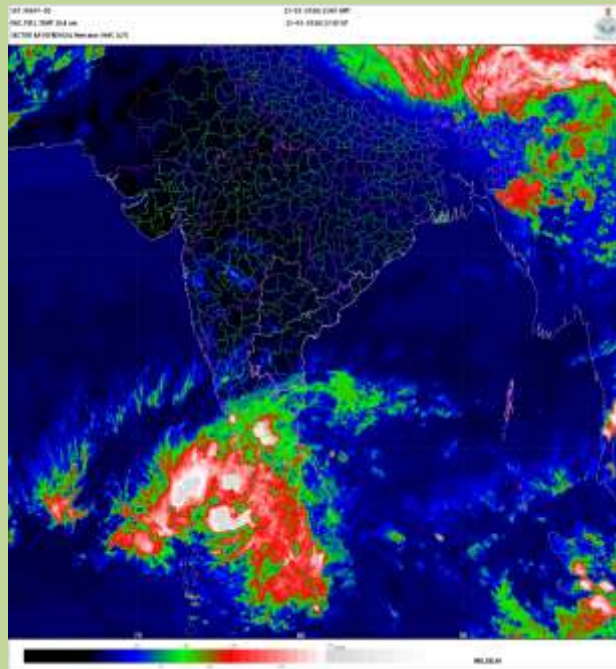




**GOVERNMENT OF INDIA  
MINISTRY OF EARTH SCIENCES  
INDIA METEOROLOGICAL DEPARTMENT**

**Depression over southeast Arabian Sea  
and adjoining equatorial Indian Ocean (13-15 March, 2018): A Report**



INSAT-3D enhanced coloured IR imagery based on 1200 UTC of 13<sup>th</sup> March

**Cyclone Warning Division  
India Meteorological Department  
New Delhi  
April 2018**

## **Depression over southeast Arabian Sea and adjoining equatorial Indian Ocean (13-15 March, 2018)**

### **1. Introduction**

A low pressure area formed over equatorial Indian Ocean and adjoining southwest Bay of Bengal (BoB) and south Sri Lanka coast on 10th March. It lay as a well-marked low pressure (WML) area over Maldives-Comorin area on 12th March. It concentrated into a depression in the morning of 13th March over southeast Arabian Sea and adjoining equatorial Indian Ocean. It initially moved northwestwards and later north-northwestwards and weakened into well marked low pressure area over Lakshadweep and adjoining southeast Arabian Sea (AS) in the early morning of 15th March (0530 hours IST). It lay as a low pressure area over Lakshadweep Area and adjoining southeast AS on 16th and became less marked on 17th March. Its genesis, movement and associated adverse weather could be predicted well by IMD. The salient features of the system were as follows:

- (i) The system had a straight moving track.
- (ii) The life period of the system was 45 hours.
- (iii) It caused heavy to very heavy rainfall at isolated places in south Tamil Nadu and Kerala on 13<sup>th</sup>, heavy at isolated places over Kerala and Lakshadweep on 15th and Tamilnadu & interior Karnataka on 16th.

IMD mobilised all its resources to track the system and regular warnings w.r.t. track, intensity, landfall and associated adverse weather were issued to concerned central and state disaster management agencies, print & electronic media and general public. Regular advisories were also issued to WMO/ESCAP Panel member countries including Sri Lanka.

The brief life history, associated weather and forecast performance of IMD/RSMC, New Delhi are presented below.

### **2. Brief life history**

A trough of low developed at mean sea level over Equatorial Indian Ocean and adjoining southeast BoB and Nicobar Islands on 7th March, 2018. It lay over Equatorial Indian Ocean and adjoining southeast BoB on 08th March 2018 and over Equatorial Indian Ocean and adjoining central parts of south BoB on 09th. It lay as a low pressure area over southwest BoB off Sri Lanka- south Taminadu coasts with the associated cyclonic circulation extending up to mid tropospheric levels on 10th. It lay over Equatorial Indian Ocean & adjoining southwest BoB & south Sri Lanka coast with associated cyclonic circulation extending up to mid-tropospheric levels on 11th. Considering the environmental conditions at 0300 UTC of 11th, the sea surface temperature (SST) was 29-30°C, Ocean Thermal Energy (OTE) was about 50 KJ/cm<sup>2</sup> over Comorin area and more than 100 KJ/cm<sup>2</sup> over many parts of Lakshadweep area and adjoining southeast AS. Low level convergence & upper level divergence were  $10 \times 10^{-5} \text{ s}^{-1}$  &  $20 \times 10^{-5} \text{ s}^{-1}$  respectively, both to the southern parts of low pressure area adjacent to equator. Vorticity was  $50 \times 10^{-6} \text{ s}^{-1}$  over the same region. Vertical wind shear was low to moderate over the region and low over Lakshadweep area and adjoining southeast AS. Upper tropospheric ridge lay along latitude 10.00N near long. 800E. It was favouring poleward outflow and hence increasing the upper level divergence. The upper and lower level winds indicated that the system would move initially west-northwestwards and then west-northwestwards across Comorin area and emerge into Lakshadweep area and adjoining southeast Arabian Sea during next 72 hrs. All these features indicated that the low pressure area would experience further favourable environmental parameters.

