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**TROPICAL CYCLONE OPERATIONAL PLAN
FOR THE BAY OF BENGAL AND THE ARABIAN SEA**

Edition 2017

**SECRETARIAT OF THE WORLD METEOROLOGICAL ORGANIZATION
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CHAPTER I

GENERAL

1.1 Introduction

The loss of life, property and human suffering caused by tropical cyclones in coastal areas in various parts of the globe are well known. These disasters are on occasion, particularly severe in the Bay of Bengal region. The northern part of the Bay of Bengal is known for its potential to generate dangerous high storm tides a major killer when associated with cyclonic storms. In the past, out of 10 recorded cases of very heavy loss of life (ranging from about 40,000 to well over 200,000) in the world due to tropical cyclones, 8 cases were in the Bay of Bengal and the Arabian Sea (5 in Bangladesh and 3 in India). The world's highest recorded storm tide of 45 feet occurred in this region (1876, Bakherganj cyclone near Meghna Estuary, Bangladesh). These facts amply illustrate the importance of an efficient cyclone warning service in this region. Recognizing these facts, the World Meteorological Organization (WMO) and the Economic and Social Commission for Asia and the Pacific (ESCAP) jointly established the Panel on Tropical Cyclones in 1972 as an intergovernmental body. Its membership comprises countries affected by tropical cyclones in the Bay of Bengal and the Arabian Sea. Originally its member countries were Bangladesh, India, Myanmar, Pakistan, Sri Lanka and Thailand. Later Maldives joined this Panel in 1982 followed by Sultanate of Oman in 1997 and Yemen in 2016.

The Panel is one of the five regional tropical cyclone bodies established as part of the WMO Tropical Cyclone Programme (TCP) which aims at promoting and coordinating the planning and implementation of measures to mitigate tropical cyclone disasters on a worldwide basis.

The main objective of the WMO/ESCAP Panel on Tropical Cyclones is to promote measures to improve tropical cyclone warning system in the Bay of Bengal and the Arabian Sea.

As part of this endeavour, the Panel at its twelfth session adopted a comprehensive cyclone operational plan for this region. The basic purpose of the operational plan is to facilitate the most effective tropical cyclone warning system for the region with existing facilities. In doing so the plan defines the sharing of responsibilities among Panel countries for the various segments of the system and records the coordination and cooperation achieved. The plan records the agreed arrangements for standardization of operational procedures, efficient exchange of various data related to tropical cyclone warnings, issue of cyclone advisories from a central location having the required facilities for this purpose, archival of data and issue of a tropical weather outlook for the benefit of the region.

The operational plan contains an explicit formulation of the procedures adopted in the Bay of Bengal and Arabian Sea region for the preparation, distribution and exchange of information and warnings pertaining to tropical cyclones. Experience has shown that it is of great advantage to have an explicit statement of the regional procedures to be followed in the event of a cyclone, and this document is designed to serve as a valuable source of information always available for reference by the forecaster and other users, particularly under operational conditions. Relevant information, which is not subject to regional agreement is given in the annexes to the plan.

A technical plan aiming at the development and improvement of the cyclone warning system of the region has been drawn up by the Panel. Implementation of some items under the technical plan would lead to a strengthening of the operational plan.

The operational plan is evolutionary in nature. It is intended that the text of the plan be updated or revised from time to time by the Panel and that each item of information given in the annexes to the plan be kept up to date by the member country concerned.

1.2 Terminology used in the region

1.2.1 General

Panel member countries or member countries
Zone of disturbed weather*

1.2.2 Classification of cyclonic disturbances and tropical cyclones

Cyclonic disturbance (generic term)

- (i) Low or low pressure area
- (ii) Well marked low pressure area+
- (iii) Depression or tropical depression
- (iv) Deep Depression*

Tropical cyclone (generic term)

- (v) Cyclonic storm
- (vi) Severe Cyclonic storm
- (vii) Very severe cyclonic storm
- (viii) Extremely severe cyclonic storm
- (ix) Super cyclonic storm

1.2.3 Tropical cyclone characteristics

- i) Position or location
- ii) Eye
- iii) Centre
- iv) Centre fix
- v) Central pressure
- vi) Pressure depth
- vii) Direction of movement
- viii) Speed of movement
- ix) Mean wind speed or sustained wind speed
- x) Maximum wind speed
- xi) Gust
- xii) Storm surge
- xiii) Storm tide
- xiv) Coastal inundation
- xv) Heavy rainfall

1.2.4 Terms related to the warning and warning system

- i) Name of the Tropical Cyclone
- ii) Tropical cyclone season or cyclone season
- iii) Tropical weather Outlook
- iv) Tropical cyclone advisories
- v) Satellite and Radar information
- vi) Pre-cyclone watch**
- vii) Cyclone Alert*
- viii) Cyclone Warning*
- ix) Post landfall outlook**
- x) Dewatering Message**
- xi) Visual storm signal
- xii) Squally wind and gale wind
- xiii) High sea area bulletin and Coastal weather bulletin
- xiv) Bulletin or cyclone warning bulletin for India coast
- xv) Warning graphics on observed and forecast track with cone of uncertainty
- xvi) Observed and forecast winds in four geographical quadrants
- xvii) Heavy rainfall warning graphics**
- xviii) Storm surge warning graphic

** Term used nationally in India.

* Term used nationally in Bangladesh, India and Pakistan, + Term used nationally in Bangladesh and India.

1.3 Meaning of terms used for international exchange

Average wind speed: Speed of the wind averaged over the previous 10 minutes (mean surface wind) as read from the anemogram or the 3 minutes mean determined with the non recording anemometer or estimated wind at sea by the mariners using the Beaufort scale.

Bulletin: Cyclone warning bulletin or cyclone advisory bulletin

Central pressure of a tropical cyclone: Surface pressure at the centre of the tropical cyclone as measured or estimated.

Centre fix of the tropical cyclone: The estimated location of the centre of a tropical cyclone (obtained by means other than the aircraft probing of the cyclone i.e. fixation of the centre with the help of land based and other radars, satellite and conventional observations like surface and upper air observations, ships' reports, commercial aircraft observations, etc.)

Centre of the tropical cyclone: The centre of the cloud eye or if not discernible, of the wind / pressure centre.

Coastal Inundation forecast: IMD issues the coastal inundation forecast during the warning period of the tropical cyclone based on Advanced CIRCulation (ADCIRC) model run at Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. It provides location specific combined height of storm surge and astronomical tide and area of inundation.

Confidence in the centre position: Degree of confidence in the centre position of a tropical cyclone expressed as the radius of the smallest circle within which the centre may be located by the analysis.

“Position good” implies a radius of 30 nautical miles (55 kilometers) or less,

“Position fair”, a radius of 30 to 60 nautical miles (55 to 110 km) and

“Position poor”, a radius of greater than 60 nautical miles (110 km).

Cyclone: Tropical cyclone

Cyclone Alert*: A priority message for the Government officials containing tropical cyclone information and advisories issued generally 48 hours before the commencement of adverse weather.

