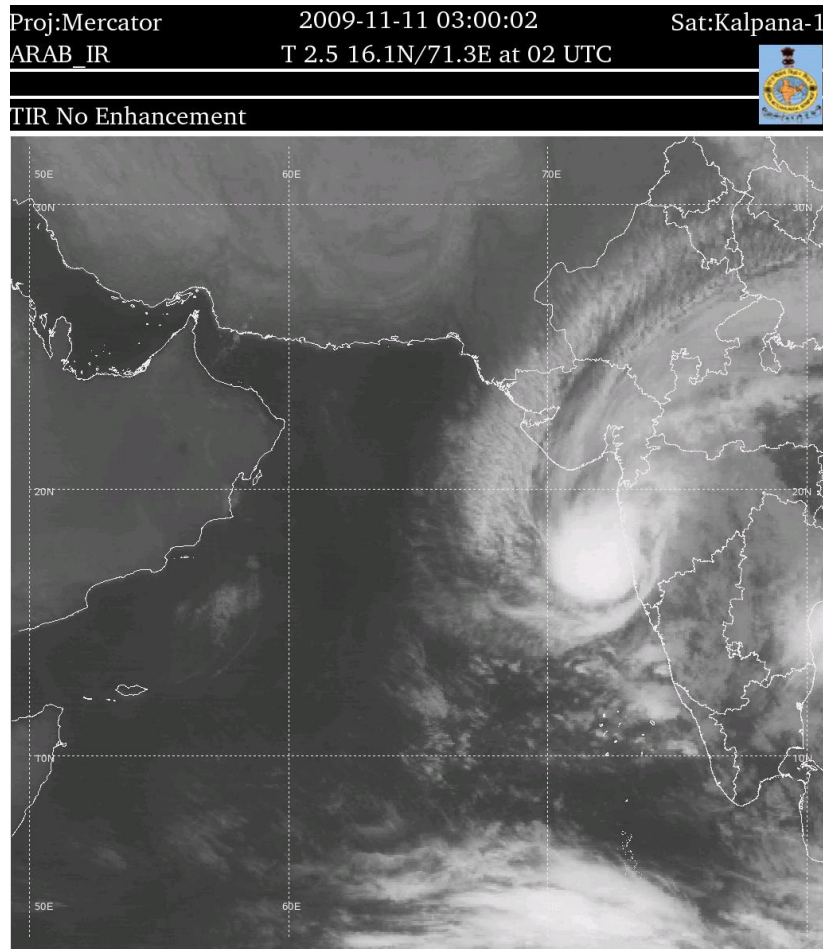


# Cyclone, 'Phyan' : A Preliminary Report



**Regional Specialised Meteorological Centre-  
Tropical Cyclone, New Delhi  
India Meteorological Department,  
Mausam Bhavan, Lodi Road, New Delhi-110003**

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## Introduction

A cyclonic storm, '**Phyan**' crossed Maharashtra coast between Alibag and Mumbai between 1530 and 1630 hrs IST of 11<sup>th</sup> November, 2009. It caused loss of seven human lives and about 44 fishermen are missing, according to Newspaper reports. The main features of this cyclone are as follows.

- (i) Cyclone, 'Phyan' moved very fast prior to landfall. It moved about 450 km during 0530 to 1730 hrs IST of 11<sup>th</sup> November 2009.
- (ii) Though it crossed as a cyclonic storm, it slightly weakened before the landfall.

The brief history of the cyclone, '**Phyan**', satellite observation, realized weather, associated damages and performance of Numerical Weather Prediction (NWP) models are described below.