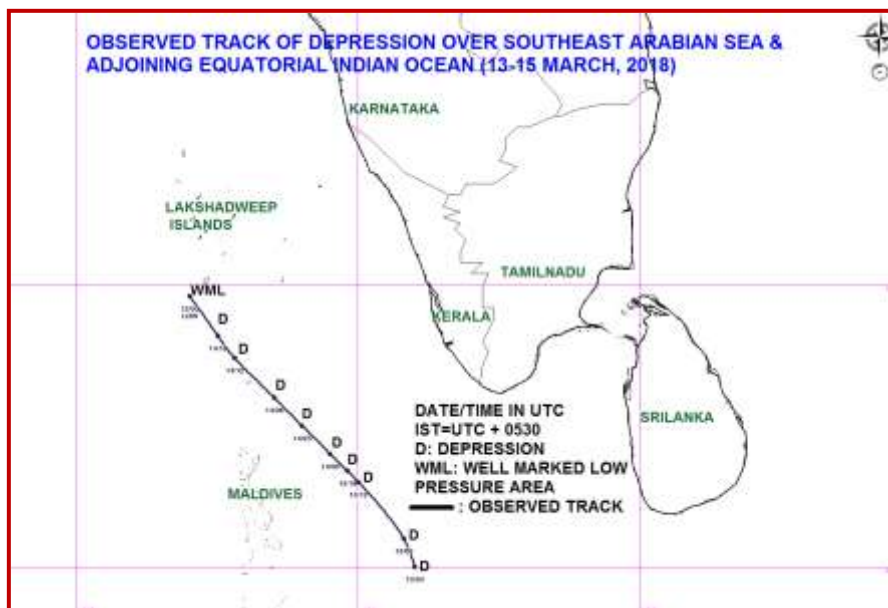
In association with favourable conditions, It lay as a WML over Equatorial Indian Ocean and adjoining south Sri Lanka and Maldives- Comorin area, with associated cyclonic circulation extending upto mid tropospheric levels on 12th. Favourable environmental features continued. Similar thermal features continued. Low level convergence was  $10 \times 10^{-5} \text{ s}^{-1}$  in the southwest sector of the system. The upper level divergence increased and was about  $30 \times 10^{-5} \text{ s}^{-1}$  in the southeast sector of the system. The vorticity increased & was about  $60-70 \times 10^{-6} \text{ s}^{-1}$  over the same region. Vorticity field was extending upto mid tropospheric level and was oriented southwest to

northeast. Vertical wind shear was low to moderate over the region and low over lakshadweep area & adjoining southeast AS. Upper tropospheric ridge continued to lie along latitude 10.0°N near long. 80.0°E. It was favouring poleward outflow and hence increased the upper level divergence. The total precipitable water (TPW) vapour imageries indicated warm air advection from southeast sector.

At 0300 UTC of 13th, similar thermal conditions prevailed. The upper level divergence was about  $30 \times 10^{-5} \text{ s}^{-1}$  in the southeast sector of the system. The vorticity increased and was about  $100 \times 10^{-6} \text{ s}^{-1}$  over the same region extending up to mid-tropospheric level. Vertical wind shear continued to be low to moderate over the region and low over Lakshadweep area and adjoining southeast AS. Upper tropospheric ridge continued to lie along latitude 10.0°N near long. 80.0°E, favouring poleward outflow. Under these conditions, the system intensified into a depression over southeast Arabian Sea and adjoining equatorial Indian Ocean at 0300 UTC of 13th. However, TPW imageries indicated reduction in the supply of moisture from southeast sector and increase in incursion of cold air to the outer periphery from southwest sector.

At 0300 UTC of 14th, the system lay over southeast AS. Similar thermal conditions prevailed over the region. The low level convergence was about  $15 \times 10^{-5} \text{ s}^{-1}$  around the system center. The upper level divergence decreased and was about  $20 \times 10^{-5} \text{ s}^{-1}$  around system center. The vorticity was about  $100 \times 10^{-6} \text{ s}^{-1}$  over the region. Vertical wind shear was low to moderate (10-15 kts) over the region. Upper tropospheric ridge lay along latitude 11.0°N near longitude 80.00E in association with anti-cyclonic circulation over southwest and adjoining west central Bay of Bengal. It was favouring poleward outflow. The upper and lower level winds indicated that the system would move northwestwards. TPW imageries indicated reduction in warm air advection and cold air was reaching southwest periphery of the system. Under these conditions, the system maintained its intensity and moved northwestwards.

At 0000 UTC of 15th moving northwestwards, the system weakened into a WML over Lakshadweep and adjoining southeast Arabian Sea. The low level convergence was about  $10 \times 10^{-5} \text{ s}^{-1}$  around the system center. The upper level divergence was about  $10 \times 10^{-5} \text{ s}^{-1}$  around system center. The vorticity was about  $80 \times 10^{-6} \text{ s}^{-1}$  over the same region. Vertical wind shear was low to moderate (5-15 kts) over the region. Upper tropospheric ridge continued at similar position. The upper and lower level winds indicated that the system will move north-northwestwards. TPW imageries indicated reduction in warm air advection and cold air reached southwest periphery of the system. The system weakened mainly due to intrusion of dry and cold air from the northwest towards the system in the middle and upper tropospheric levels.

