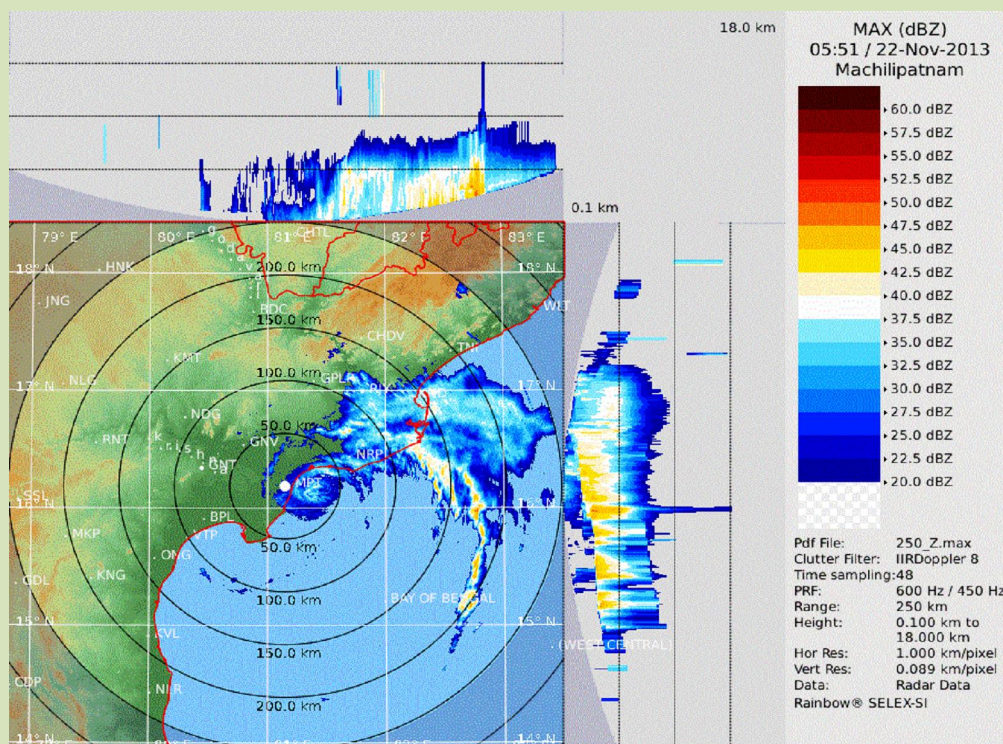




**GOVERNMENT OF INDIA**  
**MINISTRY OF EARTH SCIENCES**  
**EARTH SYSTEM SCIENCE ORGANIZATION**  
**INDIA METEOROLOGICAL DEPARTMENT**

**A Preliminary Report on Severe Cyclonic Storm 'Helen'**  
**over the Bay of Bengal**  
**(19-23 November, 2013)**



**CYCLONE WARNING DIVISION, NEW DELHI**

**FEBRUARY, 2014**

## **Severe Cyclonic Storm 'HELEN' over Bay of Bengal**

**(19-23 Nov 2013)**

### **1. Introduction**

A severe cyclonic storm Helen crossed Andhra Pradesh coast close to south of Machilipatnam (near lat. 16.1°N and long. 81.2°E) between 0800-0900 UTC of 22<sup>nd</sup> Nov. 2013 as a cyclonic storm with a wind speed of 80-90 kmph gusting to 100 kmph. The salient features of this storm are as follows:

- (i) It moved west-southwestward 12 hrs before landfall
- (ii) It weakened rapidly after the landfall and hence caused less rainfall over coastal Andhra Pradesh. Under its influence rainfall at most places with isolated heavy to very heavy rainfall occurred over coastal Andhra Pradesh.

Brief life history and other characteristic features of cyclone are described in the following sections.

### **2. Monitoring and Prediction:**

The severe cyclonic storm Helen was monitored & predicted continuously since its inception by the India Meteorological Department. The forecast of its genesis, track, intensity, point & time of landfall, as well as associated adverse weather like heavy rain, gale wind & storm surge was predicted exceedingly well with sufficient lead time which helped the disaster managers to maximize the management of cyclone in an exemplary manner. At the genesis stage, the system was monitored mainly with satellite observations, supported by meteorological buoys and coastal and Island observations. As the system lay within range of DWR, Machilipatnam and Visakhapatnam, it was continuously monitored by the radar in addition to the observations from satellite and coastal observations. Data from conventional observatories and Automatic Weather Stations (AWSs) were also used. While coastal surface observations were taken on hourly basis, the half hourly INSAT/ Kalpana imageries and every 10 minute DWR imageries, available microwave imageries and scatterometry products were used for monitoring of the system. Various national and international NWP models and dynamical-statistical models including IMD's global and meso-scale models, dynamical statistical models for genesis and intensity were utilized to predict the genesis, track, intensity and landfall of the storm. Tropical Cyclone Module, the digitized forecasting

system of IMD was utilized for analysis and comparison of various models guidance and decision making process and warning product generation.

### **3. Genesis**

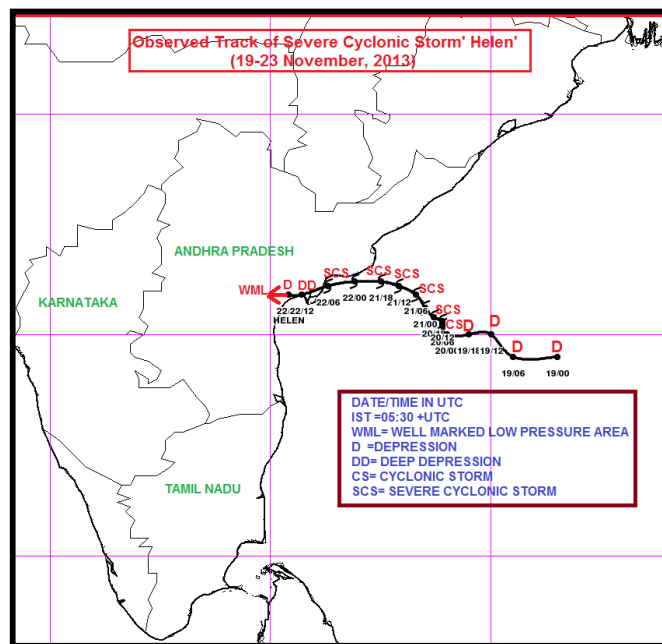
The remnant of the tropical storm (Podul) contributed to the development of a trough over the Bay of Bengal near the Andaman Islands on 16<sup>th</sup> November. It became organised as a low pressure area over the east central Bay of Bengal on 17<sup>th</sup> with the active intertropical convergence zone. It became well marked on 18<sup>th</sup> over the central Bay of Bengal and concentrated into a depression over the west central Bay of Bengal in the early morning of 19<sup>th</sup> Nov. 2013 with centre near lat. 14.5°N and long. 86.5°E, about 600 km east-southeast of Machillipatnam. The genesis took place due to favourable location of the low pressure system with warmer sea surface temperature (28-29°C), low to moderate vertical wind shear of horizontal winds (10-20 knots), increase in lower level convergence from 18<sup>th</sup> to 19<sup>th</sup> November along with upper level divergence. The upper level divergence was provided by the anticyclonic circulation which lay to the northeast of the system centre and associated ridge ran along 16.0°N. The Madden Julian Oscillation (MJO) index lay in phase 2 with amplitude less than 1.

