9. Deep depression over the Arabian Sea (26 November to 1st December, 2011)

9.1 Introduction:

A depression formed over the Comorian area on 26th November. Moving west-northwestwards, it intensified into a deep depression over Lakshadweep area. It then moved northwestwards towards Oman coast. However, due to colder sea and increase in vertical wind shear it weakened and dissipated over west central Arabian Sea off Oman coast on 1st December. The detailed characteristics of this system are described below.

The cyclogenesis, intensity and location were mainly determined based on satellite imageries and products. In-situ observations from surface observatories of India and Sri Lanka and buoy and ship observations were also immense use. . However, as the system entered into central Arabian Sea, satellite was the main source for determining location and intensity of the system.

9.2 Genesis:

Arabian Sea has been quite active in post-monsoon season (October-December), 2011. It was the third cyclonic disturbance over the Arabian Sea during this period. The higher cyclogenesis over this ocean basin could be attributed to active ITCZ and favouable large scale amplification of convection due to MJO.

Like the previous two system, this system also formed due to active ITCZ over the region. The active ITCZ roughly ran along 07^0N on 23-25 November, 2011. Under its influence, a cyclonic circulation formed over southwest Bay of Bengal off Sri Lanka and south Tamil Nadu coast on 23rd November 2011. It was seen as a low pressure area over southwest Bay of Bengal and adjoining Sri Lanka on 24th. It moved west-northwestwards and became well marked on 25th and concentrated into a depression at 0300 UTC of 26th November over the Comorian area and neighbourhood and lay centred near lat. 7.5^0N and long. 76.5^0E, about 120 km south-southwest of Thiruvanthapuram.

The favourable factors for cyclogenesis included the favourable MJO (MJO index in phase 2), warmer sea surface temperature (28-29^0C), higher ocean thermal energy (70-80 KJ/cm^2), higher relative vorticity and convergence at lower levels, higher upper levels divergence and low to moderate vertical wind shear (10-20 knots) between 200 and 850 hPa levels.

The best track parameters of the system are shown in Table 9.1. The best track is shown in Fig. 9.1. The typical satellite imageries are shown in fig. 9.2. The ECMWF model analysis during different phases of the system are shown in Fig 9.3.

9.3 Intensification and movement:

The depression lay to the south of the upper tropospheric ridge, which ran along 14^0N in association with an anticyclonic circulation over southwest peninsula of India and adjoining southwest Bay of Bengal on 26th November 2011. As the system lay far to the south of the steering ridge, it moved west-northwestwards. Also the favourable condition as mentioned in previous section continued with MJO index moving slowly to phase 3 on 27th. As a result, the depression further intensified into a deep depression and lay centred at 0000 UTC of 28th November over central Bay of

Bengal near Lat 13.5^{0}N and long. 70.0^{0}E. As the a system picked gradually northerly latitude, The upper tropospheric ridge also moved northward alongwith the anticyclonic circulation. As a result, the system continued to lie in the southwestern periphery of the anticyclonic circulation in middle and upper tropospheric levels. However, the anticyclonic circulation retrograded gradually from its central location over central Bay of Bengal off Andhra Pradesh coast at 1200 UTC of 26th to north Maharashtra and south Gujarat at 0000 UTC of 1st December. The upper tropospheric ridge ran along lat. 18^{0}N on 28th morning, 19^{0}N on 29th and 20^{0}N on 30th November 2011. At the same time a trough in mid latitude westerlies in middle and upper tropospheric levels moved gradually eastwards. It ran along 40^{0}E to the north of 15^{0}N on 28th, 45^{0}E to the north of 15^{0}N on 29th and 50^{0}E to the north of 15^{0}N on 30th November 2011.

Under all these scenario, though the vertical wind shear gradually decreased being minimum and leading to intensification in deep depression, it increased after wards. Further it experienced colder sea (SST of 26-27^{0}C) and low ocean thermal energy (<50 KJ/cm^2) from 28th November onwards. All these led to gradual weakening of the system. It weakened into a depression at 1200 UTC of 29th November and lay centred near lat. 16^{0}N and long. 66.5^{0}E and further into a well marked low pressure area over west central Arabian Sea at 0600 UTC of 1st December 2011.

Under the impact of the approaching trough in westerlies in middle and upper levels and anticyclonic circulation to the northeast of the system centre, the poleward outflow from the system reached upto Karnataka coast on 28th, Maharashtra and Gujarat coast on 29th and north Pakistan and adjoining Indian region on 30th November 2011. The track of the system as changed from west-northwesterly to northwesterly on 29th and north-northwesterly on 30th November 2011.

