

Depression over Gulf of Kutch & neighbourhood during (29 September-01 October 2019)

1. Introduction

A low pressure area formed over northeast Arabian Sea & adjoining coastal areas of Saurashtra & Kutch on 28th September, 2019. It concentrated into a Depression over Kutch and neighbourhood and lay centered at 1200 UTC of 29th September, 2019 near latitude 23.1°N and longitude 70.2°E, close to Kandla (Gujarat). It moved east-northeastwards and weakened into a well marked low pressure area over southeast Rajasthan & neighbourhood at 0300 UTC of 01st October, 2019.

The salient features of the system were as follows:

- (i) It had an east-northeastward moving track.
- (ii) It had a life period of 39 hours.
- (iii) It had a track length of 443 km.
- (iv) The system caused heavy to very heavy rainfall at few places with extremely heavy falls at isolated places over Gujarat region, Saurashtra & Kutch, east Rajasthan west Madhya Pradesh during 29th September to 1st October.

IMD mobilised all its resources to track the system and regular warnings w.r.t. track & intensity 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 Bangladesh. Its genesis, movement and associated adverse weather could be predicted well by IMD. Observed track is given in **Fig.1**. The best track parameters of the system are presented in **Table 1**. The typical satellite imageries are presented in **Fig. 2**.

The monitoring, associated adverse weather and forecast performance of IMD/RSMC, New Delhi are presented in following sections.

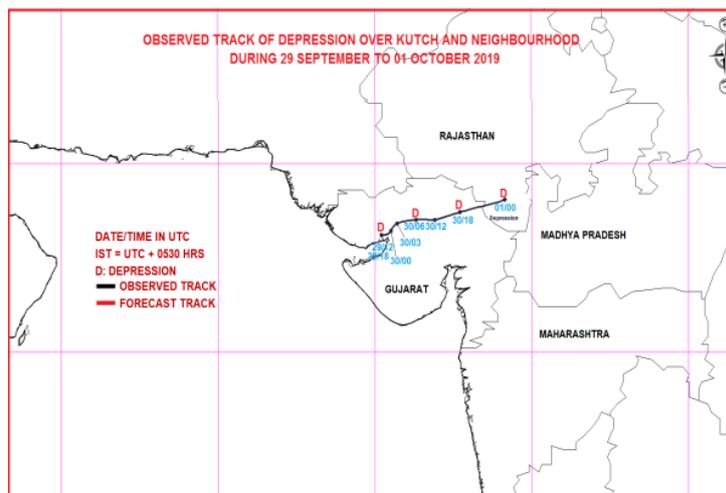


Fig.1: Observed track of Depression over Gulf of Kutch and neighbourhood (29 September-01 October)

Table 1: Best track positions and other parameters of the depression over Gulf of Kutch & neighbourhood during (29 September-01 October 2019)

Date	Time (UTC)	Centre lat. ^o N/ long. ^o E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
29/09/2019	1200	23.1 70.2	-	1002	25	04	D
	1800	23.1 70.2	-	1002	25	04	D
30/09/2019	0000	23.2 70.5	-	1002	25	04	D
	0300	23.4 70.7	-	1002	25	04	D
	0600	23.5 71.3	-	1002	25	04	D
	1200	23.5 71.9	-	1002	25	04	D
	1800	23.7 72.7	-	1002	25	04	D
01/10/2019	0000	24.0 74.1	-	1002	25	04	D
	0300	Well Marked Low Pressure Area over southeast Rajasthan & neighbourhood					

2. Monitoring & prediction

IMD predicted cyclogenesis over northeast AS & adjoining Kutch on 27th September (57 hours prior to development of depression over Gulf of Kutch and neighbourhood. IMD utilised all available capabilities viz., Meteorological observational network including surface & upper air observatories, RADAR and Satellite products and numerical models for round the clock monitoring and forecasting of heavy rainfall and strong winds associated with the system. Apart from the India weather Bulletins and severe weather warning Bulletins issued routinely, 8 National Bulletins were also issued to the concerned authorities, with specific weather warnings pertaining to the Depression.

2.1. Feature observed through Satellites:

Satellite monitoring of the system was mainly done by using half hourly INSAT-3D&3DR imageries. Satellite imageries of international geostationary satellites Meteosat-7 and microwave & SCAT Sat imageries were also considered. Typical INSAT-3D IR, visible, enhanced colored and cloud top brightness temperature imageries are presented in Fig. 2.