### **4. Intensification and movement**

The depression moved west-northwestwards and intensified into a deep depression in the night of 19<sup>th</sup> Nov. 2013 and further into a cyclonic storm, HELEN in the morning of 20<sup>th</sup> Nov. at about 330 km east-southeast of Machilipatnam. It then moved north-northwestwards till 1200 UTC of 21<sup>st</sup> and intensified into a severe cyclonic storm in the early morning of 21<sup>st</sup> Nov. at a distance of 260 km east-southeast of Machilipatnam. On 22<sup>nd</sup> November, It moved initially westwards and then west-southwestwards and crossed Andhra Pradesh coast close to south of Machilipatnam (near lat. 16.1°N and long. 81.2°E) between 0800-0900 UTC of 22<sup>nd</sup> Nov. 2013 as a cyclonic storm with a wind speed of 80-90 kmph gusting to 100 kmph. It then weakened gradually while moving west-southwestwards across Andhra Pradesh and lay as a low pressure area over coastal Andhra Pradesh and neighborhood in the early morning of 23<sup>rd</sup> Nov. 2013. As the system moved towards the coast, it experienced decreasing vertical wind shear. The vertical wind shear was low to moderate (5-15 knots) on 20<sup>th</sup> morning when the system intensified into a cyclonic storm. The low to moderate vertical wind shear continued till 20<sup>th</sup> leading to further intensification of the system into severe cyclonic storm in the early morning of 21<sup>st</sup>. Thereafter the vertical wind shear increased

gradually becoming moderate on 21<sup>st</sup> (10-20 knots) and moderate to high (15-25) knots on 22<sup>nd</sup> Nov. As a result the system weakened slightly and crossed coast on 22<sup>nd</sup> Nov. as a cyclonic storm. Over land surface, it weakened further due to interaction with land surface and cut off in moisture supply.

The system initially moved northwestwards till 20<sup>th</sup> morning under the influence of the upper tropospheric steering ridge which ran along 16.0°N in association with the anticyclonic circulation lying to the northeast of the system centre. On 20<sup>th</sup> Nov. the system came closer to the steering ridge leading to north-northwesterly movement till 1200 UTC of 21<sup>st</sup> Nov. After that the northerly movement of the system got restricted and started moving nearly westward under the influence of the anticyclonic circulation at middle levels located to the northeast and northwest of the system centre. As the system came closer to the coast the steering anticyclonic circulation over India i.e. to the northwest of the system centre became more dominant leading to west-southwestward movement from 22<sup>nd</sup> Nov. The track of the system is given in Fig.1 and the best track position and other parameters are given in Table 1. The DWR Machilipatnam radar imagery, typical satellite imagery and IMD GFS MSLP and wind at 850, 500 and 200 hpa are shown in fig.2, 3 & 4 respectively. The location of centre of the system as observed by DWR Visakhapatnam is given in Table 2.

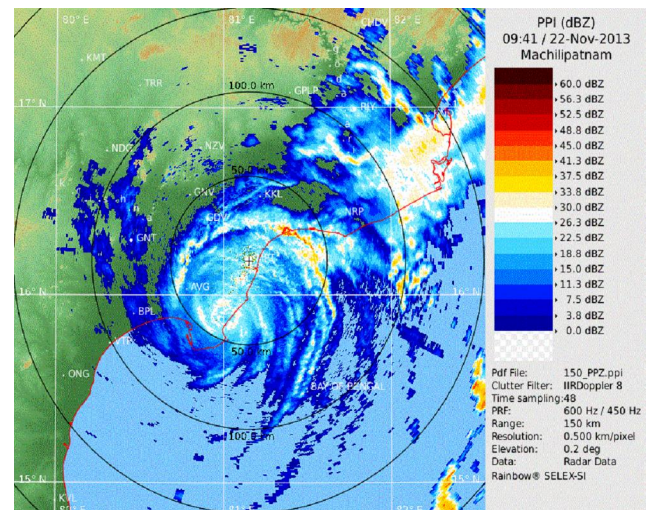
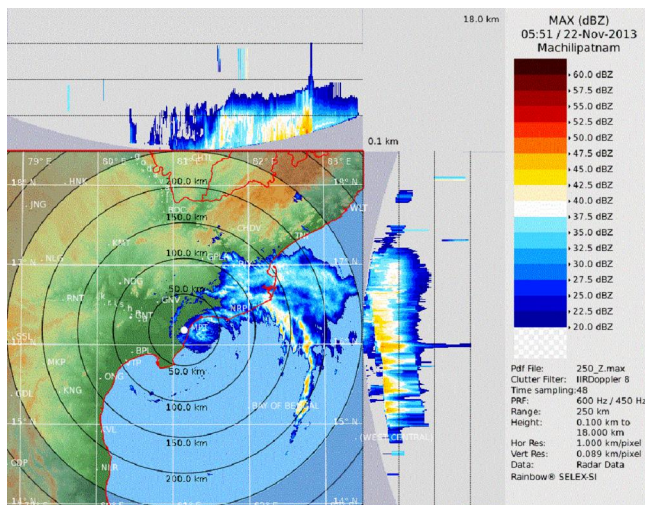
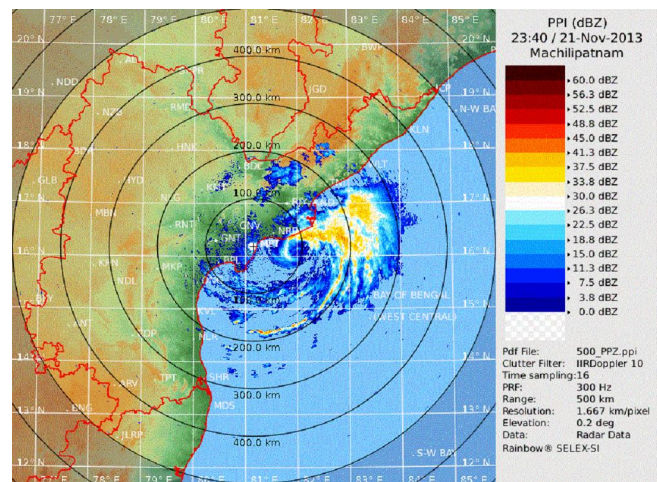
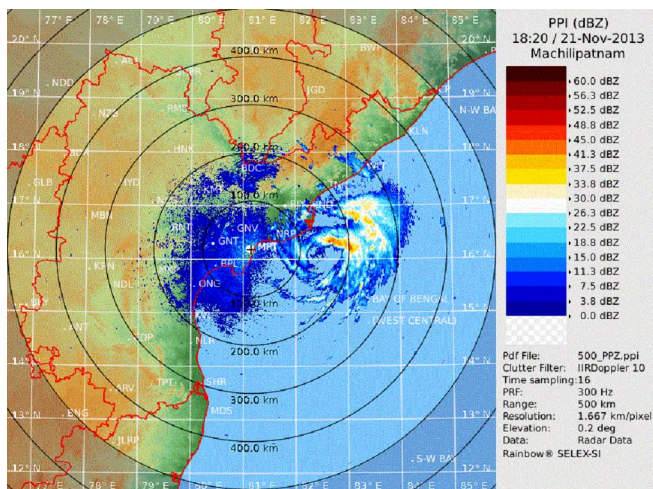