Cyclone warning*: A priority message containing tropical cyclone warning and advisories issued generally 24 hours in advance of the commencement of adverse weather.

Cyclone warning bulletin: A priority message for exchange of tropical cyclone information and advisories.

Cyclonic disturbance: A non-frontal synoptic scale low pressure area originating over tropical waters with organized convection and definite cyclonic wind circulation.

Cyclonic storm: A cyclonic disturbance in which the maximum average surface wind speed is in the range of 34 to 47 knots (62 to 88 km/h).

Depression*: A cyclonic disturbance in which the maximum sustained surface wind speed is between 17 and 27 knots (31 and 51 km/h). If the maximum sustained wind speed lies in the range 28 knots (52 km/h) to 33 knots (61 km/h) the system may be called a "deep depression".

Direction of movement of the tropical cyclone: The past direction and speed of movement mentioned in the bulletin is the average speed and direction during past six hours. The direction and speed mentioned in TCAC advisory bulletin is the forecast speed and direction of movement for next six hours.

Dewarning Message: As and when a given coastal belt is expected to become free from the impact of TCs, a dewarning message is issued to the ports and disaster management agencies as a part of four stage warning system.

* Term used nationally in Bangladesh, India and Pakistan.

** Predefined, based on minimum limit of rainfall during 24 hours or actual wind speed or both.

Eye of the tropical cyclone: The relatively clear and calm area inside the circular wall of convective clouds, the geometric centre of which is the centre of the tropical cyclone.

Extremely Severe Cyclonic Storm: A cyclonic disturbance in which the maximum average surface wind speed is in the range of 90 to 119 knots (167 to 221 km/h).

Gale force wind: Average surface wind speed of 34 to 47 knots (62 to 88 km/h).

GMDSS: Global Maritime Distress and Safety System.

Gust: Instantaneous peak value of surface wind speed recorded or expected.

Hurricane force wind: Average surface wind speed of 64 knots or more.

Low or low pressure area: An area enclosed by a closed isobar with minimum pressure inside when mean surface wind is less than 17 knots (31 km/h).

Maximum sustained wind: Maximum value of the average wind speed at the surface.

Mean wind speed: Average wind speed.

Name of the Tropical Cyclone: Once wind speed in a cyclonic disturbance attains a 34 knots threshold value it will be given an identification name by RSMC tropical cyclones, New Delhi from the consolidated name list.

Panel members countries or member countries : Countries constituting the WMO/ESCAP Panel on Tropical Cyclones viz. Bangladesh, India, Maldives, Myanmar, Oman (Sultanate of), Pakistan, Sri Lanka , Thailand and Yemen.

Post Landfall Outlook: This bulletin is issued 12 hours before cyclone landfall and contains more specific forecasts about place and time of landfall.

***Pre Cyclone Watch:** This bulletin contains early warning about likely development of a cyclonic storm and an indication of the coastal belt likely to experience adverse weather. A priority message for the Government officials containing information on the formation of a tropical disturbance as soon as it is detected and which is expected to affect the coast. It is issued at least 72 hours in advance of commencement of adverse weather along the coast.

Radius of Maximum Wind: It is the distance from the centre to the location of maximum sustained surface wind in association with a cyclone.

Severe cyclonic storm: A cyclonic disturbance in which the maximum average surface wind speed is in the range of 48 to 63 knots (89 to 118 km/h).

Severe cyclonic storm with a core of hurricane winds⁺: A cyclonic disturbance in which the maximum average surface wind speed is 64 knots (119 km/h) or more.

Speed of movement of the tropical cyclone: Speed of movement of the centre of the tropical cyclone.

Squally wind: When sudden increases of wind speed occur in squalls with the increased speed reaching a minimum of 22 knots (40 km/h) and persist for at least one minute.

Storm force wind: Average surface wind speed of 48 to 63 knots.

Storm season: The periods April to May and October to December during which most of the cyclonic storms occur in the Bay of Bengal and Arabian Sea.

Storm surge: The difference between the actual water level under the influence of a meteorological disturbance (storm tide) and the level, which would have been reached in the absence of the meteorological disturbance (i.e. astronomical tide). (Storm surge results mainly from the shoreward movement of water under the action of wind stress. A minor contribution is also made by the hydrostatic rise of water resulting from the lowered barometric pressure.)

Storm tide: The actual water level as influenced by a weather disturbance. The storm tide consists of the normal astronomical tide and the storm surge.

Super cyclonic storm: A cyclonic disturbance in which maximum wind speed is 120 knots and above (222 km/h and above).

Tropical cyclone: Generic term for a non frontal synoptic scale cyclone originating over tropical or subtropical waters with organized convection and definite cyclonic surface wind circulation. The term is also used for a storm in the Southwest Indian Ocean in which the maximum of the sustained wind speed[#] is estimated to be in the range of 64 to 90 knots and in the South Pacific and Southeast Indian Ocean with the maximum of the sustained wind speed over 33 knots.)

(Note: # Maximum sustained wind speed: Average period of one, three or ten minutes depending upon the regional practices.)

Tropical cyclone advisory: A priority message for exchanging information, internationally, on tropical cyclones in the north Indian Ocean including Bay of Bengal and the Arabian Sea.

Tropical depression: Depression.

Tropical storm: Tropical cyclone.

Tropical Weather Outlook: A priority message for exchange between the Panel countries of synoptic and satellite inferences for the the north Indian Ocean including Bay of Bengal and the Arabian Sea region.

Very severe cyclonic storm: A cyclonic disturbance in which maximum wind average is 64 knots to 89 knots (118 to 166 km/h).

Visual storm signals: Visual signals displayed at coastal points of the port to warn ships of squally winds, gales and tropical cyclones.

Weather warning: Meteorological message issued to provide appropriate warnings of hazardous weather conditions.

Zone of disturbed weather: A zone in which the pressure is low relative to the surrounding region and there is convective cloud masses which are not organized.

TCAC Bulletin: The tropical cyclone advisory bulletin issued every six hourly by Tropical Cyclone Advisory Centre (TCAC), New Delhi for the purpose of international civil aviation.

+ Meaning of term as used nationally in Bangladesh

1.4 Units used

1.4.1 Units used in international exchange

- (i) Distance in nautical miles and km, the unit (nm and km) being stated.
- (ii) Location (position) by degrees and where possible tenths of degrees of latitude and longitude preferably expressed by words.
- (iii) Direction to the nearest sixteen points of the compass given in words.
- (iv) Speed (wind speed and direction of movement of tropical cyclones) in knots and kilometer per hour, the unit (kt and kmph) being stated.

1.4.2 Units used in national bulletins

- (i) Distance in kilometers (km).
- (ii) Location in longitude and latitude (degrees and tenths of degrees) or bearing in sixteen points of compass and distance from two or three well known fixed place.
- (iii) Direction in sixteen points of compass.
- (iv) Speed in km/h.