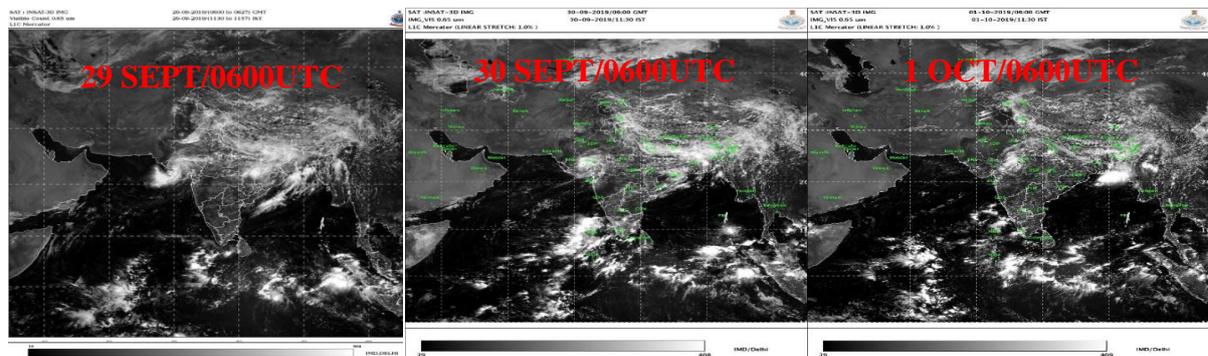


Fig. 2(i): INSAT-3D visible imageries during 29 September-01 October 2019

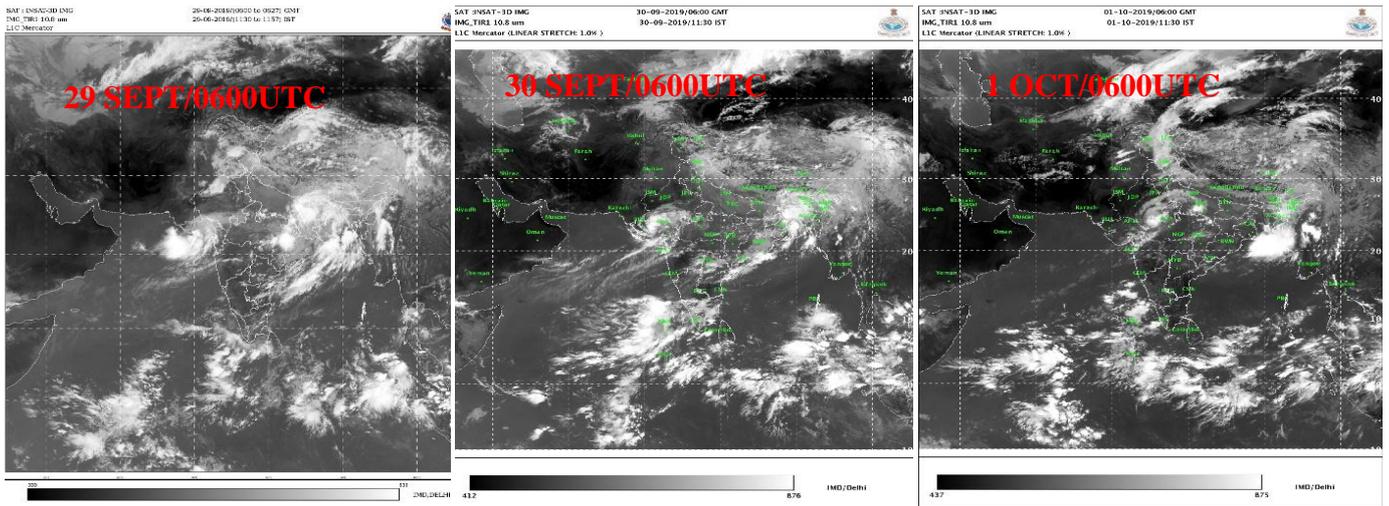


Fig. 2 (ii): INSAT-3D IR 1 imageries during 29 September-01 October 2019

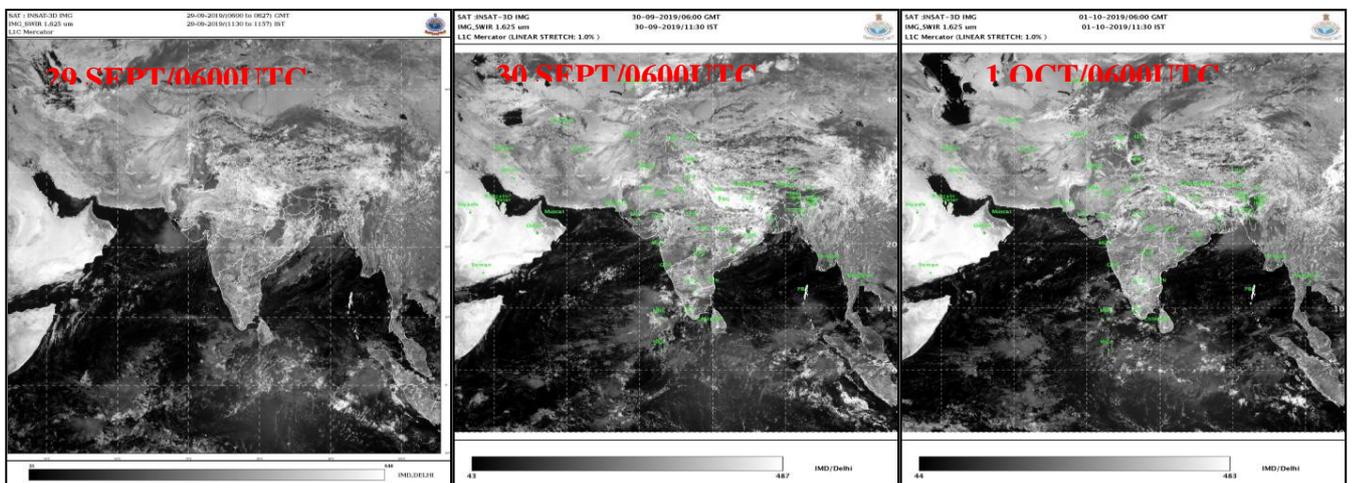


Fig. 2 (iii): INSAT-3D SWIR during 29 September-01 October 20

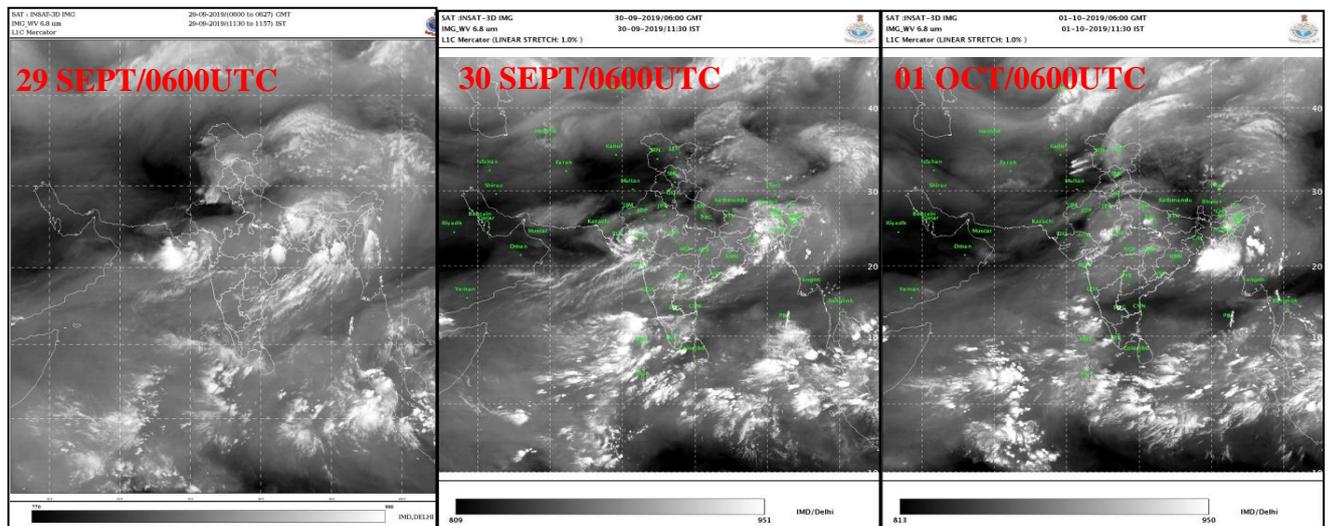