**Fig.1. Track of severe cyclonic storm Helen (19-23 Nov 2013)**

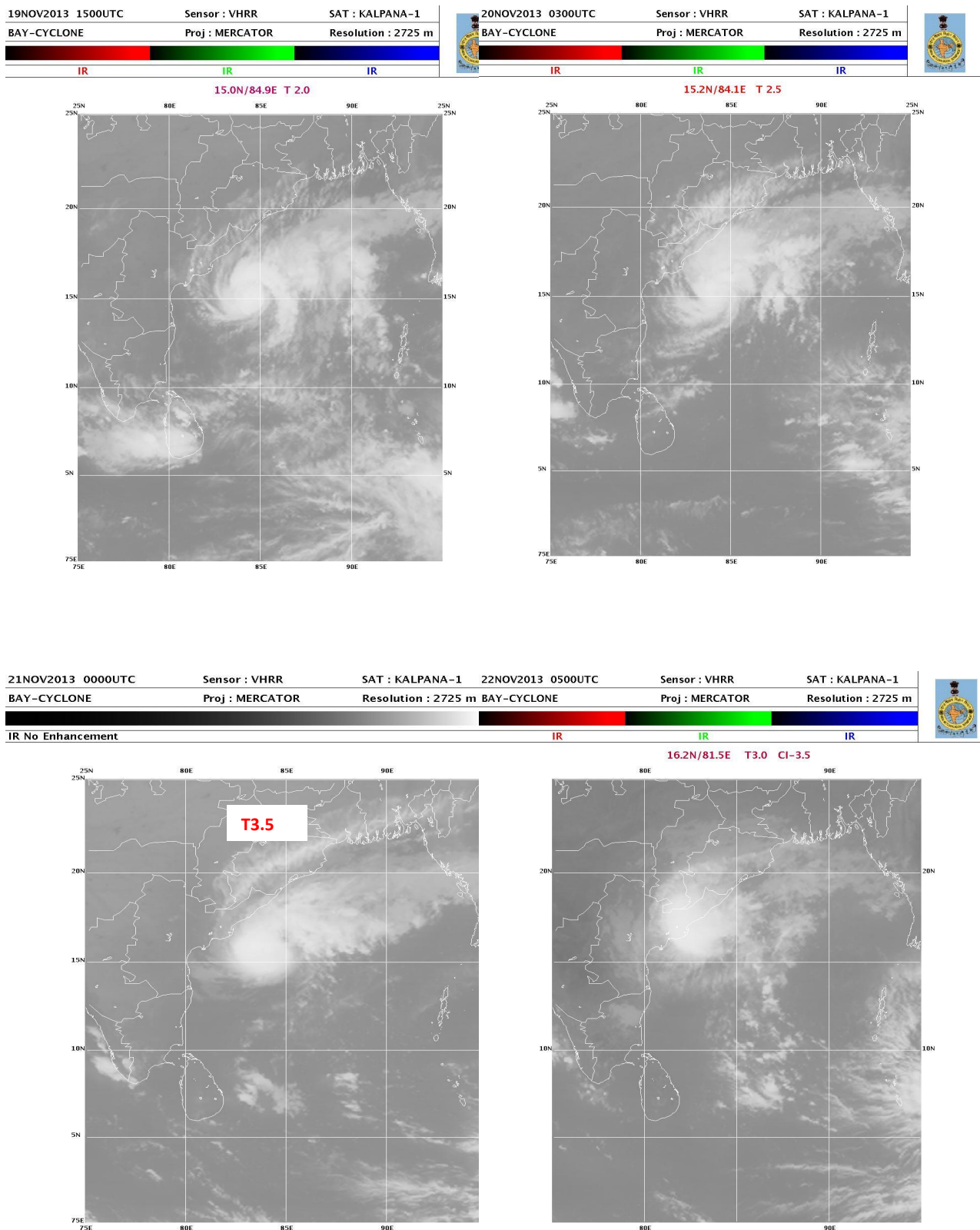
**Table 1: Best track positions and other parameters of the Severe Cyclonic Storm 'Helen' over the Bay of Bengal during 19-23 November, 2013**

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
19-11-2013	0000	14.5/86.5	1.5	1004	25	3	D
	0300	14.5/86.0	1.5	1004	25	3	D
	0600	14.5/85.5	1.5	1004	25	3	D
	1200	15.0/85.0	1.5	1004	25	3	D
	1500	15.0/85.0	2.0	1002	30	5	DD
	1800	15.0/84.5	2.0	1002	30	5	DD
20-11-2013	0000	15.0/84.0	2.0	1002	30	5	DD
	0300	15.0/84.0	2.5	1000	35	8	CS
	0600	15.2/84.0	2.5	1000	40	8	CS
	0900	15.2/84.0	2.5	1000	40	8	CS
	1200	15.3/83.9	3.0	998	45	10	CS
	1500	15.3/83.9	3.0	998	45	10	CS
	1800	15.4/83.7	3.0	996	45	10	CS
	2100	15.5/83.6	3.0	996	45	10	CS
21-11-2013	0000	15.6/83.5	3.0	994	50	15	SCS
	0300	15.8/83.4	3.0	992	50	17	SCS
	0600	15.9/83.3	3.5	990	55	17	SCS
	0900	16.0/83.1	3.5	990	55	17	SCS
	1200	16.1/82.9	3.5	990	55	17	SCS
	1500	16.1/82.7	3.5	990	55	17	SCS
	1800	16.2/82.7	3.5	990	55	17	SCS
	2100	16.2/82.3	3.5	990	55	17	SCS
22-11-2013	0000	16.2/81.9	3.5	990	55	17	SCS
	0300	16.2/81.7	3.5	990	55	17	SCS
	0600	16.2/81.3	3.5	990	55	17	SCS
	The system crossed Andhra Pradesh coast close to south of Machilipatnam near 16.1°N/81.2°E between 0800-0900UTC						
	0900	16.1/81.2	-	1000	40	8	CS
	1200	15.9/80.7	-	1002	30	5	DD
	1800	15.9/80.4	-	1004	25	3	D
23-11-2013	0000	The system weakened into a well marked low pressure area over coastal Andhra Pradesh and neighbourhood.					



