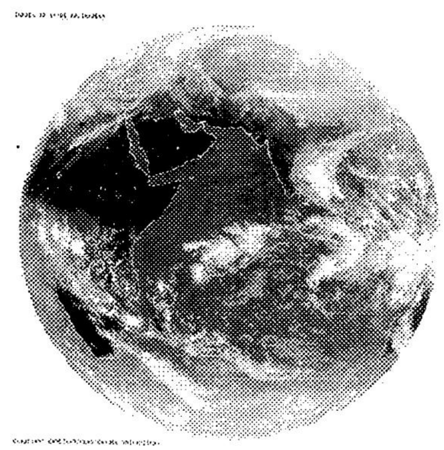


Fig 8: Meteosat -5 'IR' imagery at 1100 UTC 20 December, 2005 showing deformed convective cloud structure.

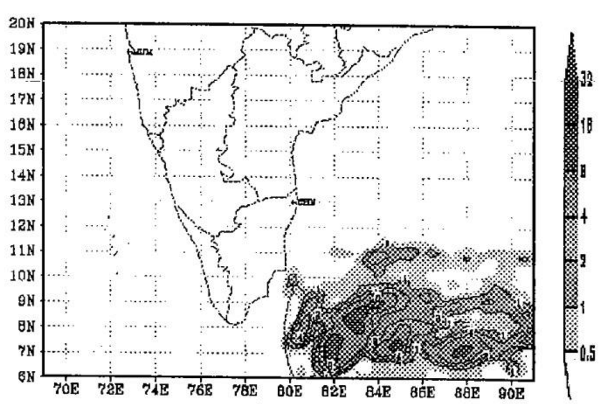


Fig 9 (a): MM5 (NCMRWF) rainfall forecast on 17 December, 2005.

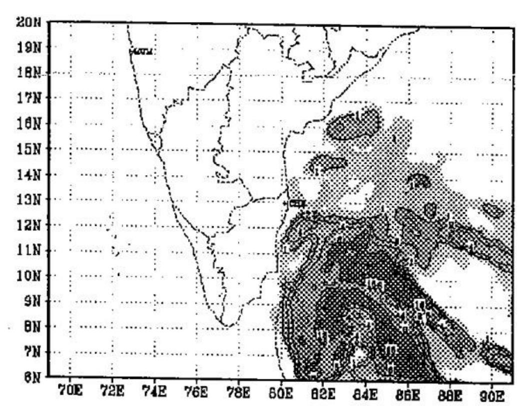


Fig 9 (b): MM5 (NCMRWF) rainfall forecast 0n 18 December,2005.

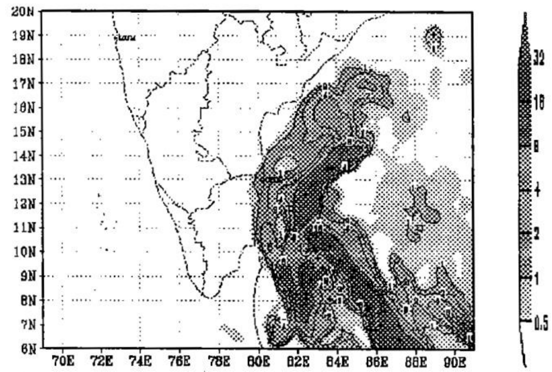


Fig 9 (c): MM5 (NCMRWF) rainfall forecast on 19 December, 2005.

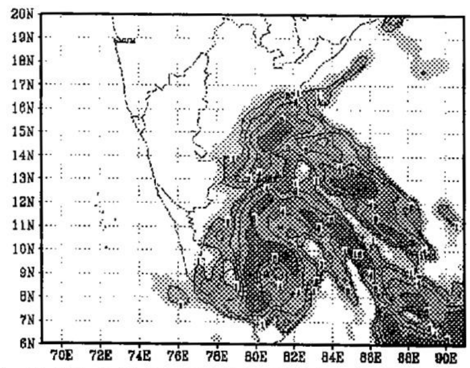


Fig 9 (d): MM5 (NCMRWF) rainfall on 19 December, 2005.