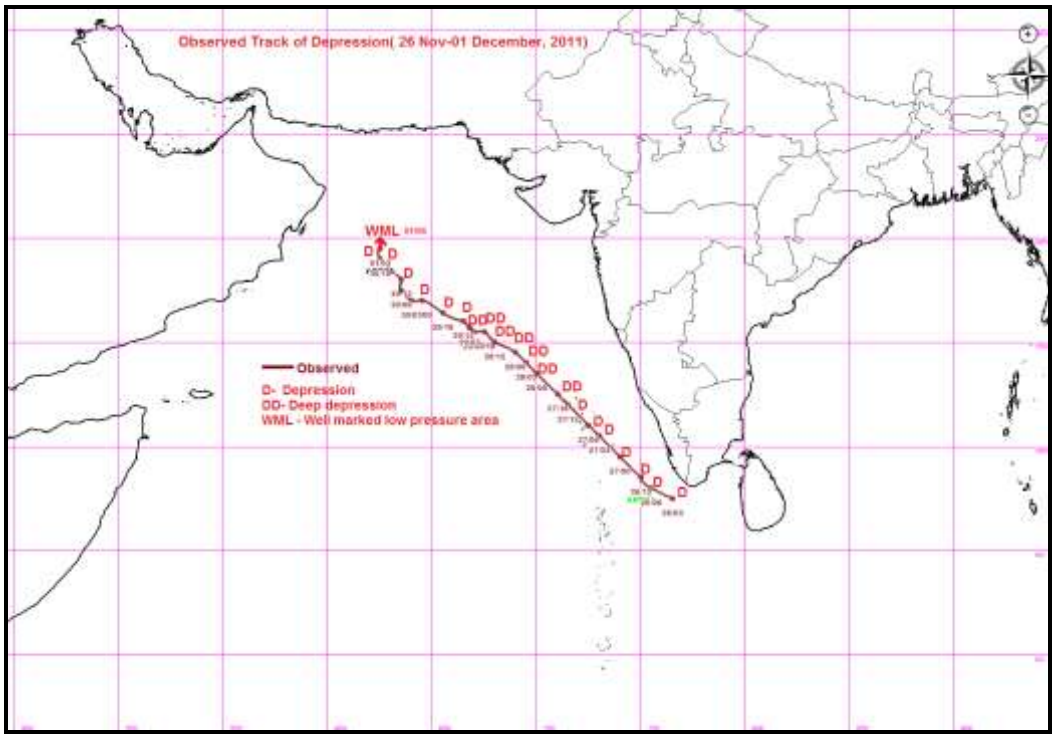

Fig. 9.1 Track of deep depression over the Arabian Sea during 26 N0vember-01 December, 2011

Table 9.1 Best Track positions and other parameter of deep depression over the Arabian Sea during 26 N0vember-01 December, 2011

Date	Time (UTC)	Centre (Lat ^{0}N/ Long ^{0}E)	C.I. No.	Estimated central Pressure (hPa)	Estimated Maximum sustained surface wind speed(Kt)	Estimated pressure drop at the centre (hPa)	Grade
26-11-2011	0300	7.5//	1.5	1002	25	3	D
	0600	8.0/75.5	1.5	1002	25	3	D
	1200	8.5/75.0	1.5	1000	25	3	D
	1800	8.5/75.0	1.5	1000	25	3	D
27-11-2011	0000	9.5/74.0	1.5	1000	25	3	D
	0300	10.5/73.0	1.5	1000	25	3	D
	0600	11.0/72.5	1.5	1000	25	4	D
	1200	12.0/71.5	1.5	1000	25	4	D
	1800	12.571.0	1.5	1000	25	4	D
28-11-2011	0000	13.5/70.0	2.0	998	30	5	DD
	0300	14.0/69.5	2.0	998	30	5	DD
	0600	14.5/69.0	2.0	998	30	5	DD
	1200	15.0/68.0	2.0	998	30	5	DD
	1800	15.5/67.5	2.0	998	30	6	DD
29-11-2011	0000	15.5/67.0	2.0	998	30	6	DD
	0300	15.7/66.8	2.0	998	30	5	DD
	0600	16.0/66.5	2.0	998	30	5	DD
	1200	16.0/66.5	1.5	1000	25	4	D
	1800	16.4/65.5	1.5	1000	25	4	D
30-11-2011	0000	17.0/64.4	1.5	1000	25	4	D
	0300	17.0/64.5	1.5	1000	25	4	D
	0600	17.5/63.5	1.5	1000	25	4	D
	1200	18.0/63.5	1.5	1000	25	3	D
	1800	19.0/62.5	1.5	1000	25	3	D
01-12-2011	0000	19.5/62.5	1.5	1002	25	3	D
	0300	19.5/62.5	1.5	1002	25	3	D
	0600	19.5/62.5	Weakened into a well marked low pressure area over westcentral Arabian Sea.				

9.4 Realised weather:

Heavy to very heavy rainfall occurred over Tamil Nadu, Puducherry, Kerala and Lakshadweep Island and also over Sri Lanka. Chief amount of rainfall (in cm) are follows:

27-11-2011:

Coonoor 16, Kodaikanal and Kovilpatti 13 each, Tiruttani 12, Kavaratti 11, Tuticorin, Ennore Port and Cuddalore 9 each, Chennai 8, Pechiparai, Thiruvanathpuram, Agati and Kanyakumari 7 each.

9.5 Damage

Sri Lanka:
(i) Number of human deaths: 19
(ii) Number of home damaged: 5700
India:
No damage has been reported due to this system.
Oman:
No damage has been reported due to this system.