Fig. 2 (iv): INSAT-3D Water Vapour during 29 September-01 October 2019

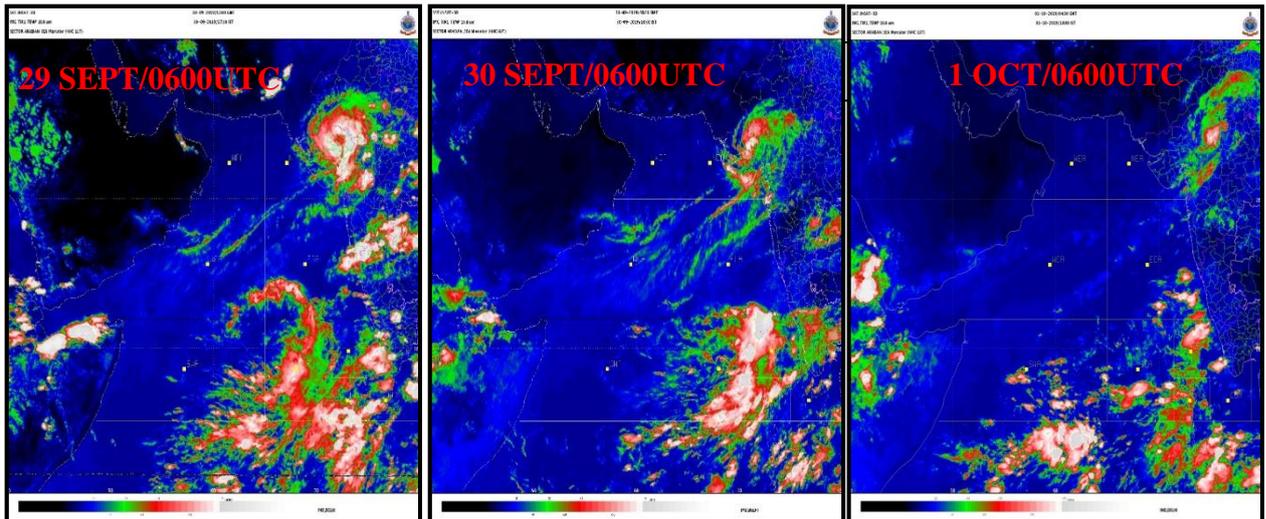


Fig. 2(v): INSAT-3D enhanced colored imageries during 29 September- 01 October 2019

3. Dynamical features

IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels are presented in Fig.3. IMD GFS was indicating cyclonic circulation over northeast AS at 0000 UTC of 29th September.