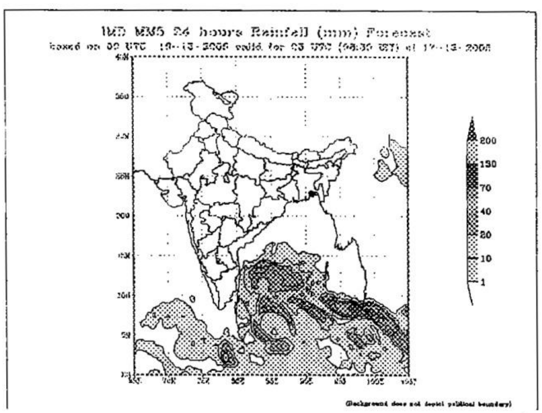


Fig 10 (a): MM5 (IMD) rainfall forecast on 17 December, 2005.

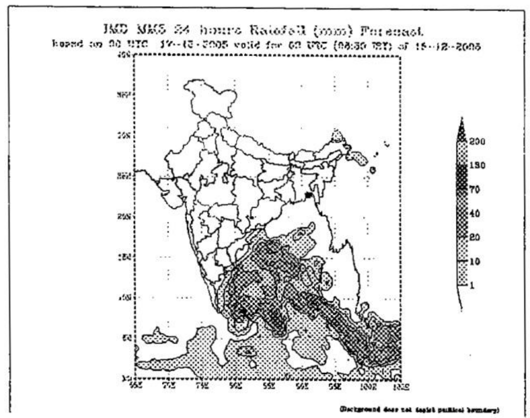
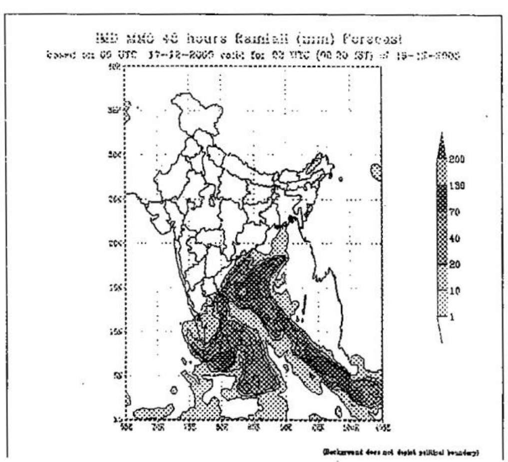


Fig 10 (b): MM5 (IMD) rainfall forecast on 18 December, 2005.



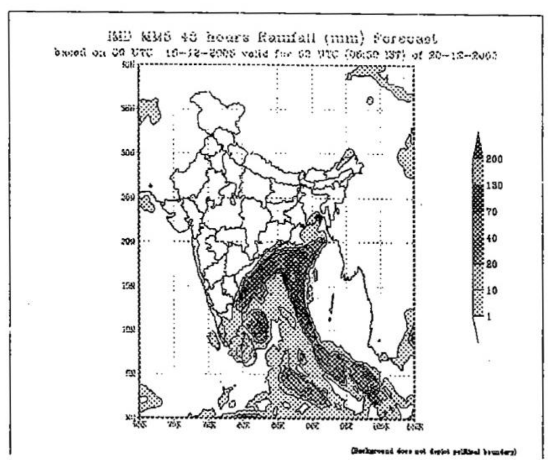


Fig 10 (c): MM5 (IMD) rainfall forecast on Fig 10 (d): MM5 (IMD) rainfall forecast

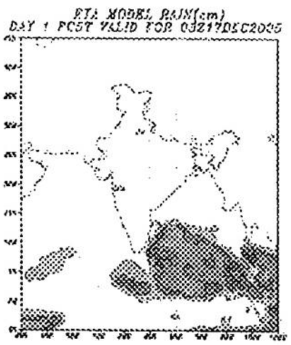


Fig 11 (a): Eta (NCMRWF) rainfall forecast on 17 December, 2005.

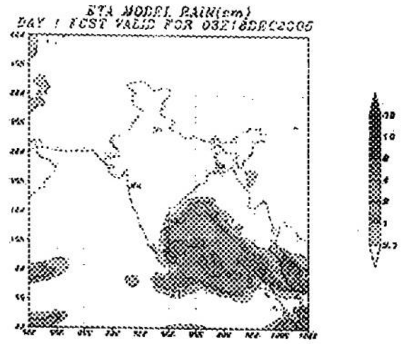


Fig 11 (b): Eta (NCMRWF) rainfall forecast on 18 December, 2005.

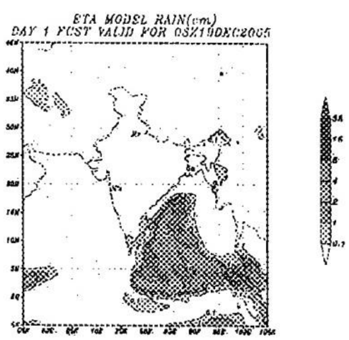


Fig 11 (c): Eta (NCMRWF) rainfall forecast on 17 December, 2005.