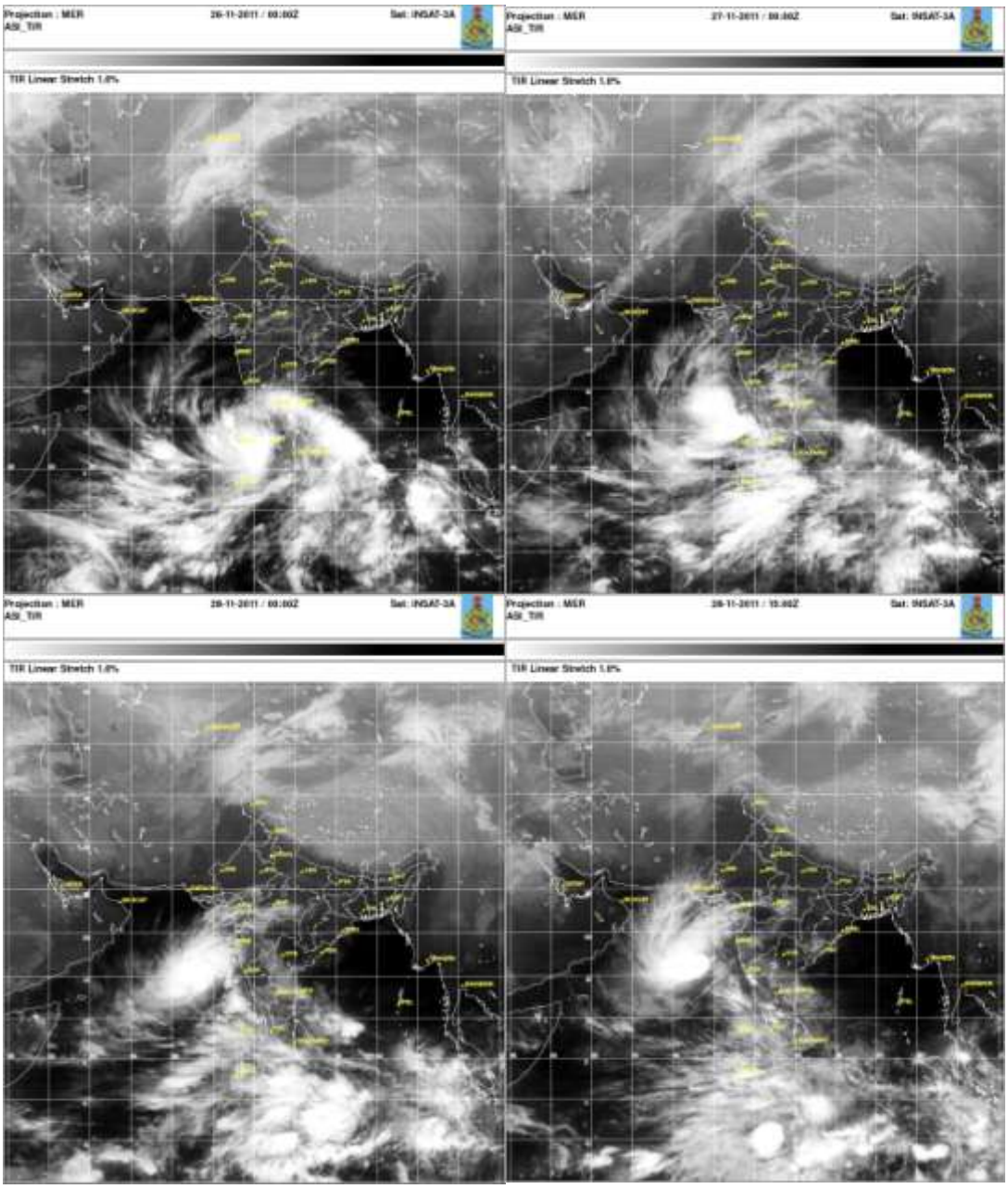

Fig. 9.2 The typical satellite imageries showing the intensification and movement of the system.

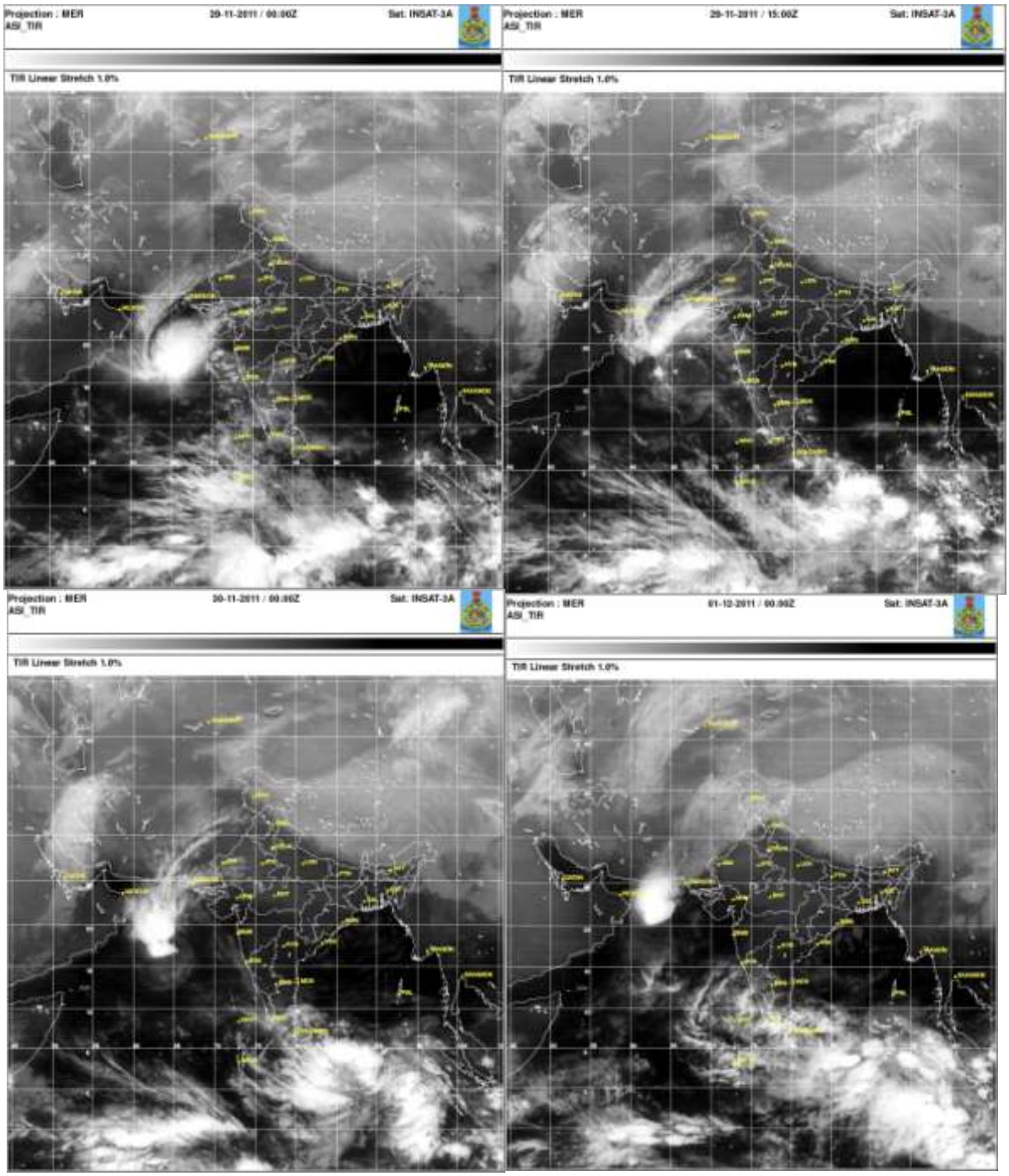

Fig. 9.2 (continued) The typical satellite imageries showing the intensification, movement and weakening of the system.