## Brief History of Cyclone

In association with active northeast monsoon surge, a low pressure area formed over Comorin area on 7<sup>th</sup> November, 2009. It became well marked over Lakshadweep area on 8<sup>th</sup>. It concentrated in to a depression and lay centred at 1430 hrs IST of 9<sup>th</sup> November, 2009 over southeast and adjoining east central Arabian Sea near lat. 11.0<sup>0</sup>N and long. 72.0<sup>0</sup>E, about 70 km west of Amini Divi. It moved initially in a north-northwesterly direction till 10<sup>th</sup> morning and then recurved north-northeastwards. The track of the system is shown in Fig.1. It intensified into a deep depression at 0830 hrs IST and into a cyclonic storm '**Phyan**' at 2330 hrs IST of 10<sup>th</sup> November, 2009. Continuing its north-northeastward movement, the cyclonic storm '**Phyan**' crossed north Maharashtra coast between Alibag and Mumbai between 1530 and 1630 hrs IST of 11<sup>th</sup> November. It moved then northeastwards and weakened into a deep depression and lay centred at 1730 hrs of 11<sup>th</sup> November, 2009 over north Konkan, about 100 km northeast of Mumbai. It further weakened into a depression and lay centred at 2330 hrs IST of 11<sup>th</sup> over Madhya Maharashtra,

near Nasik. It weakened into a well marked low pressure area over north Madhya Maharashtra and neighbourhood at 0530 hrs IST of 12<sup>th</sup> November 2009. The cyclone, 'Phyan' moved faster before crossing the coast. It moved about 450 km in 12 hours between 0530 and 1730 hrs IST of 11<sup>th</sup> November, 2009.

**Table 1. Best track Positions and other parameters for cyclonic storm PHYAN over the Arabian Sea during 09-12 November 2009**

Date	Time (UTC)	Centre lat. <sup>o</sup> N/ long. <sup>o</sup> E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Pressure drop at the Centre (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Grade	
9-11-2009	0900	11.0/72.0	1.5	1000	4	25	D	
	1200	11.5/71.5	1.5	1000	4	25	D	
	1800	12.0/71.0	1.5	1000	4	25	D	
10-11-2009	0000	12.5/70.5	1.5	998	4	25	D	
	0300	13.0/70.5	2.0	998	5	30	DD	
	0600	13.5/70.5	2.0	998	5	30	DD	
	1200	14.5/71.0	2.0	996	5	30	DD	
	1800	15.0/71.0	2.5	996	6	35	CS	
	2100	15.5/71.5	2.5	994	6	35	CS	
11-11-2009	0000	16.0/71.5	2.5	992	8	40	CS	
	0300	17.0/72.0	3.0	990	10	45	CS	
	0600	17.5/72.5	3.0	988	12	45	CS	
	0900	19.0/73.0	2.5	992	8	40	CS	
		The cyclonic storm "PHYAN" crossed Maharashtra coast between Alibag and Mumbai between 1000 & 1100 UTC of 11 <sup>th</sup> November, 2009.						
	1200	19.5/73.5	--	996	5	30	DD	
	1500	20.0/74.0	--	998	5	30	DD	
	1800	20.0/74.0	--	1000	4	20	D	
12-11-2009	0000	The system weakened into a well marked low pressure area over north Madhya Maharashtra						

D : Depression,  
 DD : Deep depression  
 CS : Cyclonic Storm

The best track data of the system are shown in Table 1. The estimated central pressure (ECP) of the system fell from 1000 hPa at 1430 hrs IST of 9<sup>th</sup> to 988 hPa at 1130 hrs IST of 11<sup>th</sup>. Considering the coastal observations, the lowest pressure of 987.9 hPa was reported by Harnai at 1030 hrs IST of 11<sup>th</sup>, when the system was located at about 50 km southwest of Harnai. The sustained maximum wind at surface is estimated to be about 45 knots for a temporary period during 11<sup>th</sup> morning. Though the maximum intensity of the system is T 2.5 according to Dvorak's technique, the coastal observations indicate that it may be T 3.0 during this period.

The sustained maximum surface wind decreased after 1130 hrs IST and it may be 40 knots at the time of landfall, which is supported by actual observations.