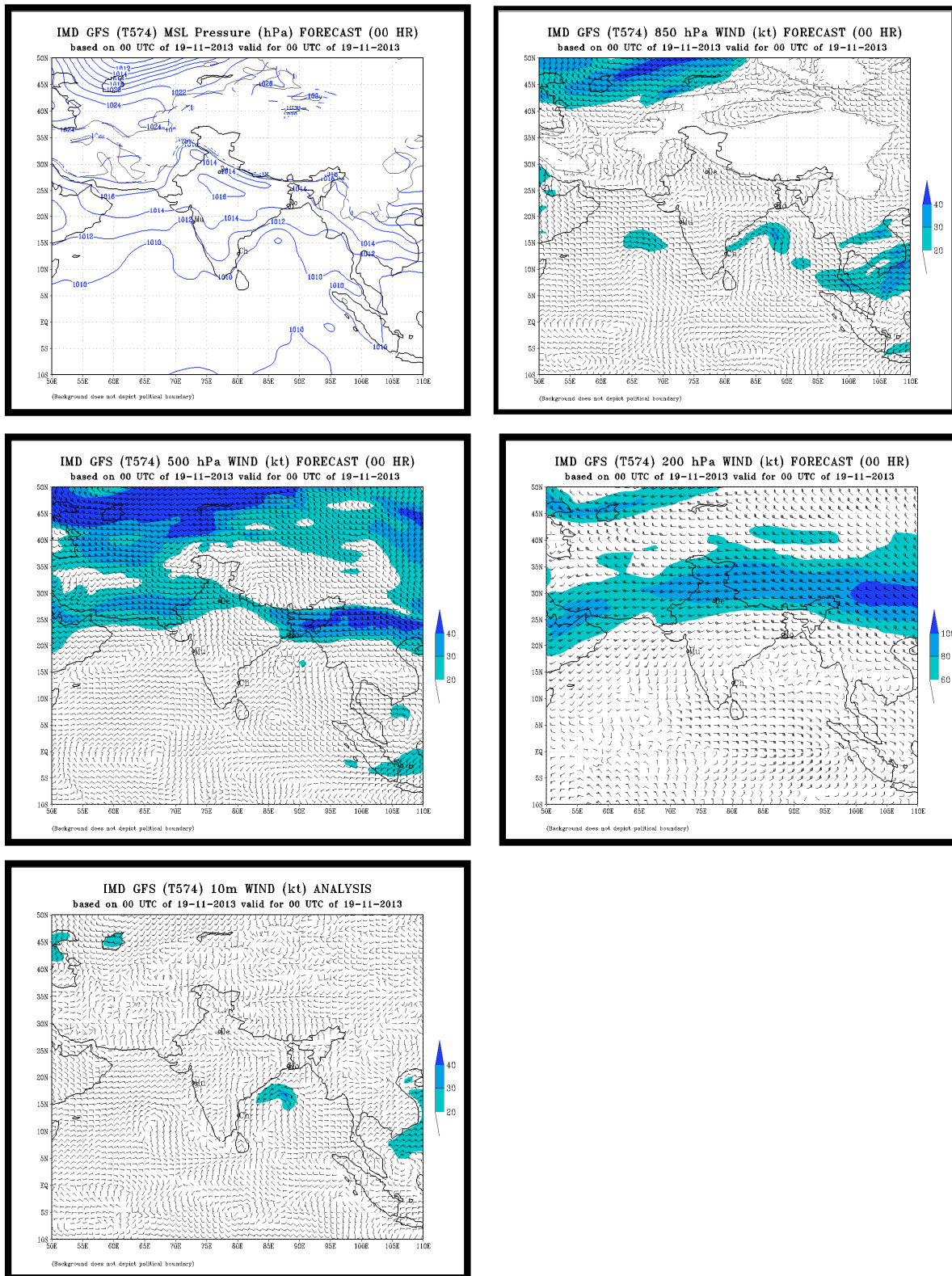


**Fig.2 Typical Radar imageries of DWR Machilipatnam at 1800 UTC of 21<sup>st</sup> and 00, 06 & 10 UTC of 22<sup>nd</sup> November 2013.**



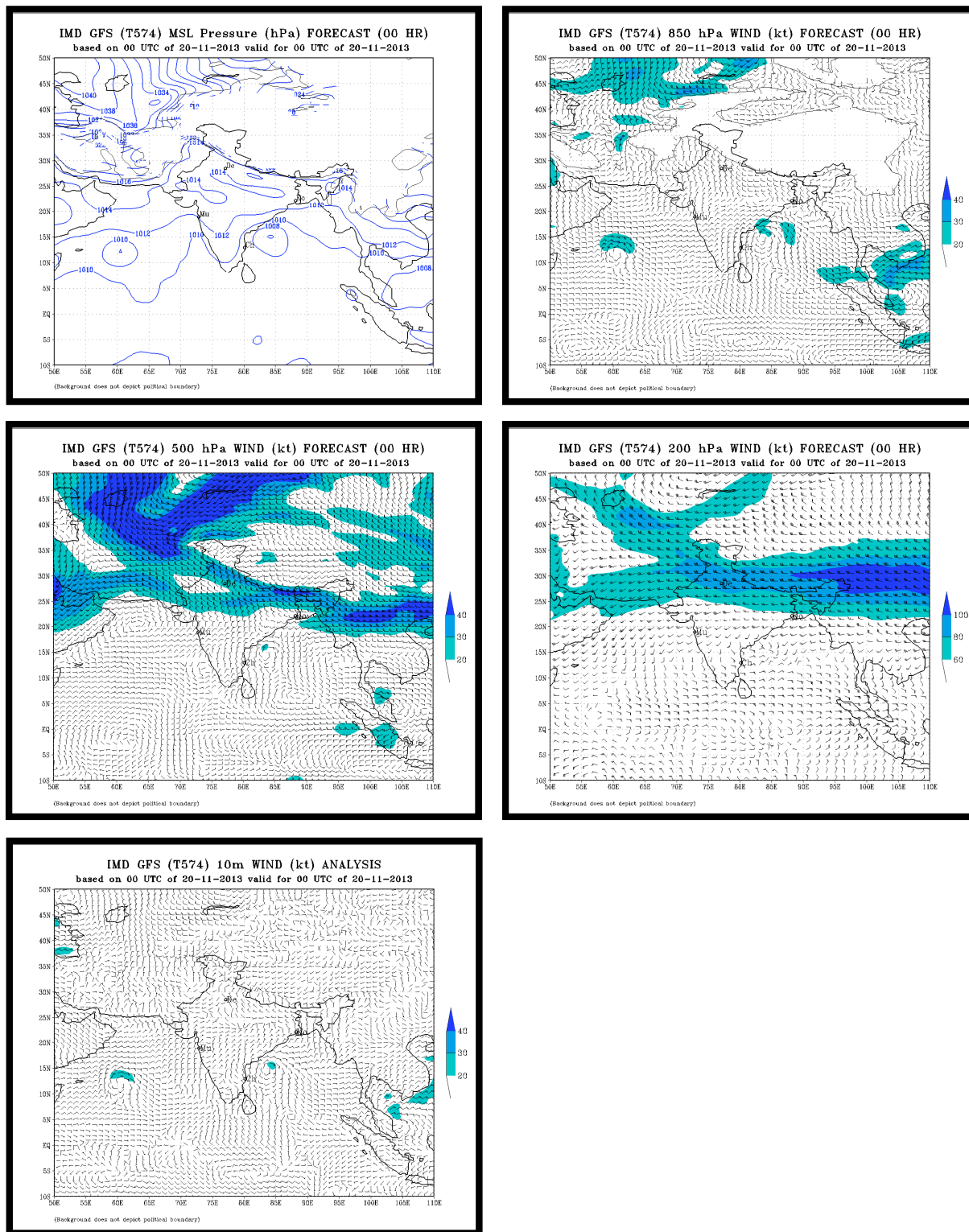
**Fig.(3) Typical Kalpana-1 Satellite imageries of severe cyclonic storm Helen at 1500 UTC of 19<sup>th</sup>, 0300 UTC of 20<sup>th</sup>, 0000 UTC of 21<sup>st</sup> and 0500 UTC of 22<sup>nd</sup> November 2013.**