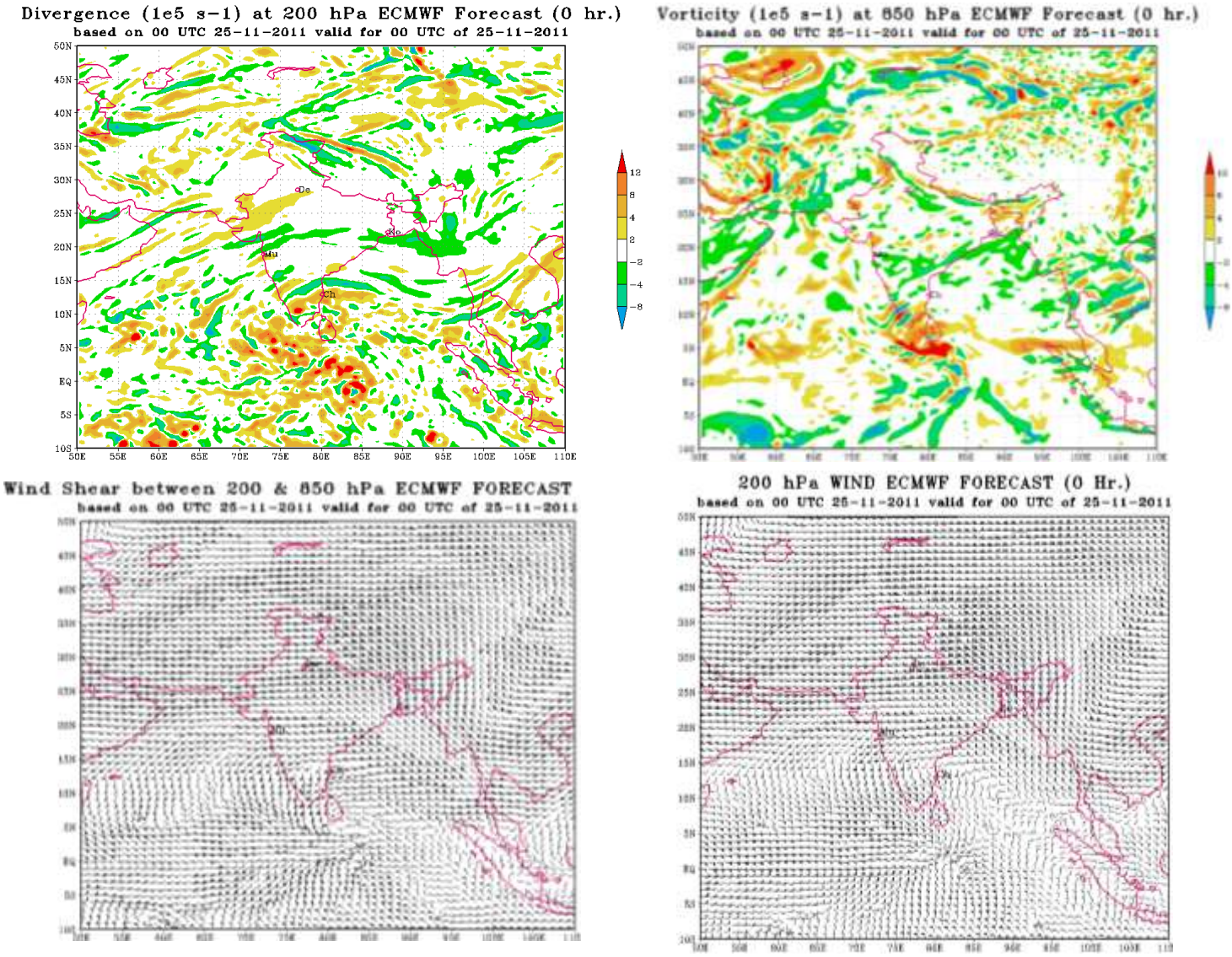

Fig. 9.3 (a) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) vertical wind shear of horizontal wind between 200 and 850 hPa level (iv) wind at 200 hPa level based on the ECMWF model analysis of 0000 UTC of 25th November, 2011.