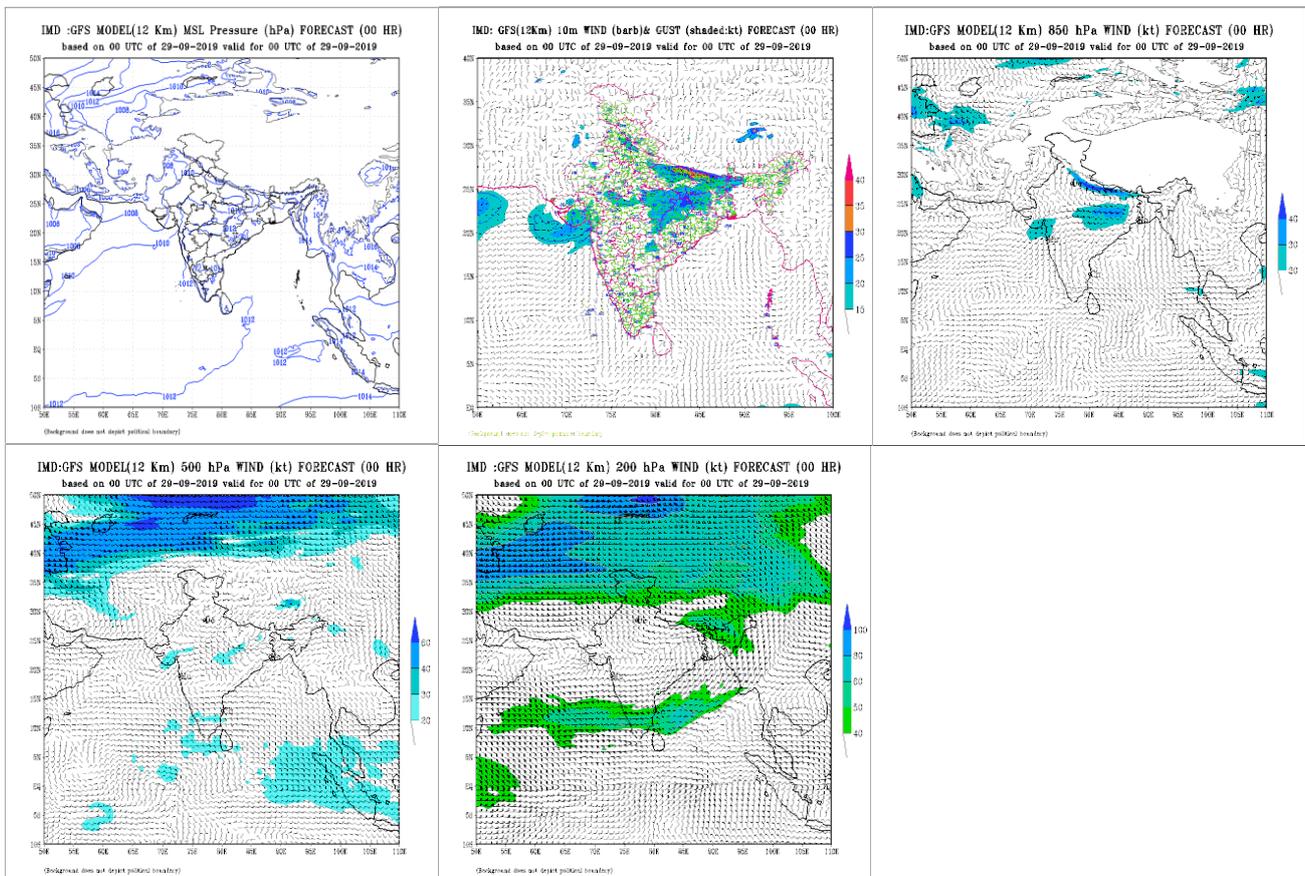


Fig. 3 (i): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 29th September

The initial conditions of 0000 UTC of 30th September indicated a depression over Kutch region near 23.0°N/72.0°E. The cyclonic circulation was extending upto 500 hPa. Actually the system lay near 23.2°N/72.5°E as a depression. Westerly winds prevailed in the upper air indicating steering of the system eastwards.