CHAPTER II

TROPICAL CYCLONE WARNINGS AND ADVISORIES

2.1 General

The responsibility of warning for the human settlements on land which are threatened by a tropical cyclone rests in all cases with the National Meteorological Services (NMS). These national responsibilities are not subject to regional agreement. Therefore, the cyclone warning systems pertaining to international users and exchanges among the Panel countries are described in this chapter and the cyclone warning systems for Panel countries are described briefly in the annex to this chapter.

2.2 Classification of cyclonic disturbances followed by RSMC, New Delhi

Classifications of cyclonic disturbances for the north Indian Ocean region for the exchange of messages among the Panel countries are given below:

<u>Weather system</u>	<u>Maximum wind speed</u>
1. Low pressure area	Wind speed less than 17 kt (31 km/h)
2. Depression	Wind speed between 17 and 27 kt (31 and 49 km/h)
3. Deep Depression	Wind speed between 28 and 33 kt (50 and 61 km/h)
4. Cyclonic storm	Wind speed between 34 and 47 kt (62 and 88 km/h)
5. Severe cyclonic storm	Wind speed between 48 and 63 kt (89 and 117 km/h)
6. Very severe cyclonic storm	Wind speed between 64 and 89 kt (118 and 166 km/h)
7. Extremely severe cyclonic storm	Wind speed between 90 and 119 kt (167 and 221 km/h)
8. Super cyclonic storm	Wind speed 120 kt (222 km/h) and above

2.3 Identification of tropical cyclones

As soon as wind speed in a cyclonic disturbance attains a 34 kt threshold value, it will be given an identification name by RSMC tropical cyclones, New Delhi from the consolidated name list (**Table II-1**). The identification system will cover the whole north Indian Ocean.

If the life of a cyclonic disturbance spans two calendar years it will be accounted for in the year in which it has intensified to the stage where the wind speed has attained the 34 kt threshold value.

TABLE II- 1

Table.1 : Table for naming tropical cyclones for the Bay of Bengal and Arabian Sea

Panel Member	Column one		Column two		Column three		Column four	
	Names	Pron'	Names	Pron'	Names	Pron'	Names	Pron'
<u>B'desh</u>	Onil	Onil	Ogni	Og-ni	Nisha	Ni-sha	Giri	Gi-ri
India	Agni	Ag'ni	Akash	Aakaa'sh	Bijli	Bij'li	Jal	Jal
Maldives	Hibaru	--	Gonu	--	Aila	--	Keila	--
Myanmar	Pyarr	Pyarr	Yemyin	Ye-myin	Phyan	Phyan	Thane	Thane
Oman	Baaz	Ba-az	Sidr	Sidr'	Ward	War'd	Murjan	Mur'jaan
Pakistan	Fanoos	Fanoos	Nargis	Nar gis	Laila	Lai la	Nilam	Ni lam
Sri Lanka	Mala	--	Rashmi	Rash'mi	Bandu	--	Viyaru	Viyaru
Thailand	Mukda	Muuk-dar	Khai Muk	Ki-muuk	Phet	Pet	Phailin	Pi-lin

Panel Member	Column five		Column six		Column seven		Column eight	
	Names	Pron'	Names	Pron'	Names	Pron'	Names	Pron'
<u>B'desh</u>	Helen	Helen	Chapala	Cho-po-la	Ockhi	Ok-khi	Fani	Foni
India	Lehar	Le'har	Megh	Me'gh	Sagar	Saa'gar	Vayu	Vaa'yu
Maldives	Madi	--	Roanu	--	Mekunu	--	Hikaa	--
Myanmar	Nanauk	Na-nauk	Kyant	Kyant	Daye	Da-ye	Kyarr	Kyarr
Oman	Hudhud	Hud'hud	Nada	N'nada	Luban	L'luban	Maha	M'maha
Pakistan	Nilofar	Ni lofar	Vardah	Var dah	Titli	Titli	Bulbul	Bul bul
Sri Lanka	Ashobaa	Ashobaa	Maarutha	Maarutha	Gaja	Gaja	Pawan	Pavan
Thailand	Komen	Goh-men	Mora	Moh-rar	Phethai	Pay-ti	Amphan	Um-pun

The names already used from the list till September, 2017 are shown in red colour

2.4 Bulletins issued by RSMC, New Delhi

2.4.1 Tropical Weather Outlook

The tropical weather outlook will be prepared once daily by RSMC tropical cyclones, New Delhi throughout the year. It will be transmitted on the GTS at 06 UTC every day. The outlook covering the North Indian Ocean indicates possible development of tropical depressions over the sea. The probability of cyclogenesis (formation of depression) is given for the day 1, day 2 and day 3 over the Bay of Bengal and Arabian Sea respectively. The terms used are (i) NIL (0%), LOW (1-25%), FAIR (26-50%), MODERATE (51-75%) and HIGH (76-100%). An example of this bulletin is given below. It includes the description of convective clouds over region and the satellite imagery of the day in addition to above. An additional Tropical Weather outlook will be

transmitted again on the GTS at 1500 UTC based on 1200 UTC observations when a depression is located over the north Indian Ocean region. The additional bulletin will be issued as and when felt necessary by RSMC, New Delhi

Examples-1 (Tropical Weather Outlook)

**REGIONAL SPECIALISED METEOROLOGICAL CENTRE-TROPICAL CYCLONES, NEW DELHI
TROPICAL WEATHER OUTLOOK**

DEMS-RSMC TROPICAL CYCLONES NEW DELHI DATED 06.12.2016

TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 72 HOURS ISSUED AT 0600 UTC OF 06.12.2016 BASED ON 0300 UTC OF 06.12.2016.

BAY OF BENGAL & ANDAMAN SEA:-

THE WELL MARKED LOW PRESSURE AREA OVER SOUTH ANDAMAN SEA AND ADJOINING SOUTHEAST BAY OF BENGAL, NOW LIES OVER SOUTHEAST BAY OF BENGAL AND ADJOINING SOUTH ANDAMAN SEA. THE ASSOCIATED UPPER AIR CYCLONIC CIRCULATION EXTENDS UPTO MIDTROPOSPHERIC LEVELS. IT IS VERY LIKELY TO CONCENTRATE INTO A DEPRESSION DURING NEXT 24 HOURS AND INTO A DEEP DEPRESSION DURING SUBSEQUENT 24 HOURS.