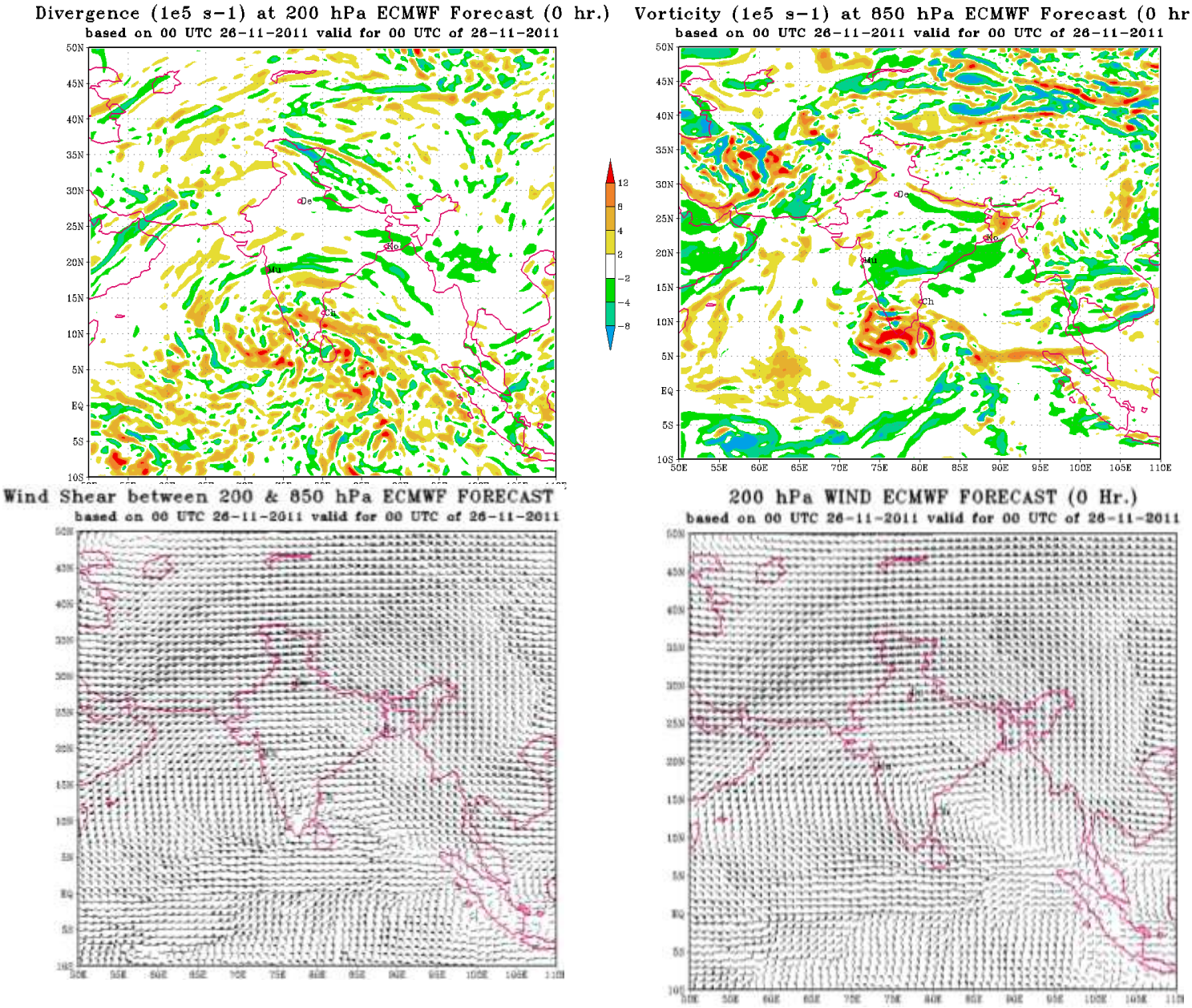

Fig. 9.3 (b) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) vertical wind shear of horizontal wind between 200 and 850 hPa level (iv) wind at 200 hPa level based on the ECMWF model analysis of 0000 UTC of 26th November, 2011.

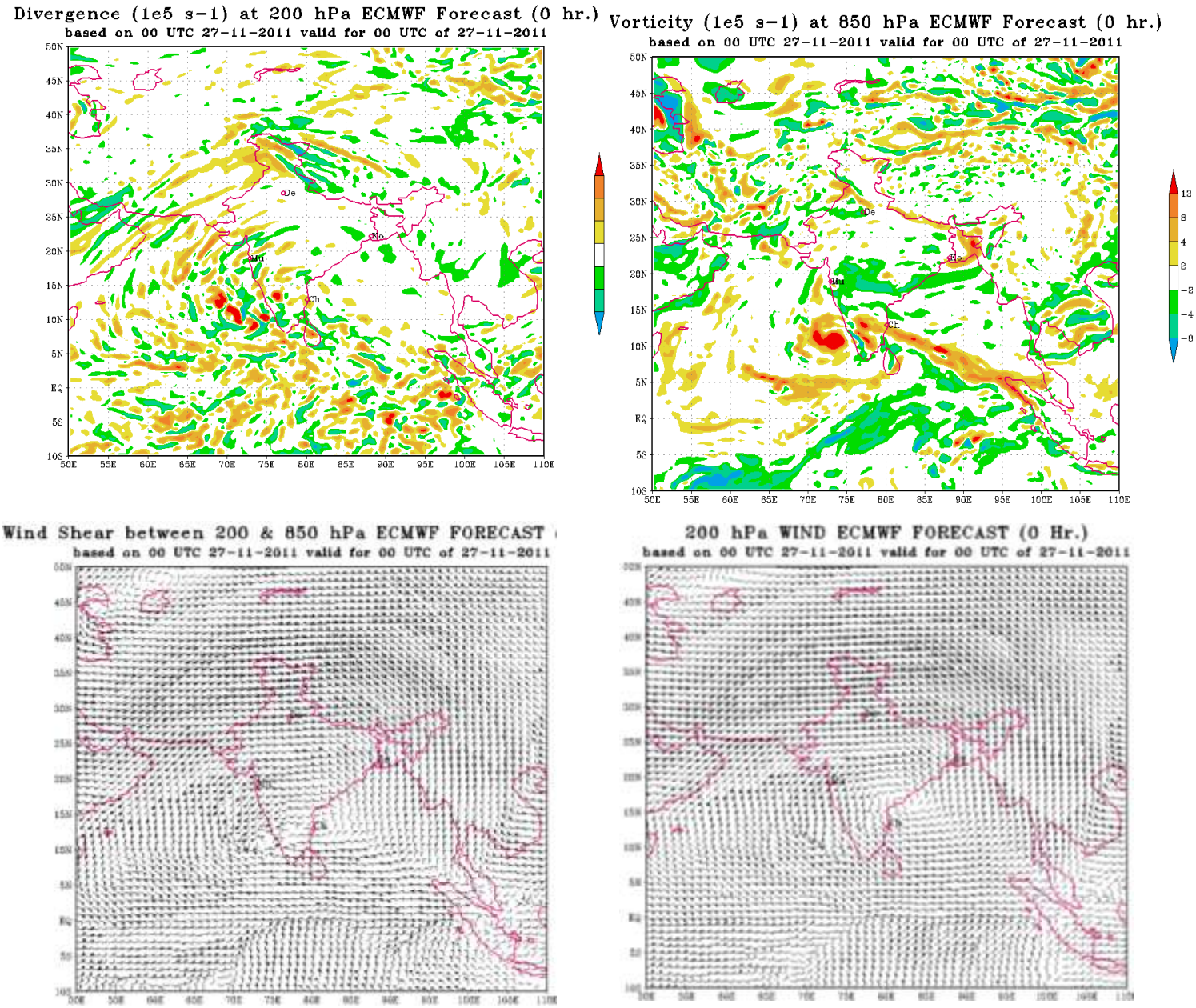

Fig. 9.3 (c) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) vertical wind shear of horizontal wind between 200 and 850 hPa level (iv) wind at 200 hPa level based on the ECMWF model analysis of 0000 UTC of 27th November, 2011.