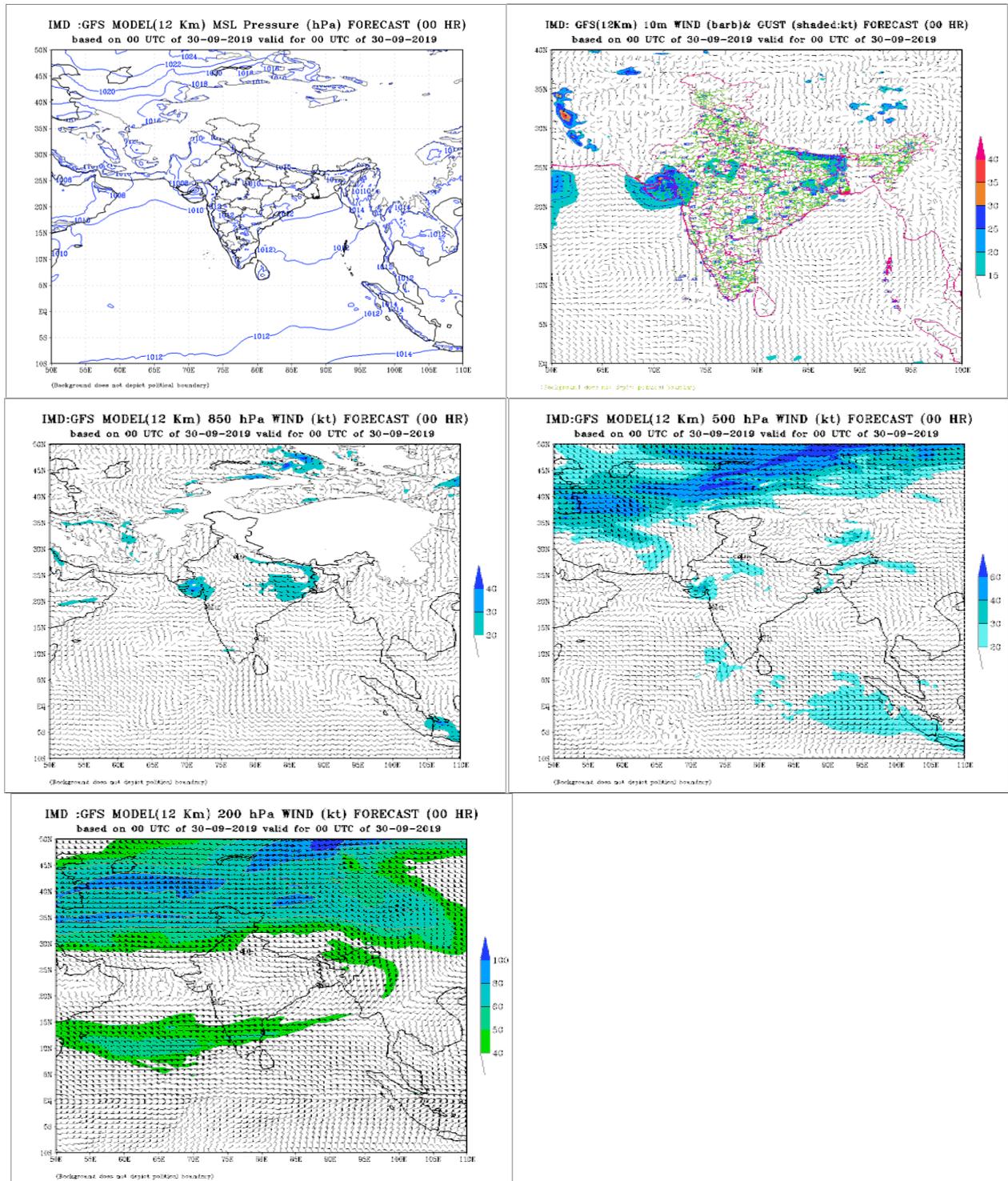


Fig.3 (ii): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 30th September

The initial conditions of 0000 UTC of 1st October indicated a depression over southeast Rajasthan near 23.0°N/72.0°E. The cyclonic circulation was extending upto 500 hPa. Actually the system lay near 23.2°N/72.5°E as a depression. GFS also captured presence of westerlies in the upper air indicating steering of the system eastwards.