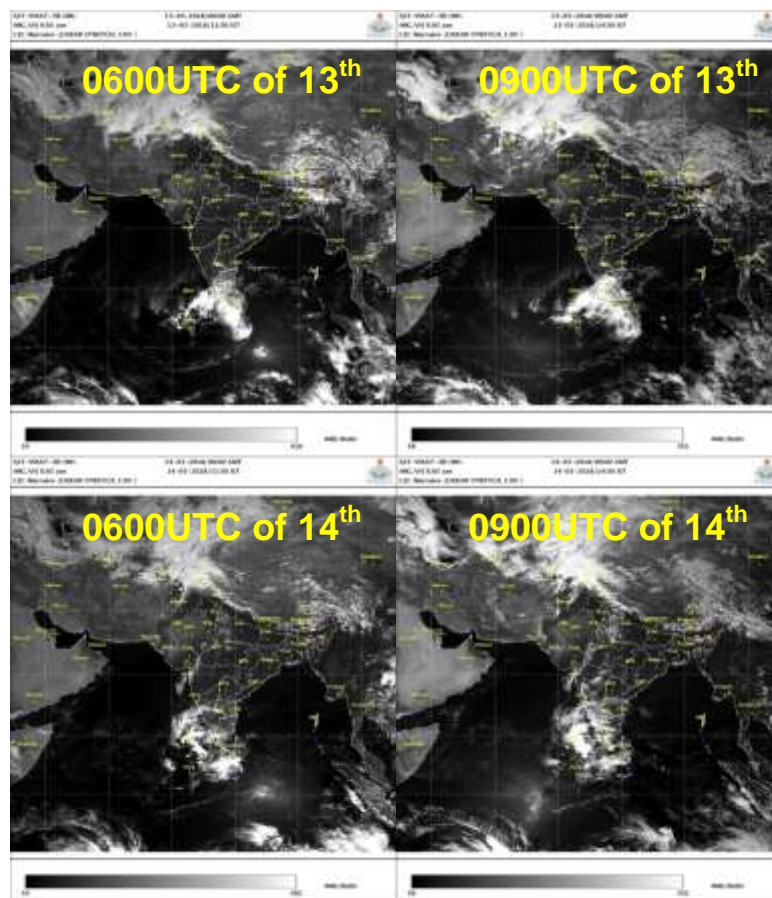


**Fig.1. Observed track of Depression over southeast Arabian Sea and adjoining equatorial Indian Ocean (13-15 March, 2018)**

The best track parameters of the system are presented in Table 1. The track of the depression is presented in Fig.1. The typical satellite imageries are presented in Fig. 2.

**Table 1: Best track positions and other parameters of the Depression over southeast Arabian Sea and adjoining equatorial Indian Ocean during 13-15 March, 2018**

Date	Time (UTC)	Centre lat. <sup>o</sup> N/ long. <sup>o</sup> E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade	
13/03/2018	0300	05.0/76.00	1.5	1006	25	3	D	
	0600	05.5/75.80	1.5	1006	25	3	D	
	1200	06.5/75.00	1.5	1006	25	3	D	
	1800	06.7/74.80	1.5	1006	25	3	D	
14/03/2018	0000	07.0/74.50	1.5	1006	25	3	D	
	0300	07.5/74.00	1.5	1006	25	3	D	
	0600	08.0/73.50	1.5	1006	25	3	D	
	1200	08.7/72.80	1.5	1006	25	3	D	
	1800	09.1/72.50	1.5	1006	25	3	D	
15/03/2018	0000	Weakened into a Well-marked low pressure area over Lakshadweep and adjoining southeast Arabian Sea						