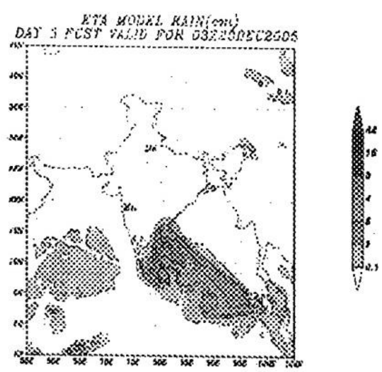
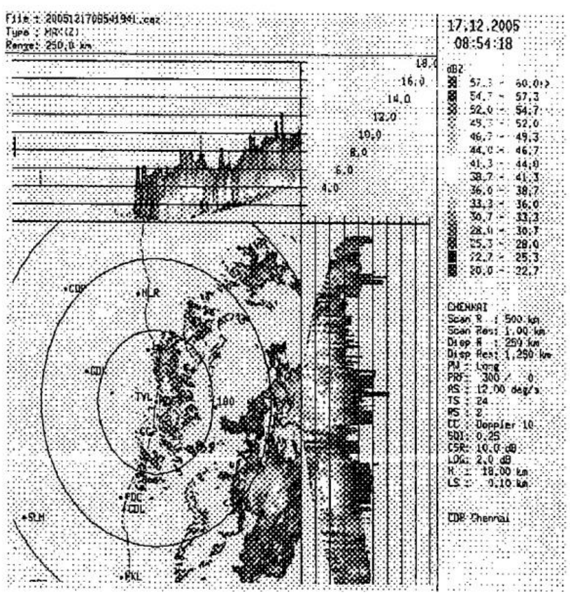


Fig 11 (d): Eta (NCMRWF) rainfall Forecast on 18 December, 2005.



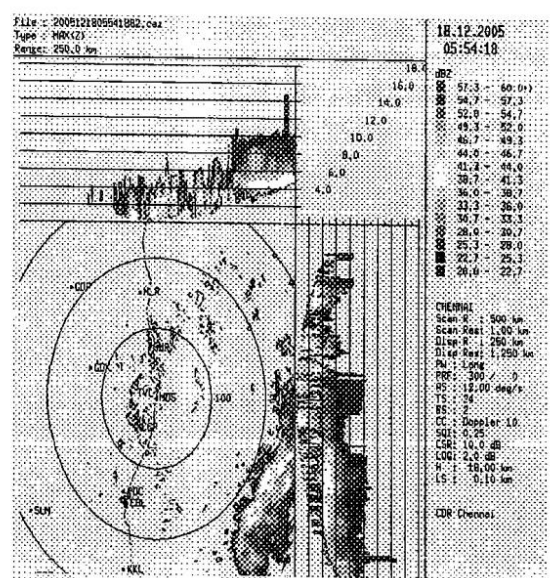
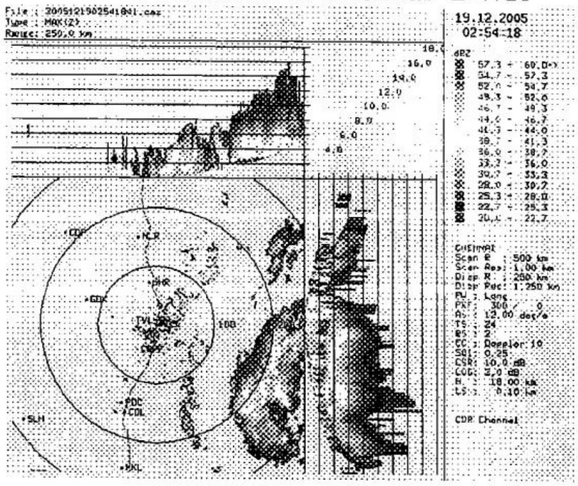


Fig 12 (a): Max reflectivity Z) on 17th December at Chennai 'DWR'

Fig 12 (b): Max. reflectivity (Z) on 18th December at Chennai 'DWR'