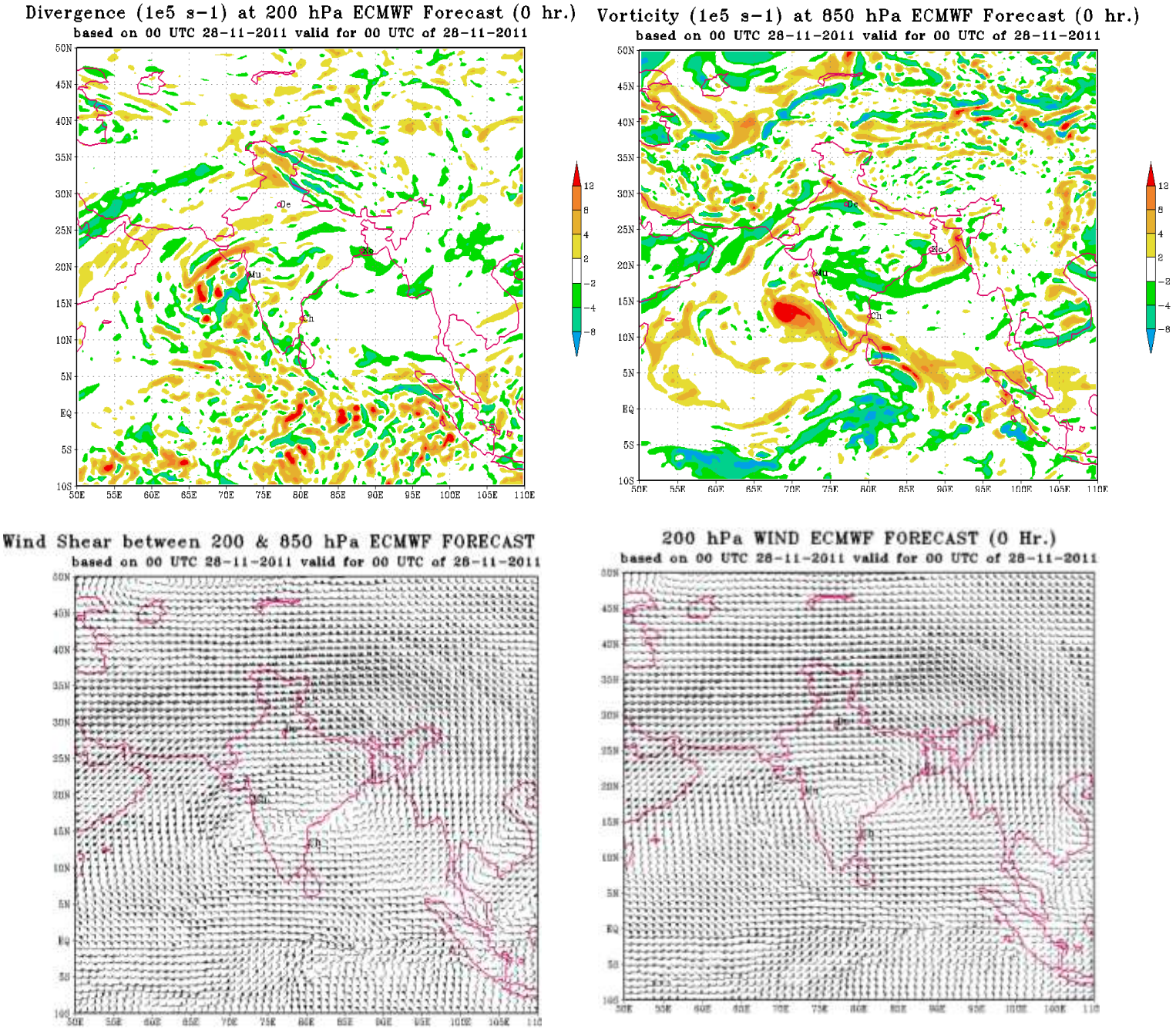

Fig. 9.3 (d) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) vertical wind shear of horizontal wind between 200 and 850 hPa level (iv) wind at 200 hPa level based on the ECMWF model analysis of 0000 UTC of 28th November, 2011.