**Fig. 2(i): INSAT-3D visible imageries during Depression (13-15 March, 2018)**

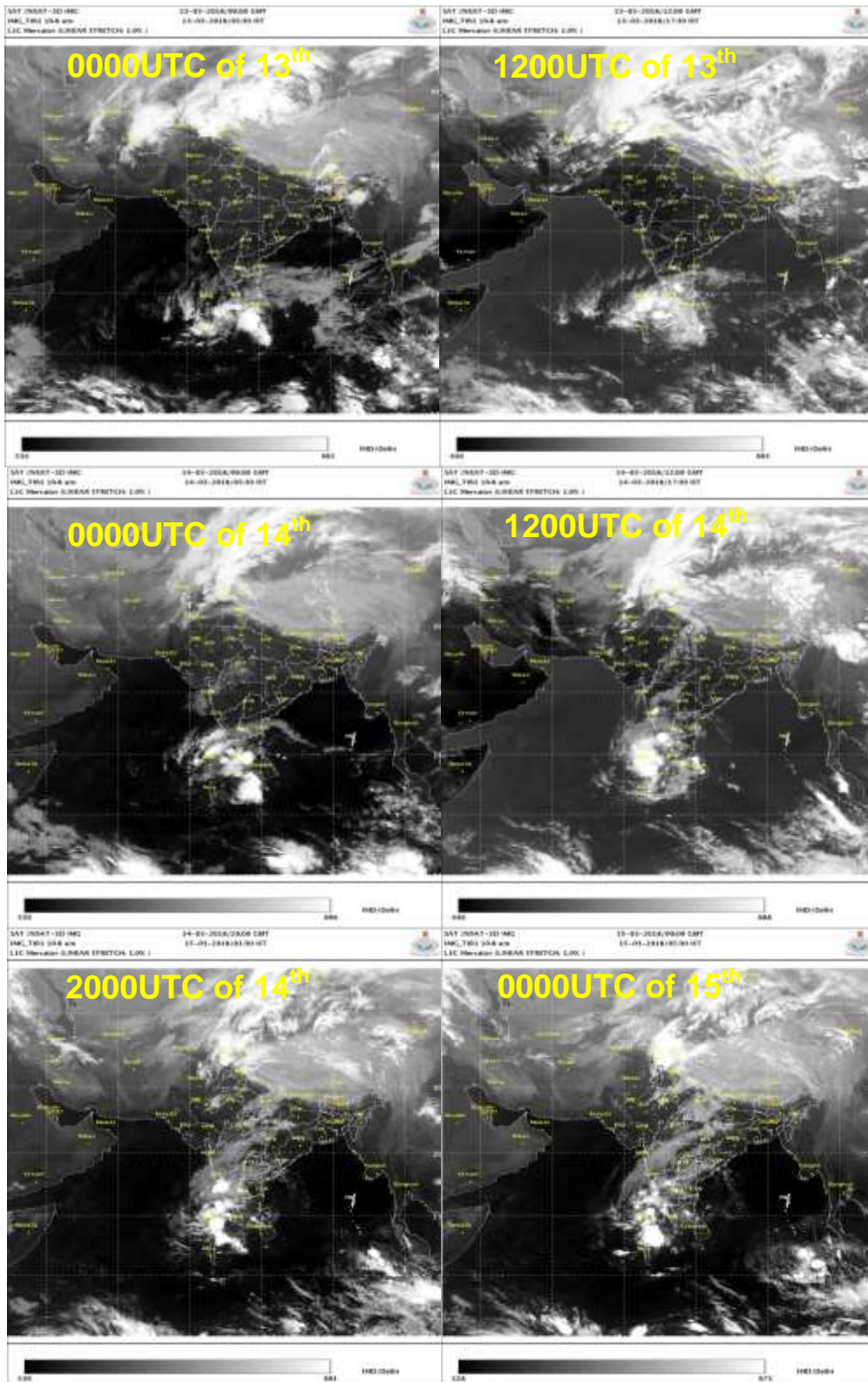
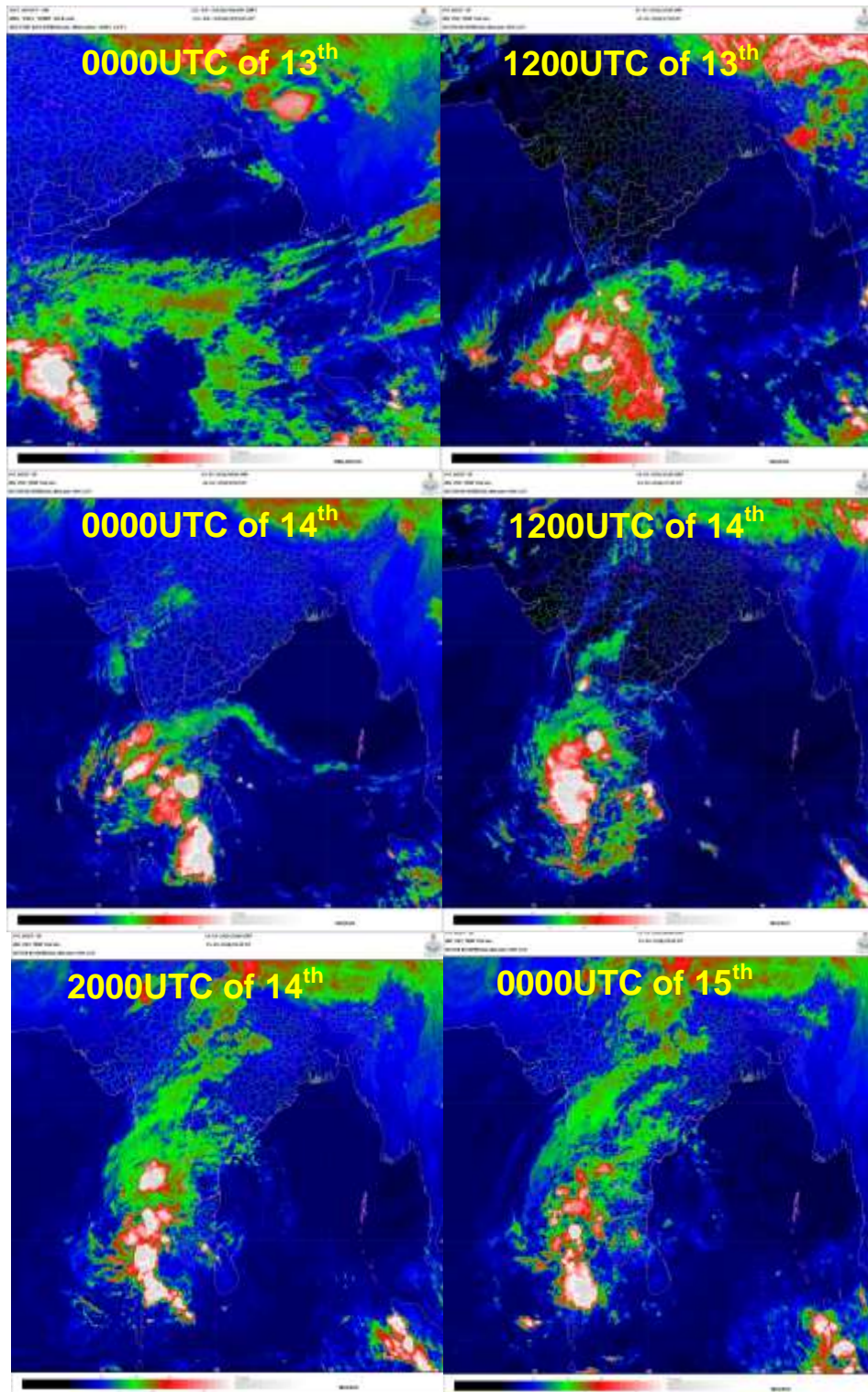


Fig. 2(ii): INSAT-3D IR imageries during Depression (13-15 March, 2018)



**Fig. 2(iii): INSAT-3D enhanced coloured imageries during Depression (13-15 March, 2018)**

### 3. Dynamical features

IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10 m, 850, 500 and 200 hPa levels are presented in Fig.3. GFS (T1534) could simulate the genesis of the system and the associated circulation features during the life period of Depression.