### **Satellite observations**

The satellite imageries of the system at different stages of intensity are shown in Fig.2. In association with deep convective cloud clusters, a low level circulation (LLC) developed over Gulf of Mannar and neighbourhood on 3<sup>rd</sup>. It lay over Comorin area and neighbourhood on 4<sup>th</sup>. It persisted over the same region and gradually organised during 4<sup>th</sup> to 7<sup>th</sup>. It became a vortex with T 1.0 at 0530 hr IST of 7<sup>th</sup> according to Dvorak's technique. It further organized while moving northwestward and curved band features appeared at 1430 hrs IST of 9<sup>th</sup> when the system was located over Lakshadweep area. Hence, the intensity of the system at 1430 hrs IST of 09<sup>th</sup> was upgraded to T1.5 corresponding to depression. From 10<sup>th</sup> onwards, the system moved nearly northward till 0430 hrs IST of 11<sup>th</sup>. It then moved north-northeastward. It intensified with T 2.0 corresponding to deep depression at 0830 hrs IST and to T 2.5 at 2130 hrs IST of 10<sup>th</sup> corresponding to cyclonic storm. The curved band pattern of the cyclone was replaced with central dense over cast (CDO) pattern in the early morning of 11<sup>th</sup>. However, the system slightly weakened from 1130 hr IST of 11<sup>th</sup> as it came close to the coast due to northeastward movement. The CDO pattern disorganised and curved band pattern reappeared. It made landfall with intensity of T 2.5. Further, the northeastward outflow from the system increased on 11<sup>th</sup> with cirrus clouds extending upto Chhattisgarh.

### **Environmental features**

The environmental features like sea surface temperature, vertical wind shear of horizontal wind, mid-tropospheric humidity, low level convergence, upper level divergence and coriolis force were favourable for cyclogenesis over the southeast Arabian Sea on 9<sup>th</sup>. The sea surface temperature was about 28-30 deg. C over southeast and east central Arabian Sea. The vertical wind shear of horizontal wind was low to moderate (10-20 knots) at 0830 hrs IST of 9<sup>th</sup>. In addition, the Madden Julian Oscillation was also favourable, as its active phase lay over west equatorial

Indian Ocean adjoining Arabian Sea region during the period of cyclone leading to enhanced and persistent convection required for cyclogenesis and intensification.

The system lay to the south of the upper tropospheric ridge at the time of cyclogenesis on 9<sup>th</sup>, as the ridge roughly ran along 14<sup>0</sup>N on 9<sup>th</sup>. However, the system came closer to the ridge position on 10<sup>th</sup> and lay to the north of the ridge position on 11<sup>th</sup> morning leading to acceleration of the system in northeasterly direction.

The vertical wind shear increased to become moderate to high, (15-25 knots) on 10<sup>th</sup> and similar condition prevailed on 11<sup>th</sup> (20-25 knots). However, the system still intensified till 1130 hrs IST of 11<sup>th</sup>. It may be due to large Ocean heat content in the thermo cline layer in association with the higher sea surface temperature (28-30<sup>0</sup> C) over southeast and east central Arabian Sea. This aspect needs further study. The slight weakening of the system before landfall may be attributed to impact of orographic interaction, which needs also further examination

## **Realised weather**

### **Rainfall**

Widespread rainfall with isolated heavy to very heavy falls occurred over Goa, Konkan and Madhya Maharashtra on 10<sup>th</sup> and 11<sup>th</sup>. Fairly widespread rainfall also occurred over south Gujarat region due to the cyclone on 11<sup>th</sup>. Chief amounts of rainfall (5cm and above) recorded at 0830 hrs IST of 11<sup>th</sup> and 12<sup>th</sup> November over Maharashtra and Goa are given below.

**11. 11. 2009**

<b><u>State</u></b>	<b><u>Stations</u></b>
<b>Goa:</b>	Canacona and Marmagao -8 each, Dabolim-7, Panjim-6, Mapusa and Margaon - 5 each.
<b>Maharashtra</b>	Pune Airport (Lohegaon) -13; Mahabaleshwar, Bhore, Paud, Vadgaon Maval -10 each; Wai, Pune city -9 each; Ghodegaon-8;

Chandwad, Satara, Uran, Islampur, Akola -7 each; Shirur, kandalbavda, Karad, Kelvan, Pernem, Dodamarg, chandgad,- 6 each; Shahuwad, Sasvad, Velhe, Rajgurunagar, Shirala, Sinner, Shrigonda, Ajra, Khed - 5.