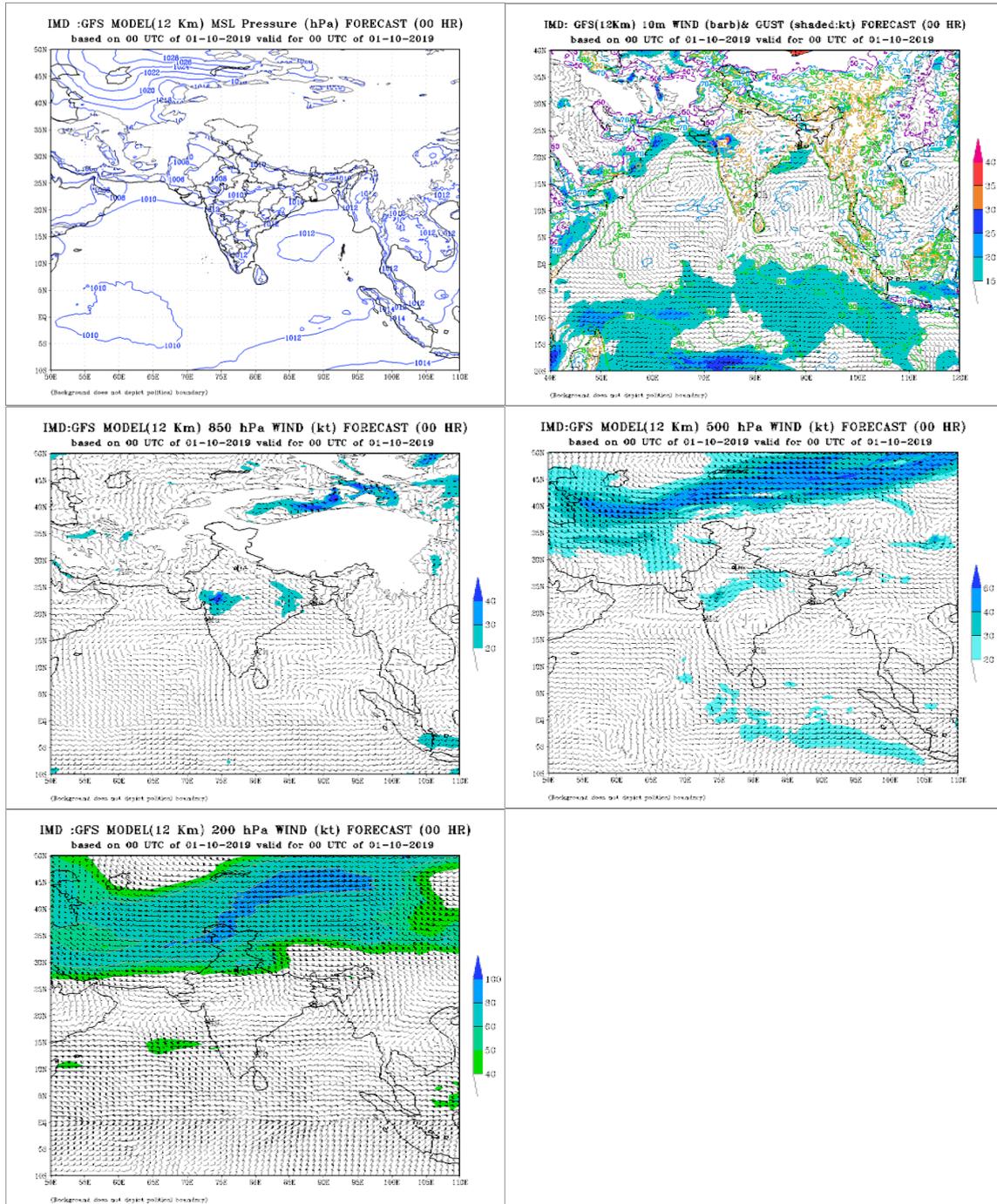


Fig.3 (iii): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 1st October

Thus IMD GFS could well capture the genesis, intensification and movement of the system.