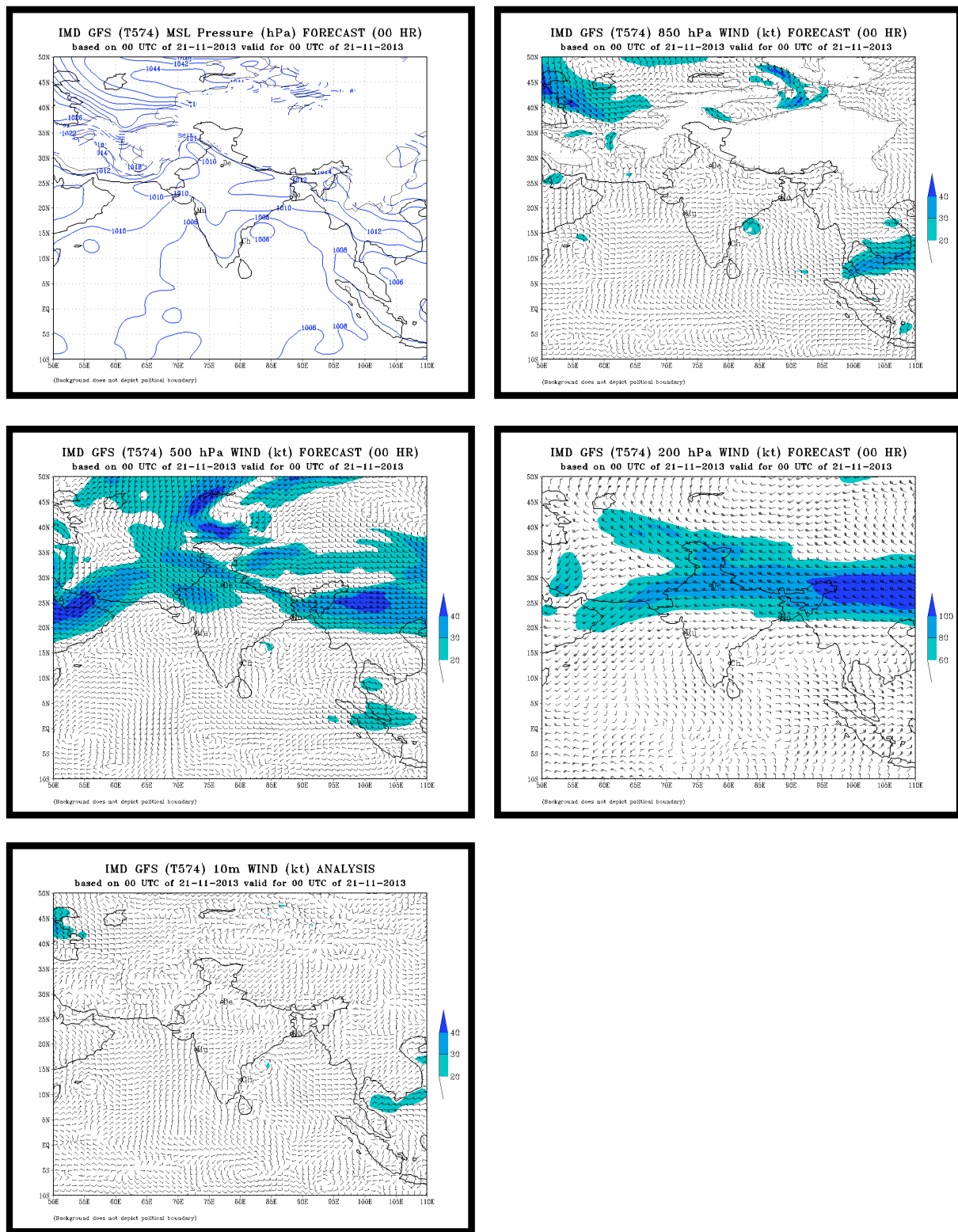


**Fig.4 (a) IMD GFS MSLP and winds at 850, 500 & 200 hpa levels analysis and 10meter wind based on 00 UTC of 19<sup>th</sup> November, 2013.**

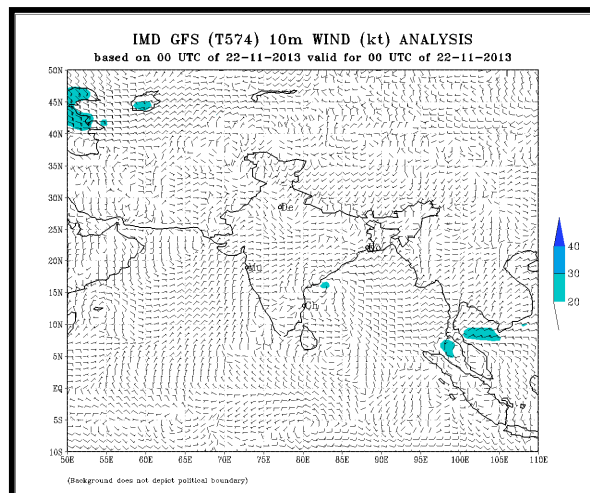
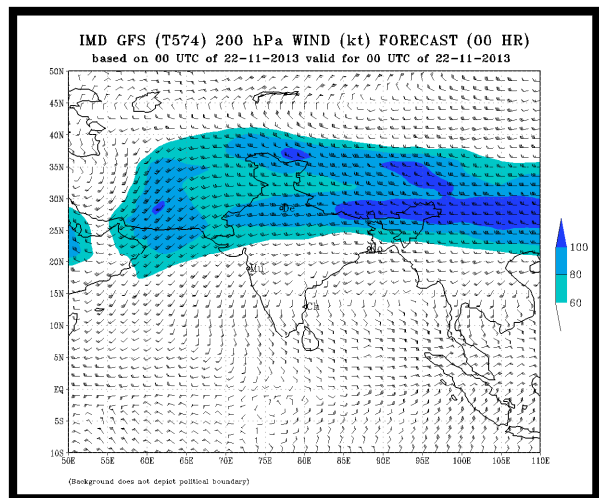
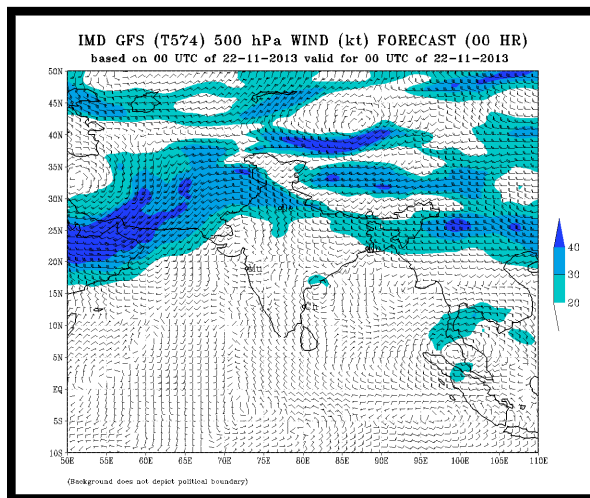
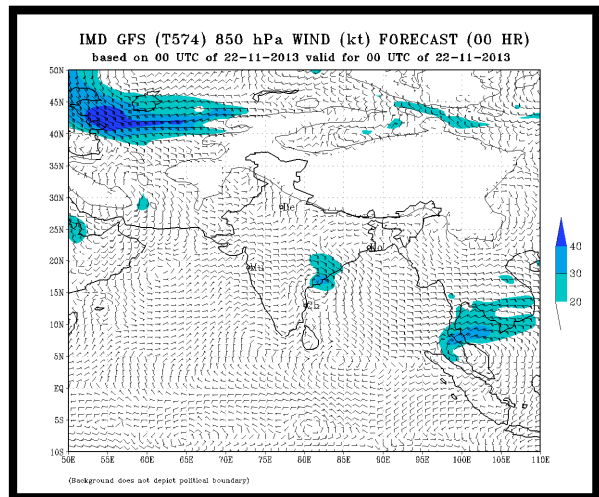
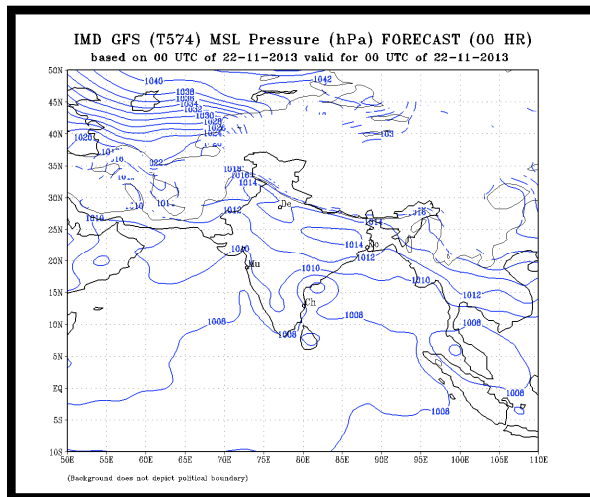