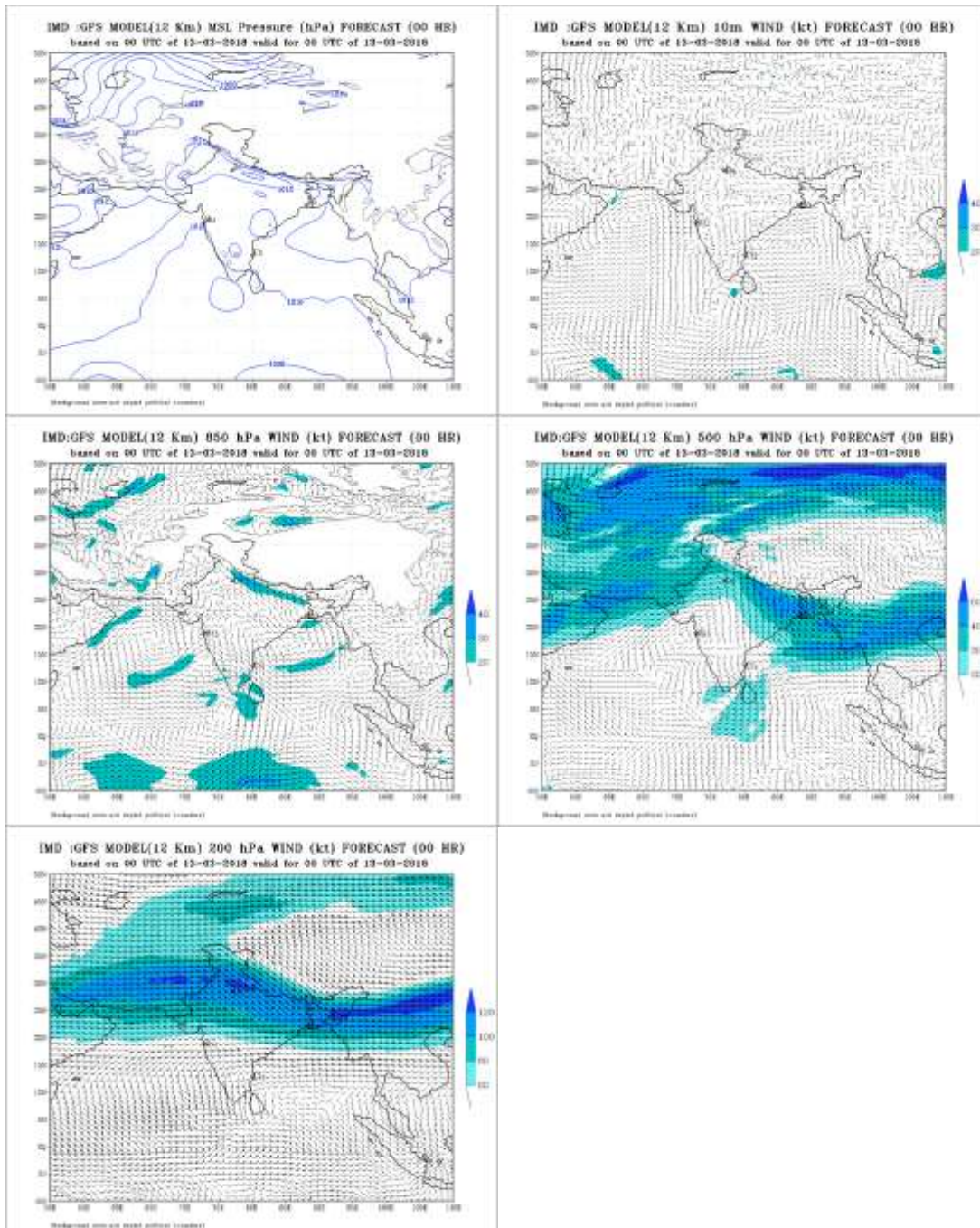
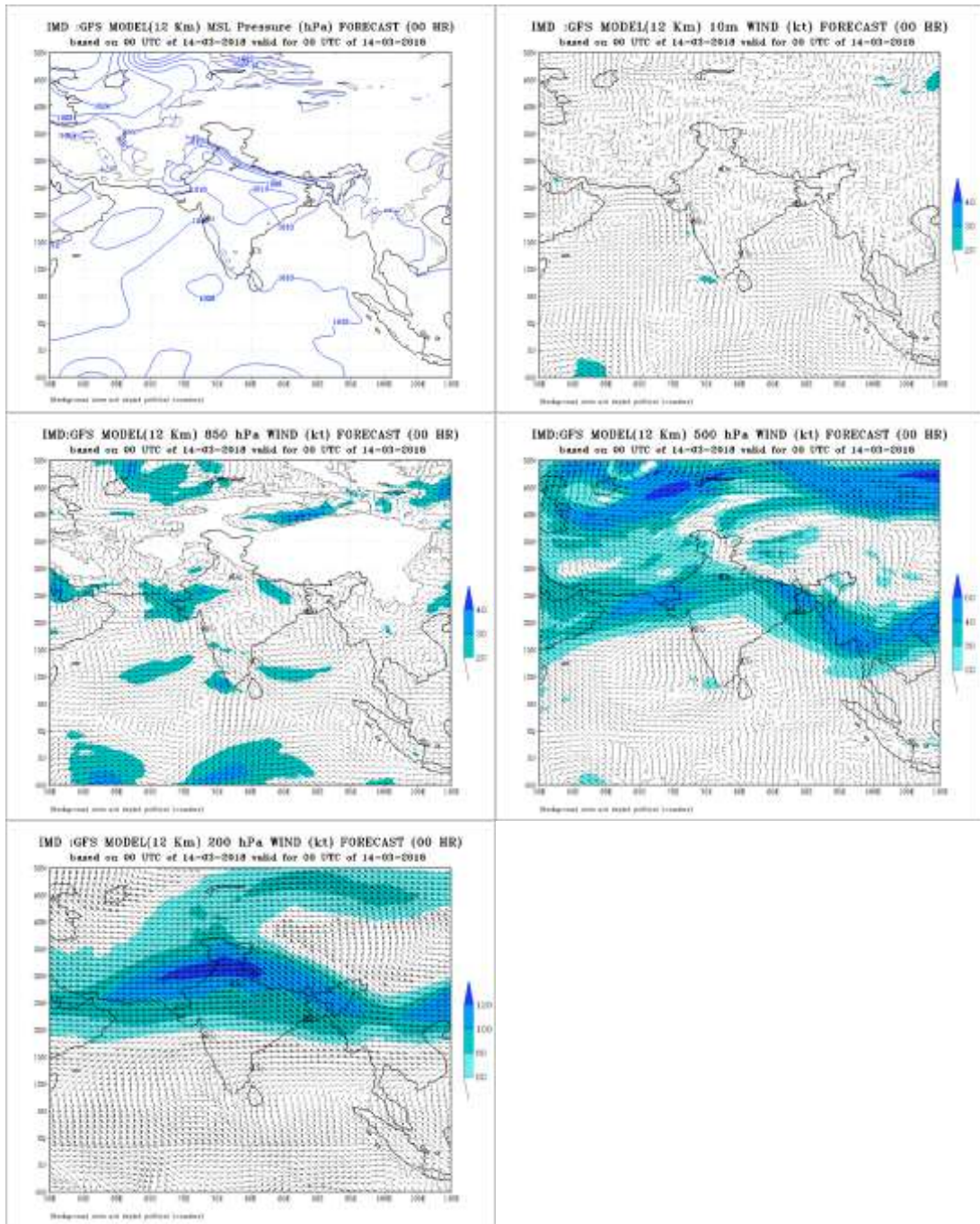
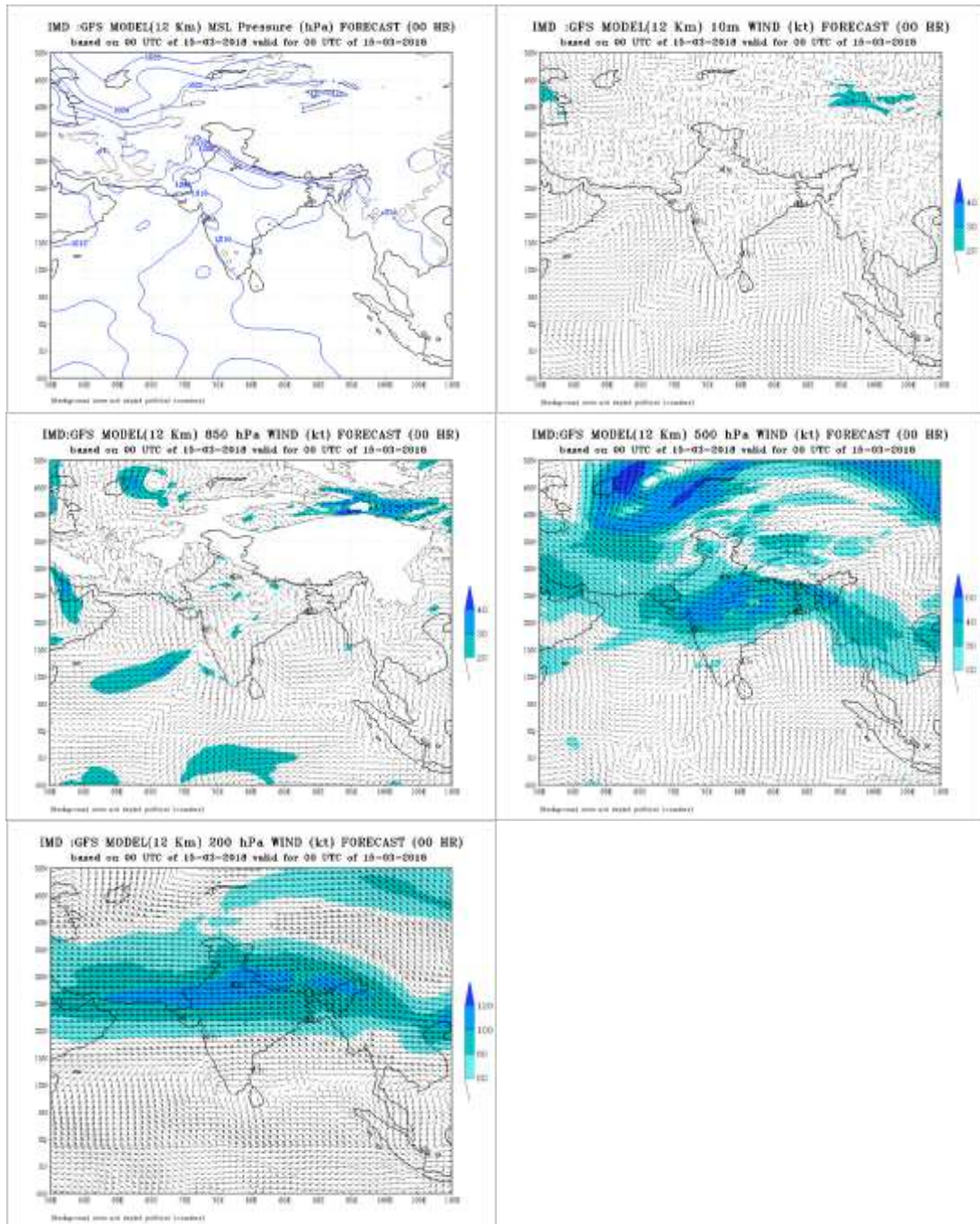