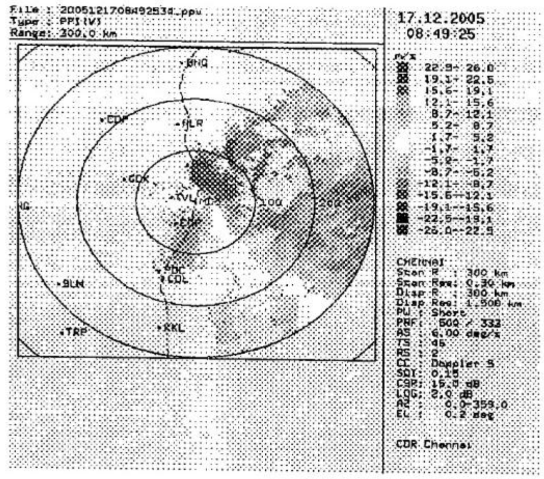
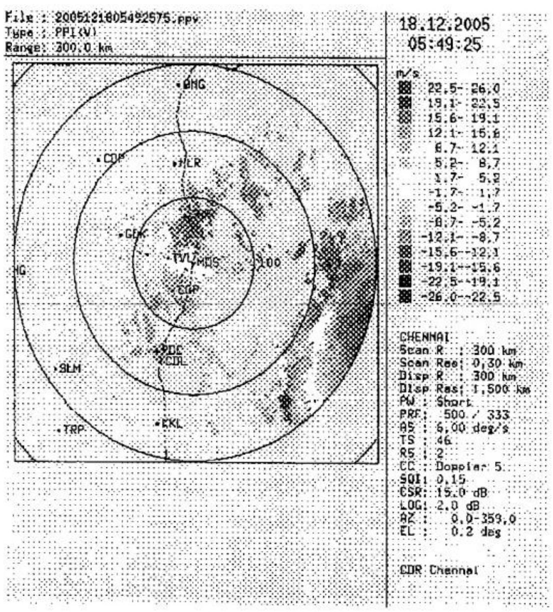


Fig 12 (c): Max reflectivity Z) on 19th December at Chennai 'DWR'

Fig 12 (d): Plan position Indicator (V), 17th December at Chennai 'DWR'



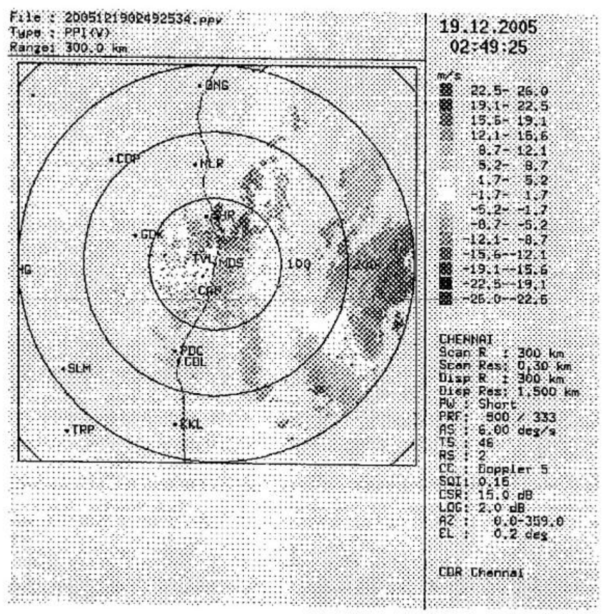


Fig 12 (d): Plan position Indicator (V), 18th December at Chennai 'DWR'

Fig 12 (d): Plan position Indicator (V), 19th December at Chennai 'DWR'

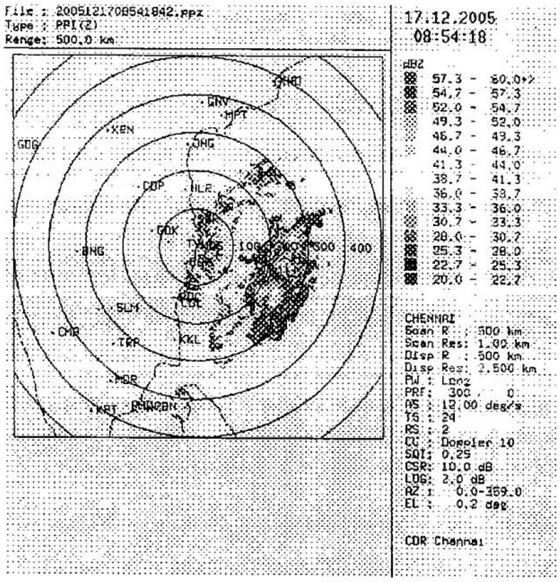


Fig 12 (e): Plan position Indicator (Z), 17th December at Chennai 'DWR'