**Fig.4 (b) IMD GFS MSLP and winds at 850, 500 & 200 hpa levels analysis and 10meter wind based on 00 UTC of 20<sup>th</sup> November, 2013.**

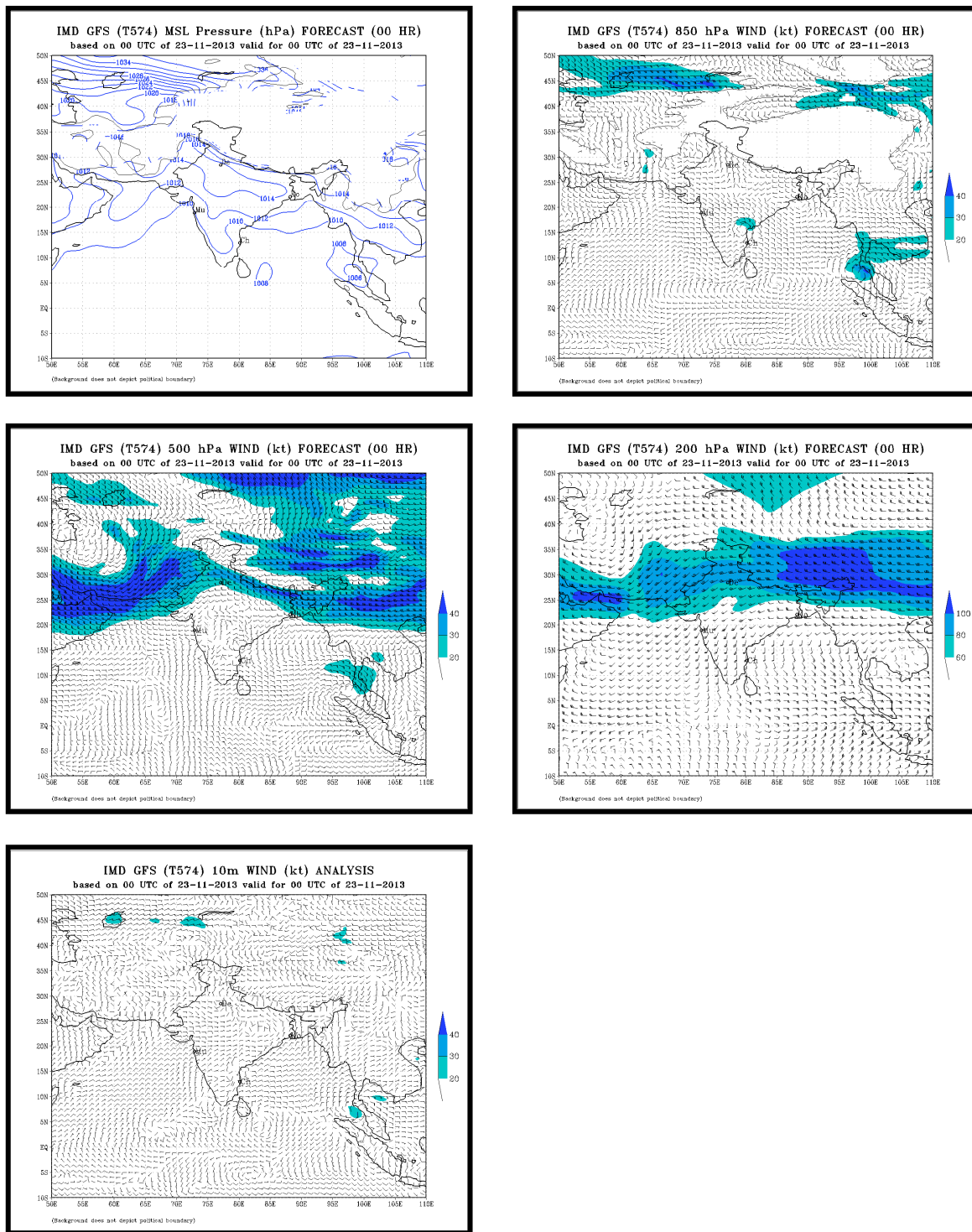


**Fig.4 (c) IMD GFS MSLP and winds at 850, 500 & 200 hpa levels analysis and 10meter wind based on 00 UTC of 21<sup>st</sup> November, 2013.**



**Fig.4 (d) IMD GFS MSLP and winds at 850, 500 & 200 hpa levels analysis and 10meter wind based on 00 UTC of 22<sup>st</sup> November, 2013.**





**Fig.4 (e) IMD GFS MSLP and winds at 850, 500 & 200 hpa levels analysis and 10meter wind based on 00 UTC of 23<sup>rd</sup> November, 2013.**



**Table 2. Centre of Cyclone HELEN based on DWR, Visakhapatnam**

Date/Time (UTC)	Intensity	LAT/LONG N/E
19.11.13/0000	Depression	14.5/86.5
19.11.13/0300	Depression	14.5/86.0
19.11.13/0600	Depression	14.5/85.5
19.11.13/1200	Depression	15.0/85.0
19.11.13/1500	Deep Depression	15.0/85.0
19.11.13/1800	Deep Depression	15.0/84.5
20.11.13/0000	Deep Depression	15.0/84.0
20.11.13/0300	Cyclonic Storm	15.0/84.0
20.11.13/0600	Cyclonic Storm	15.2/84.0
20.11.13/0900	Cyclonic Storm	15.2/84.0
20.11.13/1200	Cyclonic Storm	15.3/83.9
20.11.13/1800	Cyclonic Storm	15.4/83.7
20.11.13/2100	Cyclonic Storm	15.5/83.6
21.11.13/0000	Severe Cyclonic Storm	15.6/83.5
21.11.13/0300	Severe Cyclonic Storm	15.8/83.4
21.11.13/0600	Severe Cyclonic Storm	15.9/83.3
21.11.13/0900	Severe Cyclonic Storm	16.0/83.1
21.11.13/1200	Severe Cyclonic Storm	16.1/82.9
21.11.13/1500	Severe Cyclonic Storm	16.1/82.7
21.11.13/1800	Severe Cyclonic Storm	16.2/82.5
21.11.13/2100	Severe Cyclonic Storm	16.2/82.3
22.11.13/0000	Severe Cyclonic Storm	16.2/81.9
22.11.13/0300	Severe Cyclonic Storm	16.2/81.7
22.11.13/0600	Severe Cyclonic Storm	16.2/81.3
22.11.13/0800- 0900	Cyclonic Storm	16.1/81.2
22.11.13/0900	Cyclonic Storm	16.1/81.0
22.11.13/1200	Deep Depression	15.9/80.7
22.11.13/1800	Depression	15.9/80.4