Fig3 (i): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 13<sup>th</sup> March



**Fig3 (ii): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 14<sup>th</sup> March**





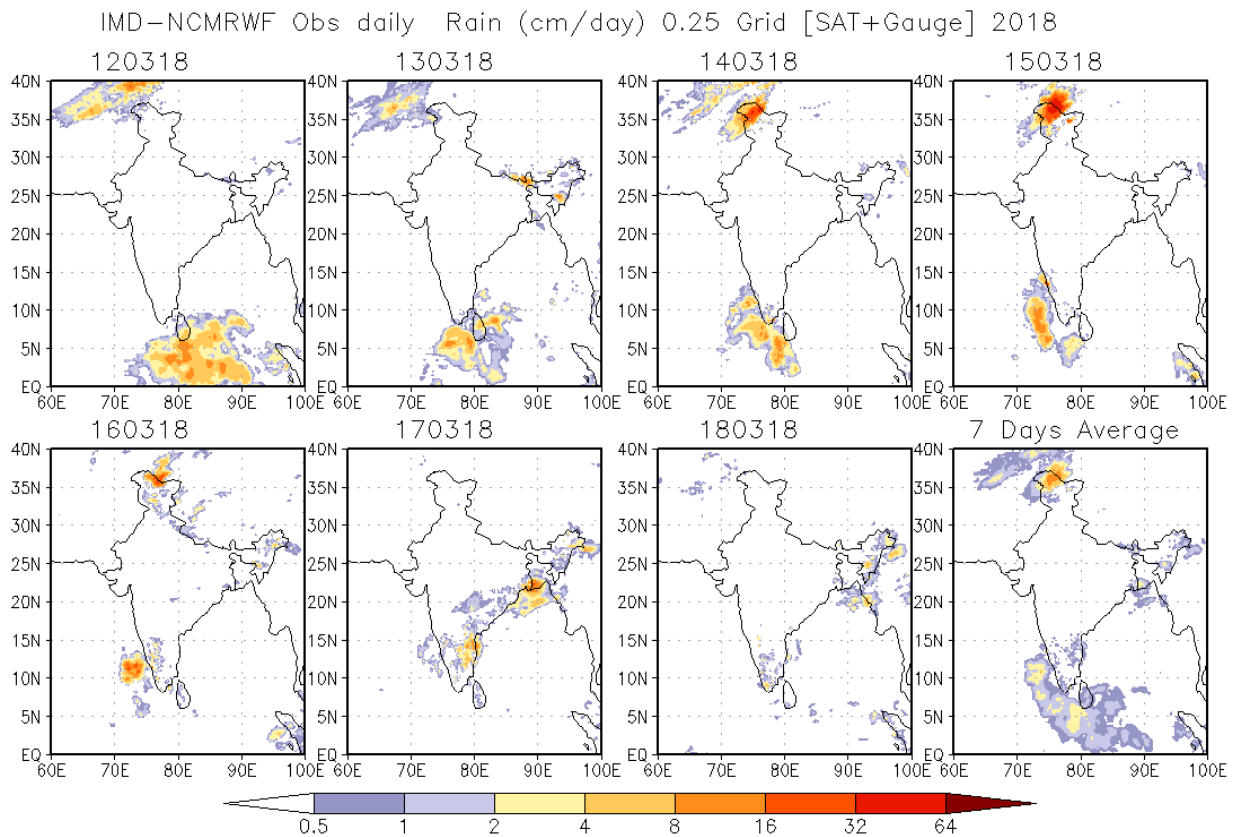
**Fig3 (ii): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 15<sup>th</sup> March**