ACCORDING TO SATELLITE IMAGERY, THE VORTEX OVER SOUTH ANDAMAN SEA ADJOINING SE BAY LAY CENTRED AT 0300 UTC OF TODAY, THE 6TH DECEMBER 2016 WITHIN HALF A DEGREE OF LATITUDE 7.7° N AND LONGITUDE 92.0° E. INTENSITY T1.0. MINIMUM CLOUD TOP TEMPERATURE (CTT) MINUS 83 DEG C. ASSTD BKN LOW/MED CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION LIES OVER SOUTH ANDAMAN SEA AND ADJOINING SOUTHEAST BAY. THE ASSOCIATED MAXIMUM SUSTAINED WIND SPEED IS ABOUT 20-25 KNOTS. THE ESTIMATED CENTRAL PRESSURE IS 1005 HPA. THE SEA SURFACE TEMPERATURE (SST) IS AROUND 28-29°C. THE SST DECREASES TOWARDS NORTHWEST AND WEST CENTRAL BAY OF BENGAL BECOMING 26-27°C NEAR NORTH ANDHRA PRADESH, ODISHA, WEST BENGAL AND BANGLADESH COAST. THE OCEAN HEAT CONTENT IS ABOUT 100-120 KJ/CM² OVER THE WELL MARKED LOW PRESSURE AREA AND GRADUALLY DECREASES TOWARDS NORTHWEST, BECOMING LESS THAN 50 KJ/CM² NEAR, ODISHA, ADJOINING NORTH ANDHRA PRADESH, WEST BENGAL AND BANGLADESH COAST. THE LOW LEVEL CONVERGENCE IS ABOUT 20X10⁻⁵ SECOND⁻¹. THE UPPER LEVEL DIVERGENCE IS AROUND 30X10⁻⁵ SECOND⁻¹ AND THE LOW LEVEL RELATIVE VORTICITY IS ABOUT 100X10⁻⁶ SECOND⁻¹ TO THE SOUTHWEST OF THE SYSTEM. THE VERTICAL WIND SHEAR OF HORIZONTAL WIND IS MODERATE (5-15 KNOTS) AROUND THE SYSTEM CENTRE AND INCREASES TOWARDS NORTHWEST AND WESTCENTRAL BAY OF BENGAL. THE MADDEN JULIAN OSCILLATION INDEX LIES IN PHASE 2 WITH AMPLITUDE <1. IT WILL CONTINUE IN PHASE 2 FOR NEXT 3-4 DAYS WITH INCREASING AMPLITUDE. IT IS FAVOURABLE FOR GENESIS OF DEPRESSION OVER BAY OF BENGAL. ALL THE ABOVE ENVIRONMENTAL PARAMETERS ARE FAVOURABLE FOR GENESIS OF DEPRESSION. THE UPPER TROPOSPHERIC RIDGE LIES ALONG 13°N AND HENCE THE EAST-SOUTHEASTERLY WINDS PREVAIL OVER THE REGION OF LOW PRESSURE AREA IN MIDDLE AND UPPER TROPOSPHERIC LEVELS. IT WOULD STEER THE LOW, WEST-NORTHWESTWARDS INITIALLY AND THEN NORTHWESTWARDS. MAJORITY OF MODELS SUGGEST INTENSIFICATION INTO A DEPRESSION DURING NEXT 24 HRS AND FURTHER INTENSIFICATION INTO A CYCLONIC STORM IN SUBSEQUENT 48 HRS. DYNAMICAL STATISTICAL MODEL OF IMD ALSO SUGGESTS INTENSIFICATION INTO A CYCLONIC STORM DURING NEXT 48 HRS. MODELS ALSO SUGGEST INITIAL WEST-NORTHWEST AND THEN NORTHWESTWARD MOVEMENT.

PROBABILITY OF CYCLOGENESIS DURING NEXT 72 HRS:

24 HOURS	24-48 HOURS	48-72 HOURS
HIGH	HIGH	HIGH

ARABIAN SEA:-

SCATTERED LOW/MEDIUM CLOUDS WITH EMBEDDED MODERATE TO INTENSE CONVECTION LIES OVER SE ARABIAN SEA OFF KERALA COAST SCATTERED LOW/MEDIUM CLOUDS WITH EMBEDDED ISOLATED WEAK TO MODERATE CONVECTION OVER REST EASTCENTRAL ARABIAN SEA.

PROBABILITY OF CYCLOGENESIS DURING NEXT 72 HRS:

24 HOURS	24-48 HOURS	48-72 HOURS
NIL	NIL	NIL

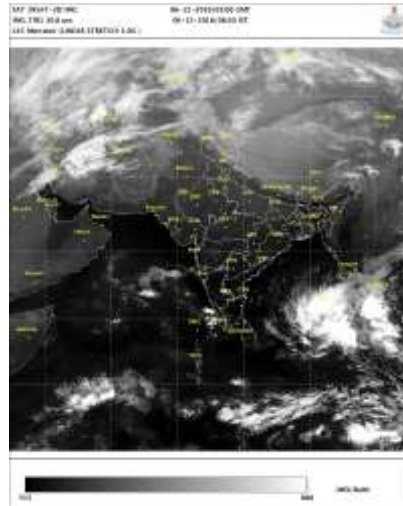


Fig. II-1: Typical Satellite imagery based on 0300 UTC of 6th December 2016

2.4.2 Special Tropical weather outlook

The special tropical weather outlook issued in association with the depression will provide brief descriptions of tropical depressions affecting the area. It will give the location, intensity and movement of the system as well as a general statement of land areas coming under threat. It will also contain description of the convective clouds in satellite imageries and diagnostic & prognostic features of the system. It is issued twice a day based on 0300 and 1200 UTC observations. When the depression intensifies into a deep depression, the special tropical weather outlook issued five times a day based on 0000, 0300, 0600, 1200 and 1800 UTC observations will in addition contain the 120 hrs forecast track and intensity of the system in a tabular form. These track and intensity forecasts are issued for +6, +12, +18, +24, +36, +48, +60, +72, +84, +96, +108 and +120 hrs since May 2013.

When a system reaches the cyclonic storm stage (wind speed 34 kt), RSMC tropical cyclones, New Delhi will issue cyclonic storm advisories.

Examples-2: (Special Tropical Weather Outlook in association with a depression)

SPECIAL TROPICAL WEATHER OUTLOOK

DEMS-RSMC TROPICAL CYCLONES NEW DELHI DATED 06.12.2016

SPECIAL TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 72 HOURS ISSUED AT 1200 UTC OF 06.12.2016 BASED ON 0900 UTC OF 06.12.2016.

LATEST SATELLITE IMAGERY AND OBSERVATIONS INDICATE THAT THE WELL MARKED LOW PRESSURE AREA OVER SOUTHEAST BAY OF BENGAL AND ADJOINING SOUTH ANDAMAN SEA CONCENTRATED INTO A DEPRESSION AND LAY CENTRED AT 0900 UTC OF TODAY, THE 6TH DECEMBER 2016 OVER SOUTHEAST BAY OF BENGAL NEAR LATITUDE 8.5°N AND LONGITUDE 91.0°E, ABOUT 1320 KM SOUTH-SOUTHEAST OF VISHAKHAPATNAM (43149), 1360 KM SOUTH-SOUTHEAST OF GOPALPUR (43049) AND 210 KM WEST-SOUTHWEST OF CAR NICOBAR (43368). IT IS VERY LIKELY TO MOVE INITIALLY WEST-NORTHWESTWARDS AND THEN NORTHWESTWARDS DURING NEXT 72 HRS. IT IS VERY LIKELY TO INTENSIFY INTO A DEEP DEPRESSION DURING NEXT 24 HRS AND INTO A CYCLONIC STORM IN SUBSEQUENT 24 HRS.