**12-11-2009:**

**Maharashtra :** Chandwad – 17; Akola-14; Nandgaon, Sinnar, Yeola -13 each; Ghodegaon – 12; Mahabaleshwar, Mandangad -11 each, Kopargaon, Sudhagad-10 each; Chiplun, Malegaon, Mhasla, Chopda, Edalabad, Erandol, Pachora, Harnai, Kalvan, Khandala, Paud – 9 each; Shrirampur, Shirpur, Vadgaon Maval – 8 each; Bahadgaon, Shriwardhan, Niphad, Soegaon, Kalvan – 7 each; Mangaon, Poldpur, Vijapur, Igatpuri, Satna, Kankavali – 6 each; Nasik and Aurangabad, Mahad, Pen, Kannad, Khaldabad, Sillod, Jafferabad, Khed, Sasvad, Navapur, Dindori, Baramati, Sawantwadi, Kalyan, Murvad, Shahapur -5 each.

Based on 0830 hrs IST observation of 10<sup>th</sup> November (about 30 hrs in advance), IMD predicted the system to intensify into a cyclonic storm and predicted scattered heavy to very heavy falls with isolated extremely heavy falls over Konkan & Goa and Madhya Maharashtra.

**Wind:**

The maximum wind (Kmph) reported at observatory stations of IMD at the time of land fall are given below:

Pune : 68,

Goa 63,

Colaba 56.

However, according to Newspaper report, maximum surface wind was about 75 kmph along Maharashtra coast at the time of landfall.

The wind speed predicted at the time was 65--75 kmph gusting to 85 kmph along and off Maharashtra and Goa coast based on 0830 IST observation of 10<sup>th</sup>

November (30 hrs in advance). Later It predicted maximum wind speed of 70-80 kmph gusting to 90 kmph based on observation of 2330 hrs IST of 10<sup>th</sup> November 2009.

### **Storm Surge :**

Based on nomograms developed by IMD and Storm surge prediction model developed by IIT, Delhi, IMD predicted maximum storm surge of about 1 meter above the astronomical tide over Sindhudurg, Raigad, Greater Mumbai and Thane districts of Maharashtra and adjoining Valsad district of Gujarat at the time of landfall.

### **Damage:**

According to Newspaper report, the cyclone 'Phyan' caused damage to lives, crops and properties in Goa and Konkan region especially in Ratnagiri, Sindhudurg, Raigad and Thane districts. About 1000 houses in these districts suffered damages. Seven persons died and 44 are missing due to cyclone 'Phyan'.

### **Performance of Numerical Weather Prediction (NWP) models**

The NWP models including ECMWF, UKMO, T254, WRF (IITD, NCMRWF, IMD), MM5 (IMD, IAF) and QLM were used for forecast guidance during 'Phyan'. The cyclogenesis of the system could be well predicted by various NWP models. However, there were large variations in the prediction of intensity and track of the cyclone. Most of the models predicted for the system to move in a northerly/ north-northeasterly direction towards south Gujarat coast. However among the global models, ECMWF model predicted the landfall of the system close to the north of Mumbai based on the initial condition at 1730 hrs IST of 10<sup>th</sup>, which was available in the early morning of 11<sup>th</sup> November and taken into consideration for modification of track forecast. The multi-model ensemble based track prediction on 10<sup>th</sup> also suggested north-northeastward movement of the cyclone towards south Gujarat coast.

### **Conclusion:**

IMD monitored, predicted and issued warning/advisories to different Govt. and non- Govt. agencies in regular intervals with effect from 9<sup>th</sup> November afternoon.