**4.1 Rainfall:**

**Realised weather:**

Under the influence of depression, heavy to very heavy rainfall occurred at isolated places in south Tamil Nadu and Kerala on 13<sup>th</sup> while heavy rainfall occurred at isolated places over Kerala and Lakshadweep on 15<sup>th</sup> and over Tamil Nadu and interior Karnataka on 16<sup>th</sup>. The daily rainfall

distribution ending at 0830 IST of each date during 12-18 March 2018 based on merged gridded rainfall data of IMD/NCMRWF during depression period is shown in fig.4.



**Fig.4: Daily rainfall distribution based on merged gridded rainfall data of IMD/NCMRWF during 12-18 March 2018**

The 24 hour cumulative rainfall ( $\geq 7$  cm) ending at 0830 hours IST of date during 14<sup>th</sup>-17<sup>th</sup> March is presented below:

**14th March**

**Tamilnadu & Puducherry:** Tuticorin-20, Papanasam (Tirunelveli)-19, Shencottah-10, Srivaikuntam & Thenkasi-9 each, Tiruchendur-8 and Manimutharu & Ambasamudram-7 each

**Kerala:** Aryankavu-12

**16th March**

**Kerala:** Vytiri-9

**Lakshadweep:** Agathi-11.

**17th March**

**Tamilnadu & Puducherry:** Tirupattur-8, Omalur-7

**North Interior Karnataka:** Haveri -7

**South Interior Karnataka:** Chintamani -10

**5. Bulletins issued by IMD**

IMD issued regular bulletins to WMO/ESCAP Panel member countries including Maldives and Sri Lanka, National & State Disaster Management Agencies of Tamil Nadu, Kerala, Karnataka and Lakshadweep Islands, general public and media. Special Informatory Message once a day was issued from 11<sup>th</sup> onwards. Regular Bulletins every six hourly were issued since formation of

depression over southeast AS. In addition, RSMC New Delhi also issued Press Release and SMS to registered users.

### 5.1 Bulletins issued by Cyclone Warning Division, New Delhi

Bulletins issued by Cyclone Warning Division of IMD in association with the system are given in Table 2

**Table 2(a) : Bulletins issued by Cyclone Warning Division, IMD, New Delhi**

S. No.	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	10	1. IMD's website 2. FAX and e-mail to Control Room NDM, Ministry of Home affairs, Control Room NDMA, Cabinet Secretariat, Minister of Sc. & Tech, Secretary MoES, DST, HQ Integrated Defence Staff, DG Doordarshan, All India Radio, DG-NDRF, Director Indian Railways, Indian Navy, IAF, Chief Secretary: Tamilnadu, Kerala, Chief Administrator: Lakshadweep Islands, Karnataka
2	RSMC Bulletin	7	1. IMD's website 2. All WMO/ESCAP member countries through GTS and E-mail. 3. Indian Navy, IAF by E-mail
3	Press Release	3	Disaster Managers, Media persons by email and uploaded on website
4	SMS	36493	SMS to disaster managers agencies at Centre and State level and registered users at RSMC website from Tamil Nadu, Lakshadweep, Kerala and Karnataka

**Table-2(b): Bulletins issued by Area cyclone warning Centre (ACWC) Mumbai/ (ACWC) Chennai / MC Thiruvananthapuram**

S. N.	Type of Bulletin			
		ACWC/CWC Mumbai	ACWC Chennai	MC Thiruvananthapuram
1.	Sea Area Bulletins	8	11	-
2.	Coastal Weather Bulletins	6	11	-
3.	Fishermen Warnings	NIL	12	12
4.	Port Warnings	4	5	4
5.	Heavy Rainfall Warning	NIL	12	12
6.	Information & Warning to State Government and other Agencies	27	12	-
7.	SMS	187	872	-

## 6. Operational Forecast Performance

- The first information regarding genesis of depression was issued by RSMC New Delhi in its Tropical weather outlook issued (1130IST) on 11th March (about 48 hours in advance) with moderate probability (51-75%) during next 48-72 hours. It was further upgraded to high probability in the bulletin issued on 12<sup>th</sup> March 2018(1130 IST) .
- In the first bulletin issued on 13<sup>th</sup> morning, it was predicted that depression would move northwestwards and it moved northwestwards initially and later north-northwestwards and weakened into a well-marked low pressure area over Lakshadweep and adjoining southeast Arabian Sea at 0530 hours IST of 15<sup>th</sup> March.
- Though it was predicted to intensify further into a deep depression in the bulletin issued on 13<sup>th</sup> March at 1400 hours IST, it did not intensify and maintained the intensity of depression only.
- The weakening of the depression was also well predicted by IMD. The signal of weakening of the depression was first indicated in IMD bulletin issued on 14<sup>th</sup> March at 1130 hours IST..The depression weakened into WML at 0530 hours IST of 15<sup>th</sup> March.