ACCORDING TO SATELLITE IMAGERY, INTENSITY IS T1.5. MINIMUM CLOUD TOP TEMPERATURE (CTT) IS MINUS 85 DEG C. ASSOCIATED BROKEN LOW/MED CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION LIES OVER ANDAMAN & NICOBAR ISLANDS AND ADJOINING ANDAMAN SEA & SOUTHEAST BAY. THE ASSOCIATED MAXIMUM SUSTAINED WIND SPEED IS ABOUT 25 KNOTS GUSTING TO 35 KNOTS. THE ESTIMATED CENTRAL PRESSURE IS 1002 HPA. SEA CONDITION IS

ROUGH TO VERY ROUGH AROUND SYSTEM CENTRE. THE SHIP LOCATED NEAR LATITUDE 6.3° N AND LONGITUDE 88.2° E REPORTED MEAN SEA LEVEL PRESSURE (MSLP) OF 1006.4 HPA AND MAXIMUM SUSTAINED WIND (MSW) OF 310/18 KNOTS.

THE SEA SURFACE TEMPERATURE (SST) IS AROUND 28-29°C. THE SST DECREASES TOWARDS NORTHWEST AND WEST CENTRAL BAY OF BENGAL BECOMING 26-27°C NEAR NORTH ANDHRA PRADESH, ODISHA, WEST BENGAL AND BANGLADESH COAST. THE OCEAN HEAT CONTENT IS ABOUT 100-120 KJ/CM² OVER THE DEPRESSION AND GRADUALLY DECREASES TOWARDS NORTHWEST, BECOMING LESS THAN 50 KJ/CM² NEAR, ODISHA, ADJOINING NORTH ANDHRA PRADESH, WEST BENGAL AND BANGLADESH COAST. THE LOW LEVEL CONVERGENCE IS ABOUT 20X10⁻⁵ SECOND⁻¹ TO THE NORTHEAST, THE UPPER LEVEL DIVERGENCE IS AROUND 40X10⁻⁵ SECOND⁻¹ TO THE NORTHEAST AND THE LOW LEVEL RELATIVE VORTICITY IS ABOUT 120X10⁻⁶ SECOND⁻¹ AROUND THE SYSTEM CENTRE. THE VERTICAL WIND SHEAR OF HORIZONTAL WIND IS MODERATE (10-20 KNOTS) AROUND THE SYSTEM CENTRE AND INCREASES TOWARDS NORTHWEST AND WESTCENTRAL BAY OF BENGAL. THE MADDEN JULIAN OSCILLATION INDEX LIES IN PHASE 2 WITH AMPLITUDE <1. IT WILL CONTINUE IN PHASE 2 FOR NEXT 3-4 DAYS WITH INCREASING AMPLITUDE. ALL THE ABOVE ENVIRONMENTAL PARAMETERS ARE FAVOURABLE FOR INTENSIFICATION OF SYSTEM. THE UPPER TROPOSPHERIC RIDGE LIES ALONG 13°N AND HENCE THE EAST-SOUTHEASTERLY WINDS PREVAIL OVER THE REGION OF DEPRESSION IN MIDDLE AND UPPER TROPOSPHERIC LEVELS. IT WOULD STEER THE SYSTEM, WEST-NORTHWESTWARDS INITIALLY AND THEN NORTHWESTWARDS. MAJORITY OF MODELS SUGGEST INTENSIFICATION INTO A DEEP DEPRESSION DURING NEXT 24 HRS AND FURTHER INTENSIFICATION INTO A CYCLONIC STORM IN SUBSEQUENT 24 HRS. DYNAMICAL STATISTICAL MODEL OF IMD ALSO SUGGESTS INTENSIFICATION INTO A CYCLONIC STORM DURING NEXT 48 HRS. MODELS ALSO SUGGEST INITIAL WEST-NORTHWEST AND THEN NORTHWESTWARD MOVEMENT.

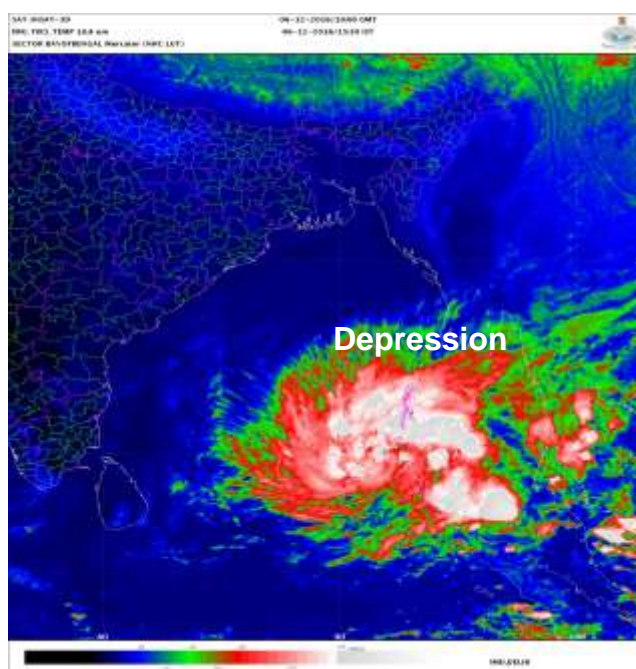


Fig. II-2: Typical Satellite imagery based on 1000 UTC of 6th December 2016

Examples-3: (Special Tropical Weather Outlook in association with a deep depression)

SPECIAL TROPICAL WEATHER OUTLOOK

DEMS-RSMC TROPICAL CYCLONES NEW DELHI DATED 23.10.2016

SPECIAL TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 72 HOURS ISSUED AT 0600 UTC OF 23.10.2016 BASED ON 0300 UTC OF 23.10.2016.

THE DEPRESSION OVER EASTCENTRAL BAY OF BENGAL MOVED EAST-NORTHEASTWARDS DURING PAST 12 HRS, INTENSIFIED INTO A DEEP DEPRESSION AND LAY CENTRED AT 0300 UTC OF TODAY, THE 23RD OCTOBER, 2016 OVER EASTCENTRAL BAY OF BENGAL, NEAR LATITUDE 15.5° N AND

LONGITUDE 93.0° E, ABOUT 420 KM NORTH OF PORT BLAIR (43333) AND 360 KM WEST-SOUTHWEST OF YANGON (48097). THE SYSTEM IS MOST LIKELY TO INTENSIFY INTO A CYCLONIC STORM DURING NEXT 24 HOURS. IT WILL MOVE NORTHEASTWARDS AND REACH CLOSE TO NORTH MYANMAR COAST BY TODAY EVENING. THEREAFTER, IT WILL RECURVE INITIALLY NORTH-NORTHWESTWARDS SKIRTING MYANMAR COAST AND THEN NORTHWESTWARDS TOWARDS NORTHWEST BAY OF BENGAL.

FURTHER UPDATE ON MOVEMENT & FORECAST TRACK OF THE SYSTEM TOWARDS INDIA COAST WILL BE PROVIDED AFTER THE RE-CURVATURE OF THE SYSTEM.