4. Realized Weather:

4.1 Rainfall:

Under the influence of depression, heavy to very heavy rainfall occurred at isolated places over Gujarat, Saurashtra & Kutch and East Rajasthan on 29th September. On 30th September, heavy rainfall at isolated places occurred over Gujarat region, and heavy rainfall occurred at few places with very heavy to extremely heavy falls at isolated places over Saurashtra & Kutch. On 1st October, heavy to very heavy falls occurred at few places with extremely heavy falls at isolated places over Gujarat region, heavy rainfall occurred at isolated places over Saurashtra & Kutch, heavy rainfall occurred at few places over East Rajasthan and heavy rainfall occurred at isolated places over West Madhya Pradesh.

The 24 hour cumulative rainfall (≥ 7 cm) ending at 0300 UTC of date during 15th-17th August is presented below:

29th September:

Gujarat region: Patan-14, Visnagar, Idar and Unjha-7 each

Saurashtra and Kutch: Mundra & Visavadar-13 each and Talala-10

East Rajasthan: Devel-17, Dungarpur Tehsil-10, Aspur-8 and Ganeshpur-7

30th September:

Gujarat region: Harij-8 and Radhanpur-7

Saurashtra and Kutch: Bhanvad-33, Jamjodhpur-22, Kalyanpur & Jamkandorna-19 each, Rapar-17, Khambhalia-16, Lodhika-15, Jodia-12, Bhachau, Bhesan and Gondal-11 each, Anjar, Junagadh, Dhoraji, Manavadar, Ranav and Morbi-10 each, Tankara, Gandhidham, Lalpur, Jamnagar & Malia Mana-9 each, Dhrangadhra, Kotdasangani, Vadia, Porbandar, Kandla & Vanthali-8 each, Talala, Jetpur, Upleta, Wankaner & Mundra-7 each.

1st October:

Gujarat region: Satlasana-20, Bhabhar-19, Bhiloda-18, Vijaynagar-17, Himatanagar-16, Vijapur-14, Idar & Radhanpur-13 each, Kankrej, Deodar & Dharoi Colony-11 each, Prantij-10, Siddhpur & Danta-9 each, Borsad, Harij, Shankheshvar, Patan, Dhansura & Becharaji-8 each, Vadgam, Dantiwada, Deesa, Visnagar, Suigam, Vadali, Anand, Palanpur, Sami, Saraswati, Kheralu & Amirgadh-7 each

Saurashtra & Kutch: Thangadh-10, Dhrangadhra-9 and Wankaner-7

East Rajasthan: Sarara & Devel-13 each, Kherwara-12, Sagwara-11, Nithuwa, Aspur, Salumber, Jhadol & Ganeshpur-10 each, Veja & Loharia-9 each, Sabla-8, Galiakot, Dhariabad, Dungarpur Tehsil & Jagpura-7 each.

West Madhya Pradesh: Mandsaur & Agar-7 each

5. Bulletins issued by IMD

IMD issued regular bulletins to WMO/ESCAP Panel member countries including Pakistan, National & State Disaster Management Agencies of Gujarat, Rajasthan & Madhya Pradesh, Administrator, Union Territory of Daman & Diu and Dadra Nagar Haveli, general public and media. Regular Bulletins every six hourly were issued

since formation of depression over northeast AS. Statistics of bulletins issued by Cyclone Warning Division of IMD in association with the system are presented in Table 2.

Table 2: Bulletins issued by Cyclone Warning Division, IMD, New Delhi

S.No.	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	8	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 Defense Staff, DG Doordarshan, All India Radio, DG-NDRF, Director Indian Railways, Indian Navy, IAF, Chief Secretary:Gujarat, Madhya Pradesh and Rajasthan & Administrator, Union Territory of Daman & Diu and Dadra Nagar Haveli
2	RSMC Bulletin	8	1. IMD's website 2. All WMO/ESCAP member countries through GTS and E-mail. 3. Indian Navy, IAF by E-mail
3	Face book /Twitter	Once a day	Highlights uploaded on Face book/ Twitter since formation of depression.

6. Operational Forecast Performance

In the tropical weather outlook dated the 27th September, it was indicated that a low pressure area would form around 28th over Saurashtra and adjoining areas with further intensification during next 2 days. A low pressure area formed over northeast Arabian Sea & adjoining coastal areas of Saurashtra & Kutch on 28th and it concentrated into a Depression over Kutch and neighbourhood on 29th. Thus, genesis could be predicted about 57 hours in advance.

The verification of heavy rainfall warnings issued by IMD for the depression during 29thSept- 1st October is presented in Table 3. It can be found that the occurrence of heavy rainfall in association with the system could also be predicted correctly well in advance.