IMD issued warning bulletins to the concerned central and state disaster management authorities & press and media. The verification of heavy rainfall warnings issued by IMD for depression during 13-15<sup>th</sup> March 2018 is presented in Table 3. It can be found that the occurrence of heavy rainfall in association with the system could be predicted well in advance.

**Table 3 : Verification of heavy rainfall warning issued by IMD for Deep Depression over Bay of Bengal (13-15 March, 2018)**

Date/Time of issue	Heavy rainfall warning	Realised heavy rainfall (7cm or more) ending at 0830 hrs IST of date
1200 IST of 13th March 2018	Isolated heavy rainfall on 13th March over south Tamil Nadu. Isolated heavy rainfall over south Kerala on 14th and over Kerala on 15th.	<b>14th March</b> <b>Tamilnadu &amp; Puducherry:</b> Tuticorin-20, Papanasam (Tirunelveli)-19, Shencottah-10, Srivaikuntam & Thenkasi-9 each, Tiruchendur-8 and Manimutharu & Ambasamudram-7 each <b>Kerala:</b> Aryankavu-12
1130 IST of 14 <sup>th</sup> March 2018	Isolated heavy rainfall over south Tamil Nadu on 14 <sup>th</sup> March ; isolated heavy falls on 14 <sup>th</sup> and 15 <sup>th</sup> March over Kerala; heavy to very heavy rainfall at most places with heavy falls at a few places on 14 <sup>th</sup> and at isolated places on 15 <sup>th</sup> March over Lakshadweep Islands.	<b>16th March</b> <b>Kerala:</b> Vyttiri-9 <b>Lakshadweep:</b> Agathi-11  <b>17th March</b> <b>Tamilnadu &amp; Puducherry:</b> Tirupattur-8, Omalur-7 <b>North Interior Karnataka:</b> Haveri -7 <b>South Interior Karnataka:</b> Chintamani -10
0530 IST of 15 <sup>th</sup> March 2018	Isolated heavy rainfall over Kerala,coastal Karnataka and Lakshadweep during next 24 hours.	

**Table 4. Verification of Gale Wind Forecast**

<b>Date/ Time(IST)</b>	<b>Squall/ Gale wind Forecast</b>	<b>Recorded wind speed (knots)</b>
<b>13.03.2018 0300 UTC</b>	Squally winds speed reaching 40-50 kmph gusting to 60 kmph is very likely over Comorin area and along and off south Tamilnadu coast during next 24 hrs and 45-55 kmph gusting to 65 kmph along & off Kerala coast on 14 <sup>th</sup> and 40-50 kmph gusting to 60 kmph on 15 <sup>th</sup> March 2018. Squally winds, speed reaching 45-55 kmph gusting to 65 kmph, is very likely over Lakshadweep area and adjoining southeast Arabian Sea on 14 <sup>th</sup> & 15 <sup>th</sup> March 2018.	<b>1)</b> A ship near south Kerala coast reported 20kt (37kmph) at 0530 hours IST of 14th March and 30 kt (55kmph) at 1730hours IST of 14 <sup>th</sup> March <b>2)</b> Maximum wind of 20kt (37kmph) was reported by ship over Lakshadweep area and adjoining southeast Arabian sea at 1730 hours IST of 14 <sup>th</sup> .
<b>14.03.2018 0300 UTC</b>	Squally winds speed reaching 40-50 kmph gusting to 60 kmph is very likely over Comorin area and along and off south Tamilnadu coast during next 24 hrs and 45-55 kmph gusting to 65 kmph along & off Kerala coast on 14 <sup>th</sup> and 40-50 kmph gusting to 60 kmph on 15 <sup>th</sup> March 2018. Squally winds, speed reaching 45-55 kmph gusting to 65 kmph, is very likely over Lakshadweep area and adjoining southeast Arabian Sea on 14 <sup>th</sup> & 15 <sup>th</sup> March 2018.	<b>3)</b> Amini Divi reported 15 kt (28kmph) at 2330 hours IST of 14 <sup>th</sup> March. <b>4)</b> A buoy in Comorin area reported 15 kt (27kmph) at 1130 hours IST of 14 <sup>th</sup> .

## 7. Summary and Conclusion:

A low pressure area formed over equatorial Indian Ocean and adjoining southwest Bay of Bengal (BoB) and south Sri Lanka coast on 10th March. It lay as a well-marked low pressure area near Maldives-Comorin area on 12th March and later concentrated into a depression in the morning of 13th March over southeast Arabian Sea and adjoining equatorial Indian Ocean. It initially moved northwestwards and later north-northwestwards and weakened into well marked low pressure area over Lakshadweep and adjoining southeast AS in the early morning of 15th March (0530 hours IST), a low pressure area over Lakshadweep Area and adjoining southeast AS on 16th and less marked on 17th March. It caused heavy to very heavy rainfall over Tamil Nadu, Kerala and Lakshadweep islands. Its genesis, movement and associated adverse weather could be predicted well by IMD.

## 8. Acknowledgements:

India Meteorological Department (IMD) duly acknowledges the contribution from all the stake holders who contributed to the successful monitoring, prediction and early warning service of the system. We specifically acknowledge the contribution from Indian Space Research Organisation (ISRO) and all sister organizations of Ministry of Earth Sciences including National Centre for Medium Range Weather Forecasting Centre (NCMRWF), NIOT & INCOIS. The support from various Divisions/Sections of IMD including Area Cyclone Warning Centre (ACWC) Chennai, MC Thiruvananthapuram, Numerical Weather Prediction (NWP) Division, Information System & Services Division (ISSD) and Satellite Division at IMD HQ New Delhi is also acknowledged for monitoring the system.