FORECAST TRACK AND INTENSITY OF THE SYSTEM ARE GIVEN IN THE TABLE BELOW:

Date/time(UTC)	Position (lat. 0N/ long. 0E)	Maximum sustained surface wind speed (kmph)	Category of cyclonic Disturbance
23-10-2016/0300	15.5/93.0	050-060 gusting to 70	Deep Depression
23-10-2016/0600	15.6/93.2	050-060 gusting to 70	Deep Depression
23-10-2016/1200	15.9/93.7	050-060 gusting to 70	Deep Depression
23-10-2016/1800	16.2/94.1	060-070 gusting to 80	Cyclonic Storm
24-10-2016/0000	16.6/94.1	060-070 gusting to 80	Cyclonic Storm
24-10-2016/1200	17.2/93.5	070-080 gusting to 90	Cyclonic Storm
25-10-2016/0000	17.6/92.4	070-080 gusting to 90	Cyclonic Storm
25-10-2016/1200	17.9/91.2	070-080 gusting to 90	Cyclonic Storm
26-10-2016/0000	18.2/89.9	070-080 gusting to 90	Cyclonic Storm
26-10-2016/1200	18.5/88.6	080-090 gusting to 100	Cyclonic Storm
27-10-2016/0000	18.8/87.3	090-100 gusting to 110	Severe Cyclonic Storm

ACCORDING TO SATELLITE IMAGERIES, THE CONVECTIVE CLOUDS SHOW SHEAR PATTERN. CONVECTIVE CLOUDS ARE SHEARED TOWARDS WEST. THE INTENSITY OF THE SYSTEM IS T 2.0 ASSOCIATED BROKEN LOW AND MEDIUM CLOUDS EMBEDDED WITH INTENSE TO VERY INTENSE CONVECTION LIE OVER BAY OF BENGAL BETWEEN 12.0°N TO 17.0°N AND LONGITUDE 83.5°E TO 92.0°E. THE LOWEST CLOUD TOP TEMPERATURE (CTT) IS ABOUT -85° C. MAXIMUM SUSTAINED SURFACE WIND SPEED IS ESTIMATED TO BE ABOUT 30 KNOTS GUSTING TO 40 KNOTS AROUND THE SYSTEM CENTRE. THE STATE OF THE SEA IS VERY ROUGH AROUND THE SYSTEM CENTRE. THE ESTIMATED CENTRAL PRESSURE IS ABOUT 1000 HPA.

REMARKS:

THE SEA SURFACE TEMPERATURE IS 29-30°C, OCEAN THERMAL ENERGY IS ABOUT 100 KJ/CM². LOW LEVEL CONVERGENCE AROUND THE SYSTEM CENTRE SHOWS RISE DURING PAST SIX HOURS AND IS ABOUT 20 X 10⁻⁵ SECOND⁻¹. UPPER LEVEL DIVERGENCE ALSO SHOWS INCREASE OVER THE AREA DURING PAST SIX HOURS AND IS ABOUT 30 X 10⁻⁵ SECOND⁻¹. THE LOW LEVEL RELATIVE VORTICITY INCREASED DURING PAST SIX HOURS AND IS ABOUT 150X10⁻⁶ SECOND⁻¹ AND VORTICITY CENTRE LIES TO THE EAST-NORTHEAST OF THE SYSTEM CENTRE. THE VERTICAL WIND SHEAR OF HORIZONTAL WIND HAS DECREASED DURING PAST SIX HOURS AND IS MODERATE (10-15 KNOTS) AROUND THE SYSTEM CENTRE AND IT FURTHER DECREASES TOWARDS NORTHEAST BECOMING 5-10 KNOTS NEAR ARAKAN & ADJOINING TENASSERIM COAST. THERE IS AN ANTICYCLONIC CIRCULATION OVER MYANMAR CLOSE TO IRRAWADDY DELTA. IT MAY STEER THE SYSTEM TO NORTH-NORTHWEST AS THE SYSTEM MOVES CLOSER TO COAST. HOWEVER, DUE TO EXPECTED LAND INTERACTION, THE INTENSIFICATION WILL BE STEADY AND SLOW DURING NEXT 24 HRS THOUGH THE DYNAMICAL PARAMETERS ARE FAVOURABLE FOR INTENSIFICATION. MAJORITY OF NUMERICAL MODELS ALSO INDICATE STEADY INTENSIFICATION OF THE SYSTEM AND MOVEMENT TOWARDS MYANMAR COAST DURING NEXT 24 HOURS. THEREAFTER, MOST MODELS SUGGEST THE RECURVATURE OF THE SYSTEM. HOWEVER, THERE IS LARGE DIVERGENCE IN THE DIRECTION AND POINT OF RECURVATURE AND REGARDING LANDFALL OVER MYANMAR.

THE NEXT BULLETIN WILL BE ISSUED AT 1500 UTC OF 23RD OCTOBER 2016.