Due to early warning, adequate response from the national and state disaster management agencies and wide publicity in media, the loss of lives and properties has been significantly less. However, the availability of Doppler Weather Radar (DWR) at Mumbai could have helped for better monitoring & prediction of cyclone 'Phyan' and the associated adverse weather. IMD is taking steps for early installation of (DWR) at Mumbai

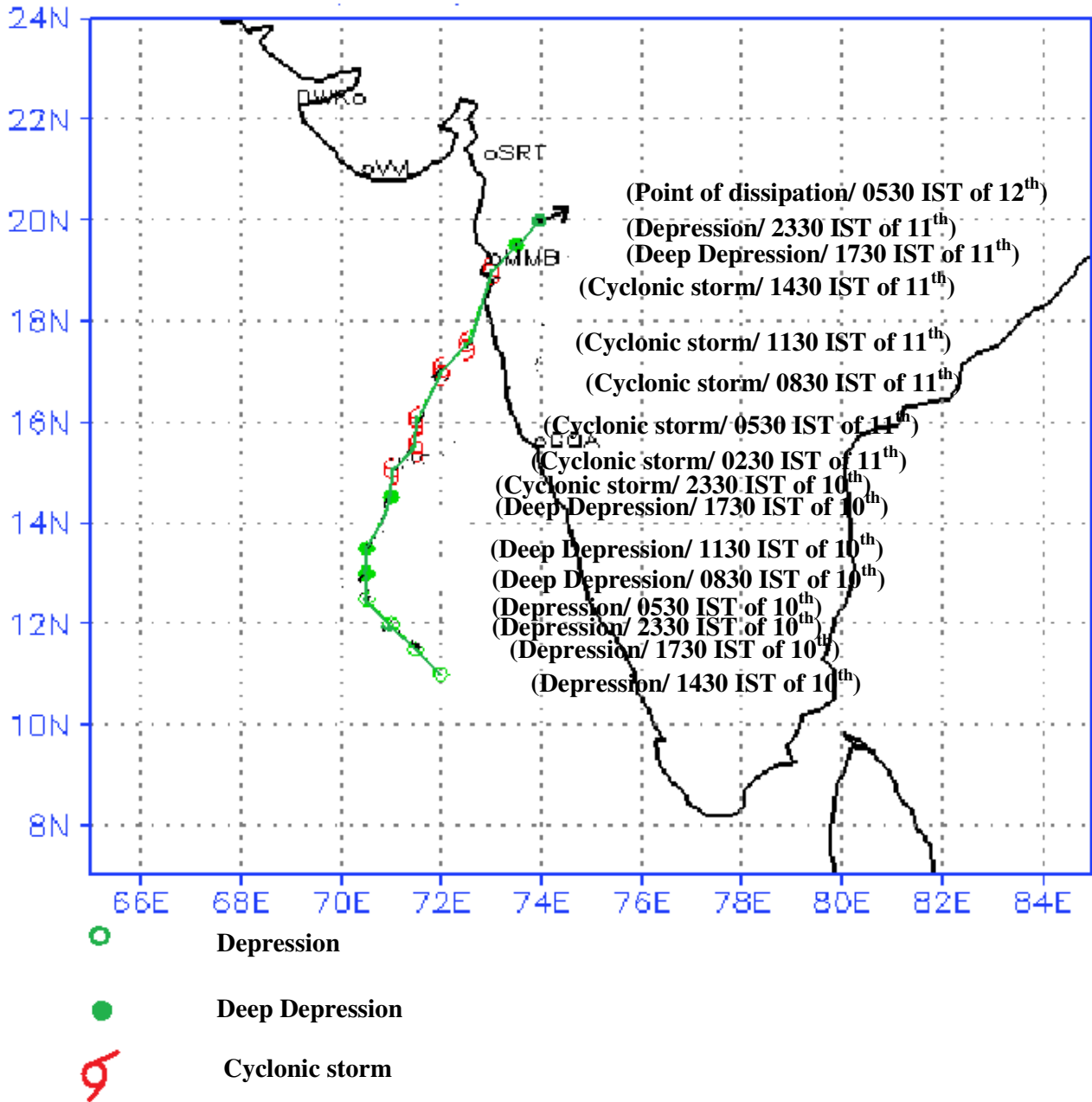
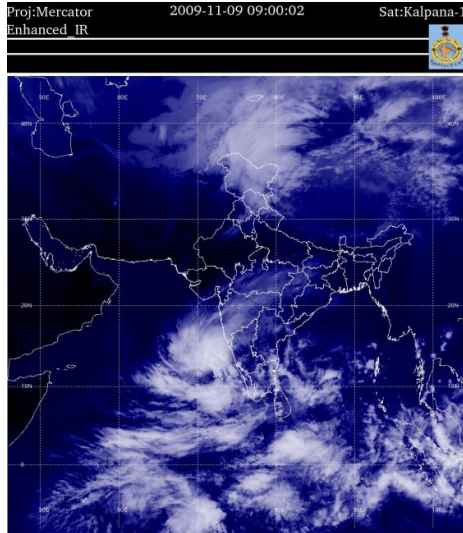
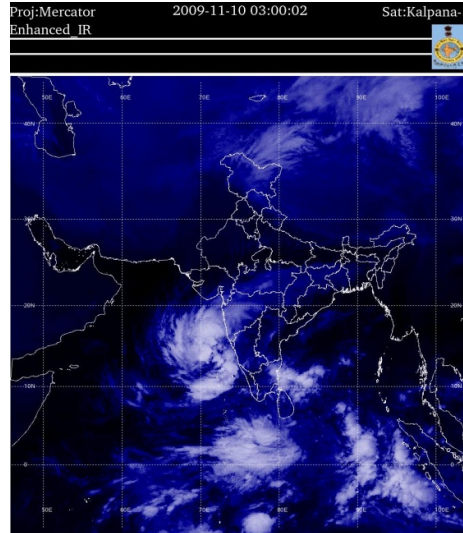