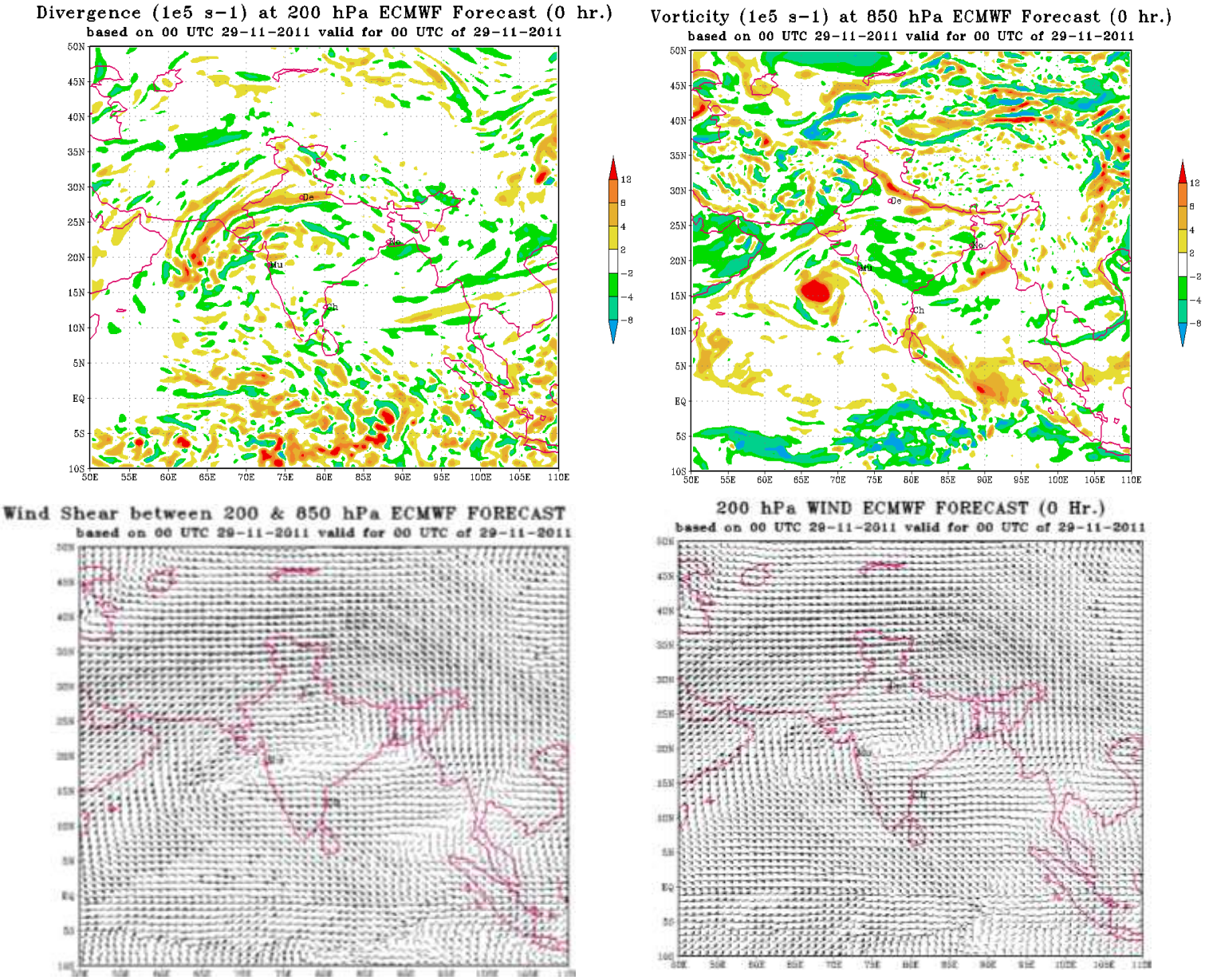

Fig. 9.3 (e) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) vertical wind shear of horizontal wind between 200 and 850 hPa level (iv) wind at 200 hPa level based on the ECMWF model analysis of 0000 UTC of 29th November, 2011.

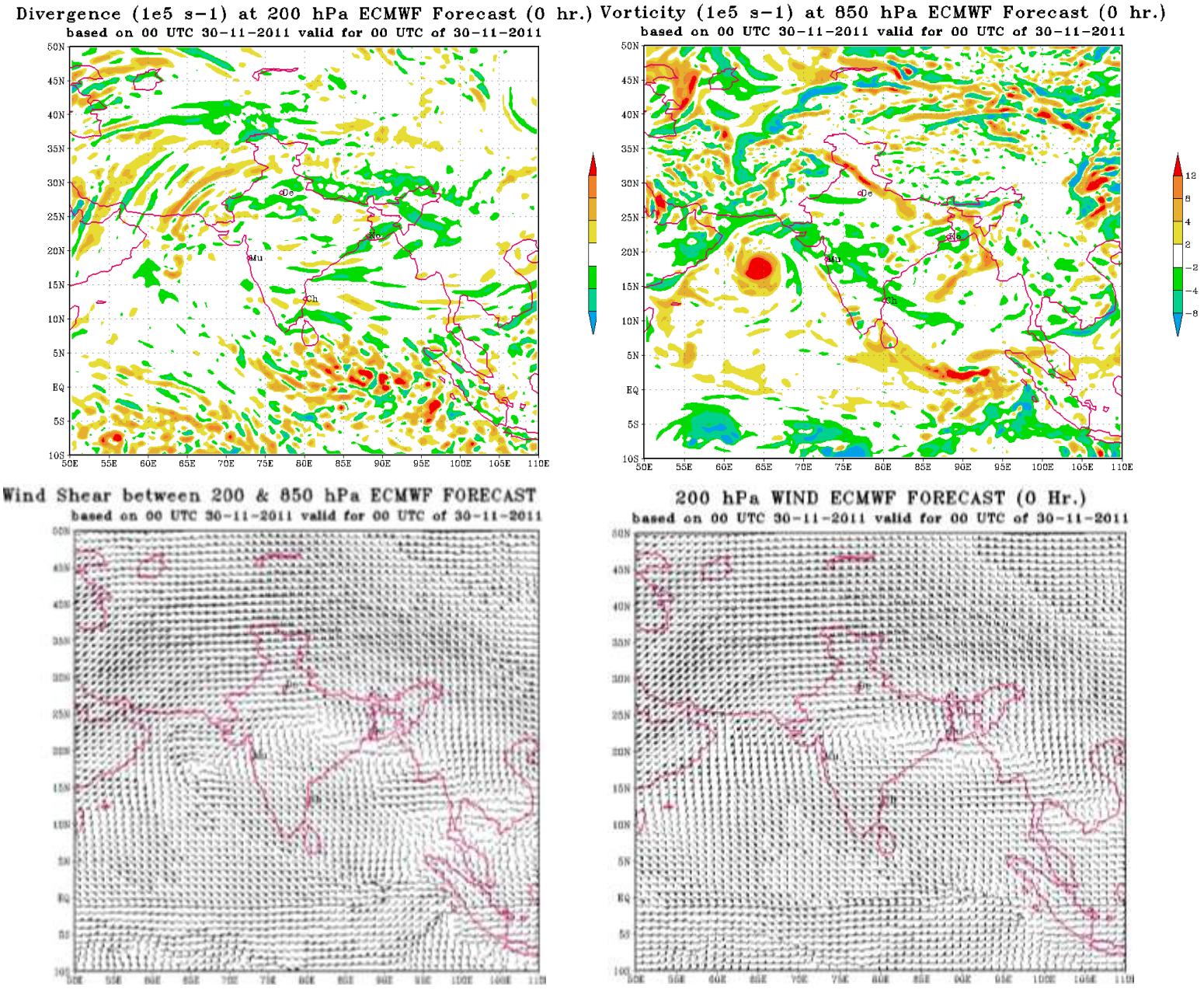

Fig. 9.3 (f) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) vertical wind shear of horizontal wind between 200 and 850 hPa level (iv) wind at 200 hPa level based on the ECMWF model analysis of 0000 UTC of 30th November, 2011.