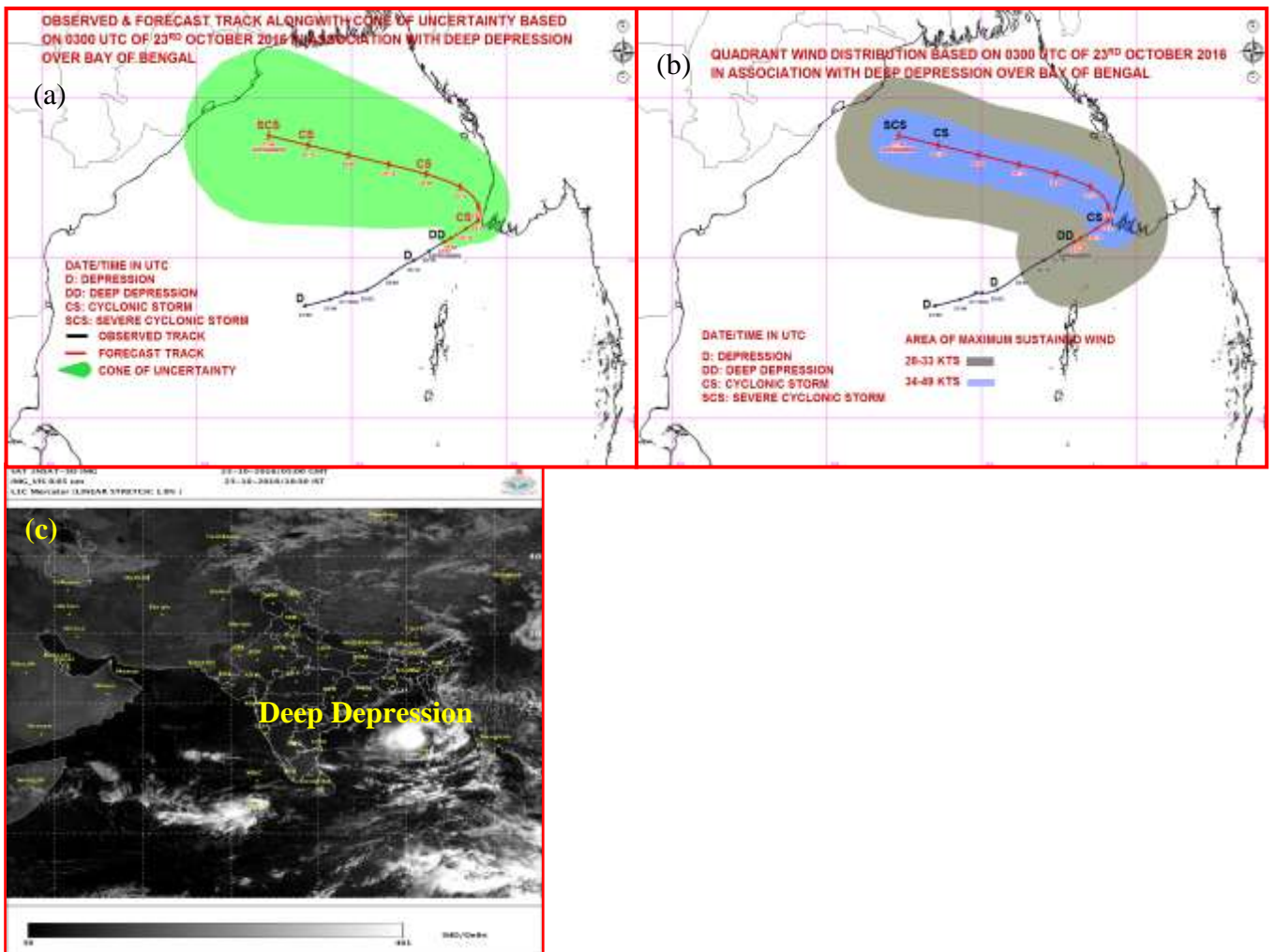


Fig. II-3: Observed and forecast track along with with (a) cone of uncertainty & (b) Quadrant wind distribution based on 0300 UTC and (c) Typical Satellite imagery based on 0500 UTC of 23rd October 2016 in association with Deep Depression over Bay of Bengal

2.4.3 Tropical cyclone advisories

When a tropical low pressure system reaches the cyclonic storm stage, or is shortly expected to reach that intensity, RSMC tropical cyclones, New Delhi will issue tropical cyclone advisories. Advisories will be issued at 00, 03, 06, 09, 12, 15, 18 and 21 UTC. The area of responsibility for the issue of tropical cyclone advisories by RSMC Tropical Cyclones, New Delhi cover sea areas of north Indian Ocean between long. 45° E to 100° E. Supplementary advisories may be issued as necessitated by circumstances, e.g., change in intensity or movement.

Tropical cyclone advisories will contain the information of tropical cyclone viz., name of the cyclone, the present location & intensity and past movement (past twelve hours) of the storm, and its forecast position, movement, intensity, maximum average surface wind speed with highest gust wind speed and sea conditions (in qualitative terms). These track and intensity forecasts are issued for +6, +12, +18, +24, +36, +48, +60, +72, +84, +96, +108 and +120 hrs. It also contains description of the convection as seen in satellite imageries and brief description of the diagnosis and prognosis of the system. The bulletin will contain the storm surge guidance based on IIT, Delhi Storm Surge prediction model in case of the cyclone landfalling over any member countries. Important information obtained from radar, synoptic, ship observations from the affected areas will also be reported in the advisory bulletin.

Advisories will be exchanged under appropriate headings for regional distribution by RTH, New Delhi on the GTS.

Example 4:

FROM: RSMC –TROPICAL CYCLONES, NEW DELHI
TO: STORM WARNING CENTRE, NAYPYI TAW (MYANMAR)
STORM WARNING CENTRE, BANGKOK (THAILAND)
STORM WARNING CENTRE, COLOMBO (SRILANKA)
STORM WARNING CENTRE, DHAKA (BANGLADESH)
STORM WARNING CENTRE, KARACHI (PAKISTAN)
METEOROLOGICAL OFFICE, MALE (MALDIVES)
OMAN METEOROLOGICAL DEPARTMENT, MUSCAT (THROUGH RTH JEDDAH)
YEMEN METEOROLOGICAL SERVICES , REPUBLIC OF YEMEN

TROPICAL CYCLONE ADVISORY
RSMC – TROPICAL CYCLONES, NEW DELHI

TROPICAL STORM ‘KYANT’ ADVISORY NUMBER FOUR ISSUED AT 1500 UTC OF 25TH OCTOBER 2016
BASED ON 1200 UTC CHARTS OF 25TH OCTOBER 2016

THE CYCLONIC STORM ‘KYANT’ OVER EASTCENTRAL BAY OF BENGAL MOVED WEST-SOUTHWESTWARDS IN PAST 06 HOURS WITH SPEED 09 KMPH AND LAY CENTRED AT 1200 UTC OF 25TH OCTOBER, 2016 OVER EASTCENTRAL BAY OF BENGAL, NEAR LATITUDE 16.8° N AND LONGITUDE 90.5° E, 650 KM EAST-SOUTHEAST OF GOPALPUR AND 770 KM EAST-SOUTHEAST OF VISHAKHAPATNAM AND 1000 KM EAST-NORTHEAST OF MACHILIPATNAM. THE SYSTEM IS VERY LIKELY TO SLIGHTLY INTENSIFY FURTHER DURING NEXT 36 HOURS. IT IS MOST LIKELY TO MOVE WEST-SOUTHWESTWARDS TOWARDS WESTCENTRAL BAY OF BENGAL DURING NEXT 72 HOURS.

FORECAST TRACK AND INTENSITY OF THE SYSTEM ARE GIVEN IN THE TABLE BELOW:

DATE/TIME(UTC)	POSITION (LAT. °N/ LONG. °E)	MAXIMUM SUSTAINED SURFACE WIND SPEED (KMPH)	CATEGORY OF CYCLONIC DISTURBANCE
25-10-2016/1200	16.8/90.5	060-070 GUSTING TO 080	CYCLONIC STORM
25-10-2016/1800	16.6/89.8	060-070 GUSTING TO 080	CYCLONIC STORM
26-10-2016/0000	16.5/89.2	070-080 GUSTING TO 090	CYCLONIC STORM
26-10-2016/0600	16.4/88.4	070-080 GUSTING TO 090	CYCLONIC STORM
26-10-2016/1200	16.3/87.6	070-080 GUSTING TO 090	CYCLONIC STORM
27-10-2016/0000	16.1/85.9	080-090 GUSTING TO 100	CYCLONIC STORM
27-10-2016/1200	15.9/84.4	080-090 GUSTING TO 100	CYCLONIC STORM
28-10-2016/0000	15.7/83.2	080-090 GUSTING TO 100	CYCLONIC STORM
28-10-2016/1200	15.5/82.3	070-080 GUSTING TO 090	CYCLONIC STORM
29-10-2016/0000	15.3/81.6	060-070 GUSTING TO 080	CYCLONIC STORM
29-10-2016/1200	15.1/81.1	050-060 GUSTING TO 070	DEEP DEPRESSION

ACCORDING TO SATELLITE IMAGERIES, THE CONVECTIVE CLOUDS SHOW CDO PATTERN. THE INTENSITY OF THE SYSTEM IS T 2.5. ASSOCIATED BROKEN LOW/MEDIUM CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION LIE OVER BAY OF BENGAL BETWEEN LATITUDE 14.0°N TO 19.0°N AND LONGITUDE 86.0°E TO 93.5°E. THE LOWEST CLOUD TOP TEMPERATURE (CTT) IS ABOUT -90° C. MAXIMUM SUSTAINED SURFACE WIND SPEED IS ESTIMATED TO BE ABOUT 35 KNOTS GUSTING TO 45 KNOTS AROUND THE SYSTEM CENTRE. THE STATE OF THE SEA IS HIGH AROUND THE SYSTEM CENTRE. THE ESTIMATED CENTRAL PRESSURE IS ABOUT 998 HPA.