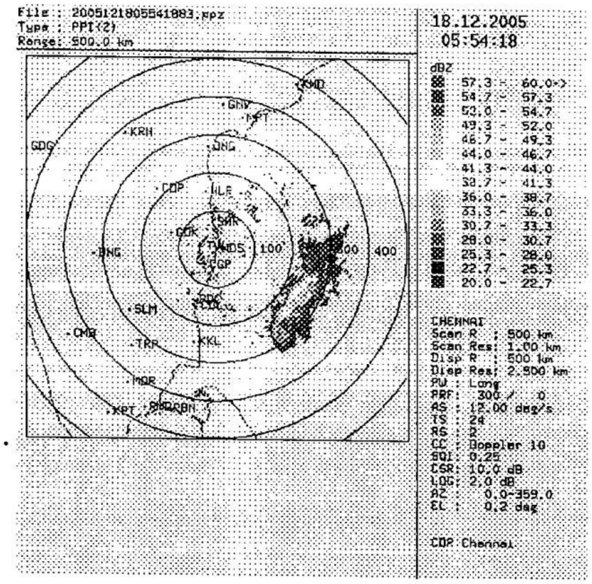


Fig 12 (f): Plan position Indicator (Z), 18th December at Chennai 'DWR'

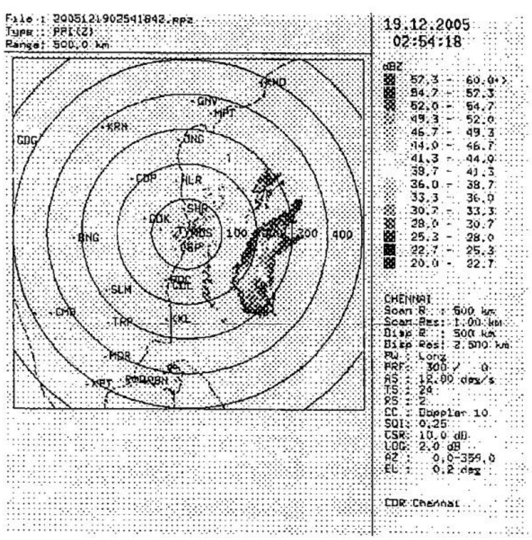


Fig 12 (g): Plan position Indicator (Z), 19th December at Chennai 'DWR'

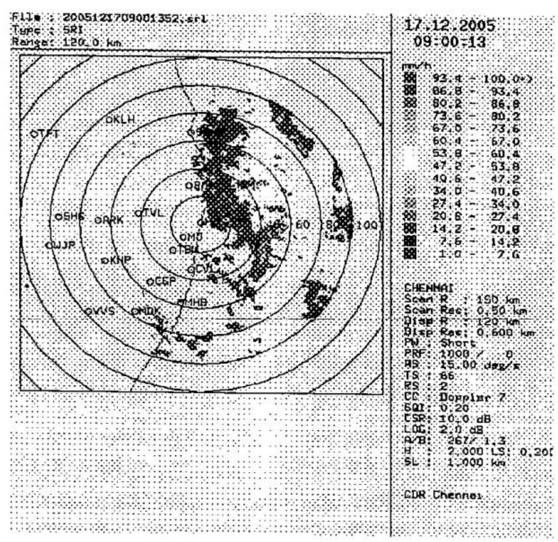


Fig 12 (h): Surface rainfall intensity on 17th December at Chennai 'DWR'