Table 3: Verification of heavy rainfall warning issued by IMD for Deep Depression over northwest Bay of Bengal and neighborhood (29 Sept-1 Oct, 2019)

Date/Base Time of observation (UTC)	24 hr Heavy rainfall warning ending at 0300 UTC of next day	Realised 24-hour heavy rainfall ending at 0300 UTC of date
30/09/2019 0300 UTC	<ul style="list-style-type: none"> • Isolated heavy to very heavy and extremely heavy falls ($\geq 20\text{cm}$) over Saurashtra & Kutch and north Gujarat region during on 30th. Isolated heavy falls over north Gujarat region on 1st October, 2019. • Isolated heavy to very heavy and extremely heavy falls ($\geq 20\text{cm}$) over southeast Rajasthan on 30th and heavy rainfall on 1st October, 2019. Isolated heavy rainfall over southwest Rajasthan on 30th. • Isolated heavy falls on 30th September and isolated heavy to very heavy over west Madhya Pradesh on 01st October, 2019. 	<p>29th September: Gujarat: Patan-14, Visnagar, Idar and Unjha-7 each Saurashtra and Kutch: Mundra & Visavadar-13 each and Talala-10 Rajasthan: Devel-17, Dungarpur Tehsil-10, Aspur-8 and Ganeshpur-7 30th September: Gujarat: Harij-8 and Radhanpur-7 Saurashtra and Kutch: Bhanvad-33, Jamjodhpur-22, Kalyanpur & Jamkandorna-19 each, Rapar-17, Khambhalia-16, Lodhika-15, Jodia-12, Bhachau, Bhesan and Gondal-11 each, Anjar, Junagadh, Dhoraji, Manavadar, Ranav and Morbi-10 each, Tankara, Gandhidham, Lalpur, Jamnagar & Malia Mana-9 each, Dhrangadhra, Kotasangani, Vadia, Porbandar, Kandla & Vanthali-8 each, Talala, Jetpur, Upleta, Wankaner & Mundra-7 each. 1st October: Rajasthan: Sarara & Devel-13 each, Kherwara-12, Sagwara-11, Nithuwa, Aspur, Salumber, Jhadol & Ganeshpur-10 each, Veja & Loharia-9 each, Sabla-8, Galiakot, Dhariabad, Dungarpur Tehsil & Jagpura-7 each. West Madhya Pradesh: Mandsaur & Agar-7 each Gujarat Region: Satlasana-20, Bhabhar-19, Bhiloda-18, Vijaynagar-17, Himatanagar-16, Vijapur-14, Idar & Radhanpur-13 each, Kankrej, Deodar & Dharoi Colony-11 each, Prantij-10, Siddhpur & Danta-9 each, Borsad, Harij, Shankheshvar, Patan, Dhansura & Becharaji-8 each, Vadgam, Dantiwada, Deesa, Visnagar, Suigam, Vadali, Anand, Palanpur, Sami, Saraswati, Kheralu & Amirgadh-7 each Saurashtra & Kutch: Thangadh-10, Dhrangadhra-9 and Wankaner-7.</p>
01/10/2019 0300 UTC	<ul style="list-style-type: none"> • Isolated heavy falls over north Gujarat region on 1st. • Isolated heavy to very heavy rainfall over southeast Rajasthan and West Madhya Pradesh on 1st. 	<p>Gujarat Region: Satlasana-20, Bhabhar-19, Bhiloda-18, Vijaynagar-17, Himatanagar-16, Vijapur-14, Idar & Radhanpur-13 each, Kankrej, Deodar & Dharoi Colony-11 each, Prantij-10, Siddhpur & Danta-9 each, Borsad, Harij, Shankheshvar, Patan, Dhansura & Becharaji-8 each, Vadgam, Dantiwada, Deesa, Visnagar, Suigam, Vadali, Anand, Palanpur, Sami, Saraswati, Kheralu & Amirgadh-7 each Saurashtra & Kutch: Thangadh-10, Dhrangadhra-9 and Wankaner-7.</p>

7. Summary and Conclusions:

A low pressure area formed over northeast Arabian Sea & adjoining coastal areas of Saurashtra & Kutch on 28th September, 2019. It concentrated into a Depression over Gulf of Kutch and neighbourhood on 29th September, 2019. It moved east-northeastwards, maintained its intensity for 33 hours over land and weakened into a WML over southeast Rajasthan & neighbourhood on 01st October, 2019. The system caused heavy to very heavy rainfall at few places with extremely heavy falls at isolated places over Gujarat region, Saurashtra & Kutch, east Rajasthan west Madhya Pradesh during 29th September to 1st October.

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) NOIDA, National Institute of Technology (NIOT) Chennai & Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. The support from various Divisions/Sections of IMD including Cyclone Warning Centre Ahmedabad, Regional Meteorological Centre Nagpur, Meteorological Centre, Jaipur, Numerical Weather Prediction (NWP) Division, Information System & Services Division (ISSD) and Satellite at IMD HQ New Delhi is also duly acknowledged for monitoring and predicting the system.