## 5. Warning services

The Cyclone Warning Division / Regional Specialised Meteorological Centre (RSMC)-Tropical Cyclone, IMD, New Delhi mobilised all its resources for monitoring and prediction of cyclonic storm, HELEN. It issued 3/6 hourly warning/advisory bulletins to national disaster management agencies. It issued forecast and warning bulletins to various national and international disaster management agencies including National Disaster Management (NDM), Ministry of Home Affairs (MHA), National Disaster Management Authority (NDMA) concerned state Govts. and other users at regular intervals. It also issued advisories to World Meteorological Organisation (WMO)/Economic and Social Cooperation for Asia and the Pacific (ESCAP) Panel member countries including Bangladesh, Myanmar, Thailand, Pakistan, Oman, Sri Lanka and Maldives during cyclone period. As Tropical Cyclone Advisory Centre (TCAC), it also issued tropical cyclone advisories with effect from the stage of deep depression for international civil aviation purpose as per the requirement of International Civil Aviation Organization (ICAO). The TCAC bulletin was also sent to Aviation Disaster Risk reduction (ADRR) centre of WMO at Hong Kong like previous year. Tropical cyclone vitals were prepared every six hourly from deep depression stage onwards and provided to various NWP modeling groups in India for synthetic vortex generation in NWP models.

The numbered warning bulletins were issued by Cyclone Warning Division, IMD, New Delhi since early morning of 19<sup>th</sup> November, 2013. The bulletins were issued every three hourly since the cyclonic storm stage, i.e. from morning of 20<sup>th</sup> Nov 2013. The number of bulletins issued by the Regional Specialised Meteorological Centre and Cyclone Warning Division, New Delhi, are given below:

**Table 3. Statistics of bulletins issued during SCS, HELEN**

S.N.	Bulletins	No. of Bulletins
1	Press Release	4
2	No. of Press conferences	1
3	Personal Briefing to Higher Officials	Daily
4	National Bulletin	29
5	RSMC Bulletin	24
6	DGMs Bulletin to higher officials at national and state level	3
7	TCAC Bulletin (Text & Graphics)	12

8	ADRR Bulletin to Hong Kong	12
9	TC Vitals	8
10	Quadrant Wind	8
11	SMS to senior Govt. officials at national and state level	11

The statistics of bulletins issued by Cyclone Warning Centre (CWC) Visakhapatnam and Bhubaneswar are given the following Tables 5 & 6

<b>Table.4. No. of bulletins issued during SCS 'Helen' by CWC Visakhapatnam</b>		
S. No.	Name of the Bulletin	Number of bulletins
1	Special Weather Bulletins	2
2	Cyclone Alert Bulletins	1
3	Cyclone Warning Bulletins	13
4	Cyclone De-warning Bulletins	1
5	CWDS Bulletins	16
6	Air Bulletins	16
7	Port Warnings	14
8	Album Page Warnings for (HRW & Gale Winds)	3
9	Fisherman Warnings	14
10	Press Bulletins	3

<b>Table.5. No. of bulletins issued during SCS 'Helen' by Bhubaneswar</b>		
S. No.	Name of the Bulletin	Number of bulletins
1	Number of Informatory message issued	20
2	Number of Port Warning issued	19
3	Fishermen Warning	14
4	Press/AIR/Doordarshan/other TV Channel Bulletin issued	20

**7. Realized Weather:**

**a. Surface Wind:** Gale wind speed reaching of 80-90 kmph gusting to 100 kmph prevailed along and off Andhra Pradesh coast at the time of land fall.

**b. Rainfall:** Chief amounts of 24 hrs. Rainfall (7 cm or more) ending at 0300 UTC from 19<sup>th</sup> November to 23<sup>rd</sup> November, 2013 are given below:

**19 November 2013**

Andaman & Nicobar Islands: Maya Bandar-7

Tamilnadu & Puducherry: Sankarapuram-10, Mayiladuthurai-8 Karaikal-7, Kodavasal-7, Kerala: Piravom-8

**20 November 2013 - Nil**

**21 November 2013**

Tamilnadu & Puducherry: Colachel-12, Thuckalay-9, Eraniel-8

**22 November 2013**

Coastal Andhra Pradesh: Visakhapatnam-11

Tamilnadu & Puducherry: Sivagiri-9

**Kerala:** Nedumangad-7, Alappuzha-7

**23 November 2013**

Coastal Andhra Pradesh: Gudivada-13, Vijayawada A.P.-10, Visakhapatnam Ap-10, Masulipatnam-9, Visakhapatnam-7

**24 November 2013**

Telangana: Narayan Khed-12

Tamilnadu & Puducherry: Watrap-15, Rajapalayam-14, Nanguneri-10, Sivakasi-9, Sivagiri-8, Colachel-8, Uttamapalayam-7, Sankarankoil-7, Coastal Karnataka: Dharmasthala-7

South Interior Karnataka: Bangalore-11, Devanhalli-9, K.R.Nagara-7, Kottigehara-7, Arkalgud-7,

Kerala: Punalur-9, Kurudamannil-9.



## 8. Forecast verification

### (a) Track forecast error

In the first bulletin issued in the early morning of 19<sup>th</sup> November 2013 (three days in advance of landfall), when the system was a depression over west-central Bay of Bengal, it was predicted that the system would intensify into a deep depression and move towards Andhra Pradesh coast during next 72 hrs. In the fifth bulletin issued on 19<sup>th</sup> November it was predicted that the system would intensify into a cyclonic storm. In the seventh bulletin issued on 20<sup>th</sup> November (early morning), it was predicted that the system would further intensify into a severe cyclonic storm and move west-northwestwards for some time, then west-southwestward and cross Andhra Pradesh coast with a wind speed of 90-100 kmph.

The average track forecast error is shown in Table 6. It was 98 & 237 km respectively for 24 and 48 hrs. forecast respectively against the long period average of 133 & 254 km based on the period of 2008-2012.

<b>Table.6. Operational average track forecast error of IMD of 'HELEN'</b>		
Lead Period	Track Forecast Error (km)	Long period average (2008-2012)
12	46.7 (11)	75.4
24	97.6 (09)	132.6
36	165.9 (07)	190.2
48	236.5 (05)	253.6
60	317.1 (03)	308.9

Due to short life of the system forecast could not be issued 72 hrs in advance or beyond.

**Table 7. Operational Track Forecast Skill (%)**

Lead period (hrs)	Track forecast skill	Long period skill (2008-2012)
12	37.7	23.1
24	36.6	34.8

36	24.3	35.1
48	14.5	41.8
60	6.4	47.4

The track forecast skill was about 37% and 15% for 24 and 48 hrs forecast respectively (Table 7).