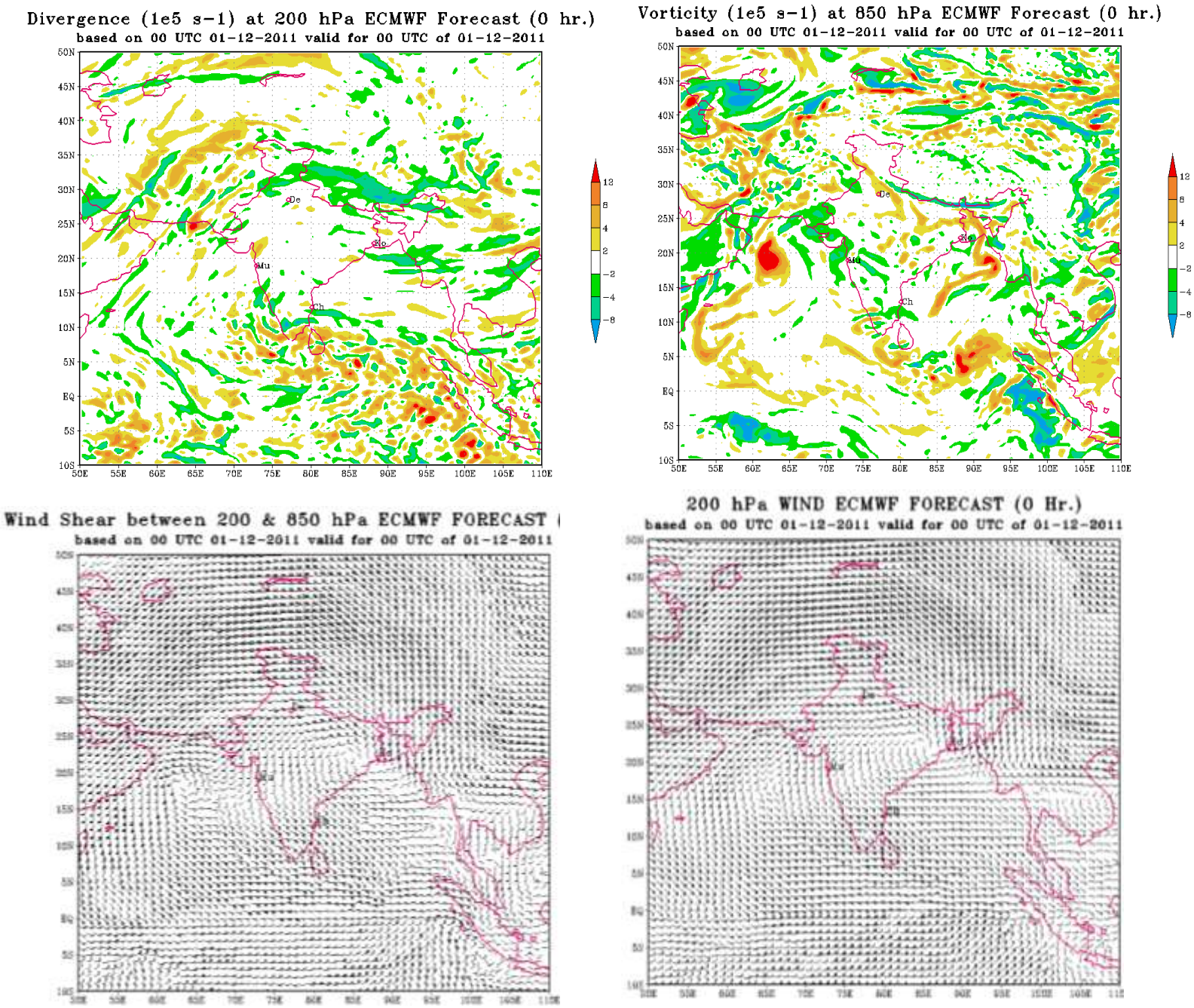

Fig. 9.3 (g) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) vertical wind shear of horizontal wind between 200 and 850 hPa level (iv) wind at 200 hPa level based on the ECMWF model analysis of 0000 UTC of 01st December, 2011.

9.6 **Bulletin issued by IMD:**

The system was continuously monitored and predicted since 24th November 2011 as a low pressure area. Once daily bulletin was issued to Oman/Yemen through e-mail in addition to the Tropical Weather Outlook. The bulletin was also issued to control room, National Disaster Management (NDM), MHA, Govt. of India and other high officials. The statistics of the number of bulletins issued by IMD are given below.

Bulletins for national disaster management agencies : 27
Bulletin for WMO/ESCAP Panel counties : 13

9.7 Forecast performance:

The forecast verification with respect to genesis, intensification and track are as below

9.7.1 Genesis: This system also formed due to active ITCZ over the region. The active ITCZ roughly ran along 07^0N on 23-25 November, 2011. Under its influence, a cyclonic circulation formed over southwest Bay of Bengal off Sri Lanka and south Tamil Nadu coast on 23rd November 2011. It was seen as a low pressure area over southwest Bay of Bengal and adjoining Sri Lanka on 24th. It moved west-northwestwards and became well marked on 25th and concentrated into a depression at 0300 UTC of 26th November over the Comorian area and neighbourhood.

9.7.2 Intensification and Track forecast verification:

Intensity forecast error of Deep Depression over Arabian Sea (26 Nov. to 1st December 2011) have been discussed below;

Average Track & Intensity Forecast Error Deep Depression 26 Nov–1Dec 2011

Lead period (hrs)	Average track forecast error (kms)	Average intensity Forecast error (kts)
12	39 (6)	6 (6)
24	121 (6)	8 (6)
36	160 (6)	9 (6)
48	174 (6)	7 (6)
60	209 (4)	5 (4)
72	245 (2)	7 (2)

The figure in bracket is the No. of forecasts verified.