Figure 1. Track of cyclonic storm, 'Phyan' during 09-12 November 2009

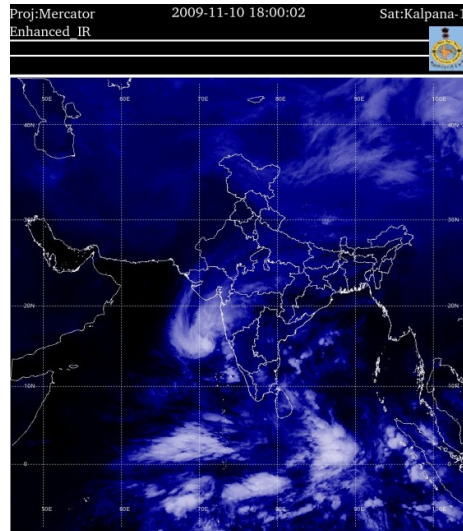
**(a) Depression**



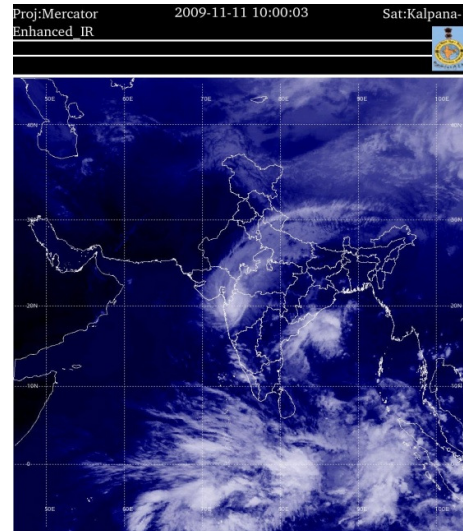
**(b) Deep Depression**



**(c) Cyclone**



**(d) Cyclone at landfall**



**Figure 2. INSAT Kalpana I imageries at different stages of intensity of cyclone, 'Phyan'**