**(b) Landfall forecast error**

The landfall point forecast errors were 16,12, and 129 km respectively for 12, 24, and 36 hrs respectively before landfall (Table 8). The landfall time error was within  $\pm 3$  hrs for the same period.

<b>Table.8. Operational Landfall forecast errors of IMD for SCS 'HELEN'</b>				
Lead Period	Landfall point and time forecast error (Difference of forecast landfall point and time and actual landfall point and time)			
	Landfall point Error (km)	Landfall Time Error (hrs)	Long period average landfall point error(km) during 2008-12	Long period average landfall time error(hrs) during 2008-12
12	16	+ ½	41.6	2.5
24	12	+3 ½	90.8	5.5
36	129	-2 ½	102.7	8.5
48	188	-7 ½	95.8	7.3
60	184	-8 ½	67.7	2.2

**(c) Intensity forecast error**

The intensity forecast errors (average absolute error (AAE) and root mean square error (RMSE)) of IMD for severe cyclonic storm, Helen are shown in Table 9. The AAE was about 3, 4 & 9 knots against the long period average of 7,10 & 13 knots based on the period of 2008-2012 for 12, 24 & 36 hr forecasts. The RMSE was about 4,9 and 14 knots against the long period average of 10,13 and 16 knots for the same period.

<b>Table.9. Operational average intensity forecast error of IMD of ‘Helen’</b>				
Lead Period	Intensity Forecast Error (knots)		Long period Average (2008-2012):Absolute Error (knots)	Long period Average (2008-2012): RMS Error (knots)
	Absolute error	Root mean square error		
12	2.8 (11)	3.9	7.3	9.9
24	4.0 (09)	9.0	10.4	13.5
36	9.5 (07)	14.0	12.7	16.1
48	12.8 (05)	15.0	13.4	17.8
60	12.6 (03)	16.8	13.4	15.3

**Table 10. Operational Intensity Forecast skill (%)**

Lead period (hrs)	Skill in term of Absolute Error (%)	Skill in term of RMS Error (%)
12	70.5	70.5
24	72.2	51.3
36	60.9	54.1
48	57.3	62.2
60	58.0	58.7

**(d) Heavy Rainfall Warning**

The heavy rainfall warning issued by IMD alongwith the actual heavy rainfall is given in Table 11.

<b>Table 11: Heavy rainfall warning and realised rainfall due to SCS HELENq</b>		
Date & time	Warning issued : Heavy rainfall	24 hr heavy rainfall realised at 0300UTC of
19/11/2013 0300 UTC	Isolated heavy to very heavy rainfall would occur over coastal Andhra Pradesh and north coastal Tamil Nadu commencing from 20 <sup>st</sup> November 2013 night.	<b>21<sup>st</sup> November Isolated heavy rainfall-</b> Tamil Nadu & Puducherry  <b>22<sup>nd</sup> November Isolated heavy rainfall</b> – Coastal Andhra
20/11/2013 0300 UTC	Isolated extremely heavy falls ( 25cm or more) would occur over south coastal Andhra Pradesh on 21 <sup>st</sup> and 22 <sup>nd</sup> November. Isolated heavy to very heavy falls would occur over Rayalseema and adjoining north Tamil Nadu on 22 <sup>nd</sup> November.	

21/11/2013 0300 UTC	Heavy to very heavy rainfall at a few places and isolated extremely heavy rainfall ( 25cm or more) would occur over coastal Andhra Pradesh during next 48 hrs commencing from 21 <sup>st</sup> November 2013 night. Isolated heavy to very heavy falls would occur over Rayalseema and Telangana on 22 <sup>nd</sup> and 23 <sup>rd</sup> November.	Pradesh, Tamil Nadu & Puducherry and Kerala  <b>23<sup>rd</sup> November Isolated Heavy to very heavy rainfall - Coastal Andhra Pradesh</b>
22/11/2013 0300 UTC	Heavy to very heavy rainfall at a few places and isolated extremely heavy rainfall (25cm or more) would occur over north coastal Andhra Pradesh and adjoining Guntur, Krishna, West Godavari districts of south coastal Andhra Pradesh during next 36 hrs. Isolated heavy to very heavy falls would occur over remaining districts of south coastal Andhra Pradesh, Rayalseema and isolated heavy to very heavy falls over Telangana during next 48 hrs.	<b>24<sup>th</sup> November Heavy to very heavy rainfall-</b> Tamil Nadu & Pudicherry and South interior Karnataka <b>Isolated heavy rainfall-</b> Telengana, coastal Karnataka & Kerala

**(e) Gale Wind Warning**

The gale wind forecast alongwith actual wind are presented in table 12.

Table 12: Gale wind warning and realised wind due to SCS <del>HELEN</del> q		
Date & Time of Issue	Wind forecast issued	Actual wind (kmph)
19.11.2013 0300 UTC	45-55 kmph gusting to 65 kmph along and off Andhra Pradesh coast commencing from 21 <sup>st</sup> November 2013.	80 . 90 kmph gusting to 100 kmph at the time of landfall along the coastal districts nearer to landfall point.
19.11.2013 0600 UTC	45-55 kmph gusting to 65 kmph along and off Andhra Pradesh coast commencing from 21 <sup>st</sup> November 2013.	
19.11.2013 1500 UTC	55-65 kmph gusting to 75 kmph along and off Andhra Pradesh coast commencing from 20 <sup>st</sup> November 2013. It would gradually increase to 80-90 gusting to 100 kmph at the time of landfall.	
20.11.2013 0300 UTC	55-65 kmph gusting to 75 kmph along and off Andhra Pradesh coast commencing from 20 <sup>st</sup> November 2013. It would gradually increase to 100-110 gusting to 120 kmph at the time of landfall	
21.11.2013 0300 UTC	55-65 kmph gusting to 75 kmph along and off Andhra Pradesh coast commencing from 21 <sup>st</sup> November 2013. It would gradually increase to 100-110 gusting to 120 kmph at the time of landfall over Guntur, Krishna, east and west Godavari districts.	



	45-55 kmph gusting to 65 kmph along and off remaining parts of Andhra Pradesh coasts commencing from 21 <sup>st</sup> evening and reach upto 60-70 kmph at the time of landfall.
22.11.2013 0300 UTC	Gale winds speed reaching 100-110, gusting to 120 kmph over Prakasham, Guntur, Krishna, east & west Godavari & Vishakhapatnam districts. Squally winds speed reaching 55-65 kmph gusting to 75 kmph would prevail along and off Andhra Pradesh coasts.

(f) **Storm surge forecast.**

Table 13: Storm surge warning and realised surge due to SCS HELENq		
20.11.2013 0600 UTC	Storm Surge of about 1 to 1.5 mt. height above astronomical tide near low lying areas of Andhra Pradesh at the time of landfall	No storm surge report has been received.
20.11.2013 0600 UTC	Storm Surge of about 1 to 1.5 mt. height above astronomical tide near low lying areas of Andhra Pradesh at the time of landfall	
22.11.2013	No warning	
23.11.2013	No warning	

### Damage Report:

The cyclone, Helen caused considerable damage over coastal Andhra Pradesh, especially over Krishna, west & east Godavari districts. It uprooted trees and electrical poles and damaged crops (paddy, banana & coconut etc). The typical damage photographs are shown in Fig. 5. Number of human death was 11 due to this system.



Fig.5. Damage over Machilipatnam and Koduru due to SCS Helen.