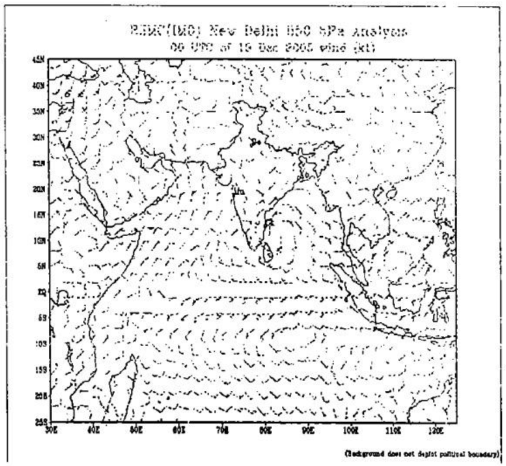


Fig 13 (c): Winds analysis RSMC, (New Delhi) at 850 hPa 19 December

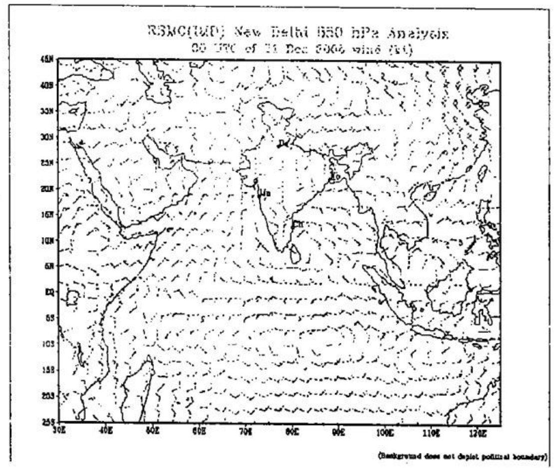


Fig 13 (d): Winds analysis RSMC, (New Delhi) at 850 hPa, 21 December

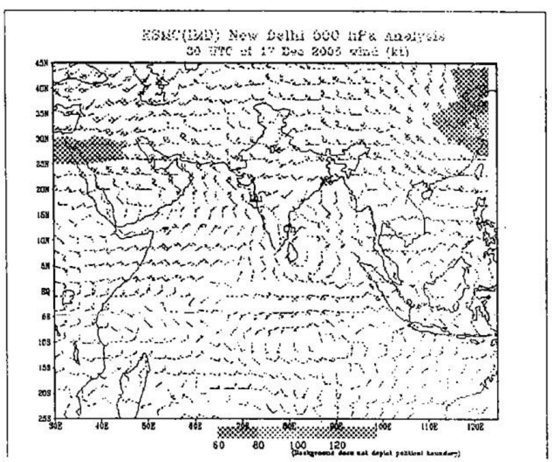


Fig 13 (e): Winds analysis RSMC, (New Delhi) at 500 hPa 17 December

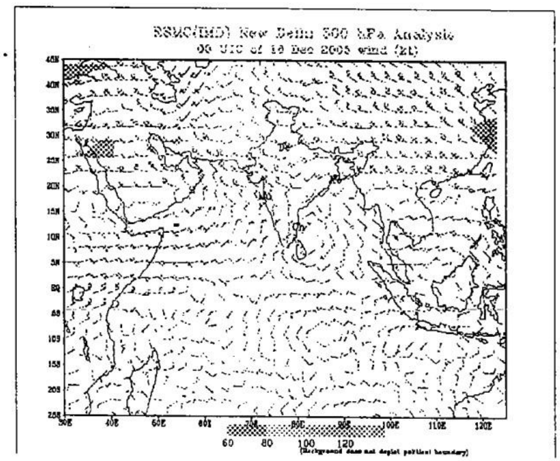


Fig 13 (f): Winds analysis RSMC, (New Delhi) at 500 hPa, 18 December

CONCLUDING REMARKS

The results derived from the numerical study are preliminary and needs to be generalized with systematic inter-comparison with other mesoscale models (like operational weather research forecast (WRF) model simulation analysis). The National centre for medium range weather forecasting (NCMRWF) forecasting charts of Eta and MM5 rainfall simulation analysis with India meteorological department (IMD) MM5 rainfall simulation analysis charts shows that MM5 predicts the rainfall distribution both spatially and intensity wise reasonably well. But the Eta model rainfall simulation for the given vortex shows lesser rainfall intensity than rainfall predicted by MM5 model. But the spatial distribution of rainfall for 17^{th} December, 2005 is lesser than that predicted by MM5 simulated rainfall. The Surface rainfall Intensity on 17^{th} December, 2005 as estimated by DWR shows that most of the rainfall lays 150 -300 km area in SE and NE direction from Chennai station. On 18^{th} and 19^{th} December, 2005 this distribution confined into 100-200 km area in NW direction. It is clear that tremendous potential exists for optimum utilization of radar reflectivity, radial velocity and spectrum width in the tropical region. The PPI (V) which normally a measure of turbulence is very important in now casting the expected weather over the area. In this way the RSMC, New Delhi upper air winds charts; model analysis and non conventional information from satellite and DWR provide very valuable information in forecasting and intensity prediction of the storm. Rainfall simulation is very important in forecasting the heavy rainfall events over the area. Also rainfall intensity of DWR clearly specifies the area of heavy rainfall because southwest sector of the tropical depression is more rain producing sector it is because of the formation of very deep convective clouds in this sector.

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