REMARKS:

THE SEA SURFACE TEMPERATURE IS AROUND 31°C, OCEAN THERMAL ENERGY IS ABOUT 100 KJ/CM². LOW LEVEL CONVERGENCE AROUND THE SYSTEM CENTRE IS ABOUT 15X10⁻⁵ SECOND⁻¹. UPPER LEVEL DIVERGENCE IS ABOUT 20X10⁻⁵ SECOND⁻¹ AROUND THE SYSTEM CENTRE. THE LOW LEVEL RELATIVE VORTICITY IS ABOUT 200X10⁻⁶ SECOND⁻¹ AND IS TO THE SOUTHEAST OF THE SYSTEM CENTRE. THE VERTICAL WIND SHEAR OF HORIZONTAL WIND IS MODERATE (10-20 KNOTS) AROUND THE SYSTEM CENTRE. IT INCREASES TOWARDS SOUTH AND SOUTHWEST DIRECTION COVERING WESTCENTRAL BAY OF BENGAL. THIS HIGH VERTICAL WIND SHEAR CONDITIONS MAY PREVAIL AFTER 24-36 HOURS. HENCE, THERE IS POSSIBILITY OF TEMPORARY INTENSIFICATION OF THE SYSTEM DURING NEXT 24/36 HOURS UNDER MODERATE WIND SHEAR CONDITIONS.

THEREAFTER, AS THE SYSTEM MOVES TO WESTCENTRAL BAY, THERE IS POSSIBILITY OF GRADUAL WEAKENING OF THE SYSTEM DUE TO HIGH VERTICAL WIND SHEAR.

AN ANTICYCLONIC CIRCULATION LIES TO THE NORTHWEST OF THE SYSTEM IN MIDDLE & UPPER TROPOSPHERIC LEVELS. IT IS STEERING THE SYSTEM IN WEST-SOUTHWEST DIRECTION WITH A SPEED OF 4-5 KNOTS. SIMILAR CONDITIONS MAY CONTINUE FOR NEXT 72-96 HOURS LEADING TO WEST-SOUTHWESTWARDS MOVEMENT OF THE SYSTEM.

MAJORITY OF THE NUMERICAL MODELS ARE IN AGREEMENT WITH THIS FORECAST.

THE NEXT BULLETIN WILL BE ISSUED AT 1800 UTC OF 25TH OCTOBER 2016.

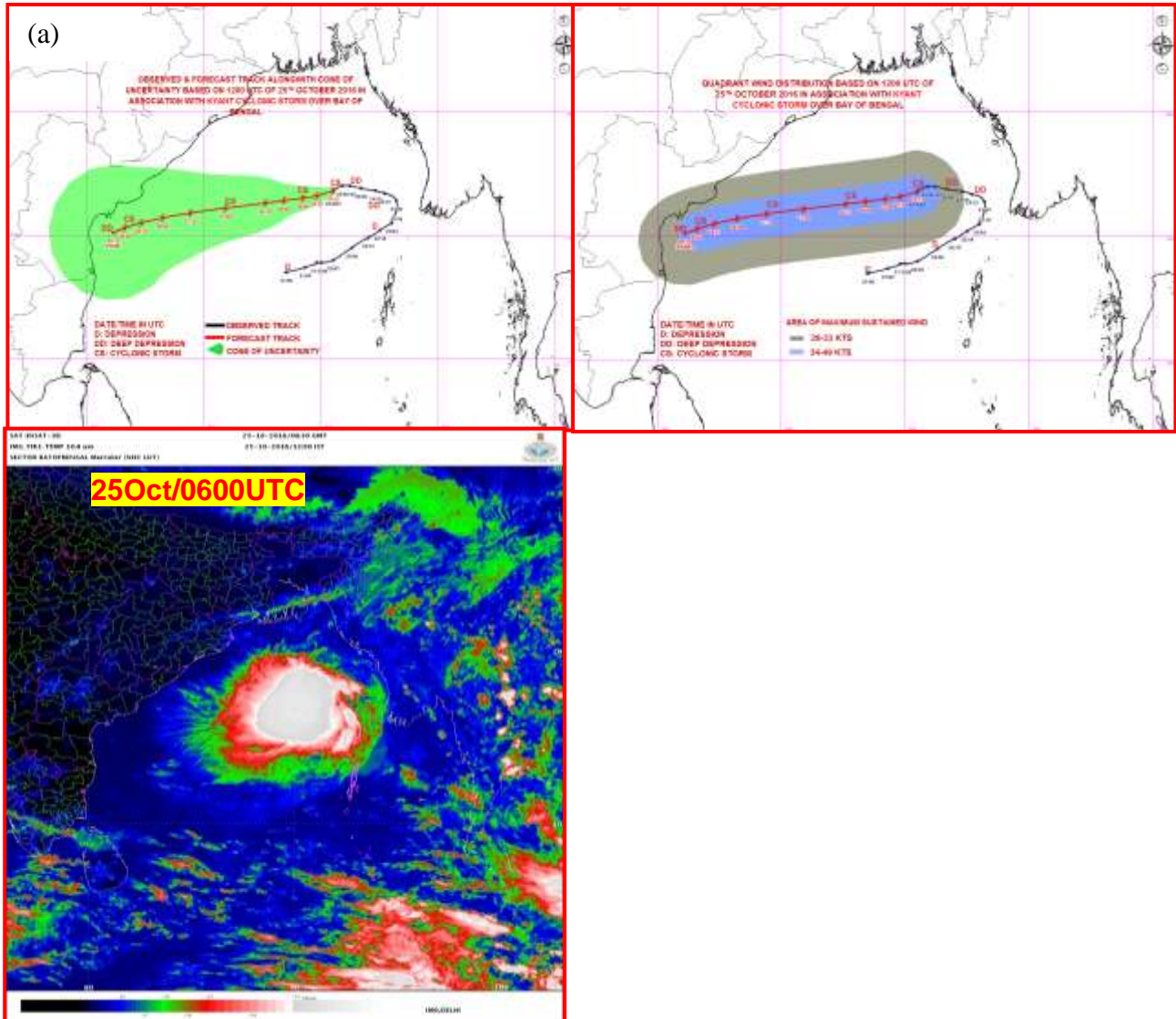


Fig. II-4: Observed and forecast track alongwith with (a) cone of uncertainty & (b) Quadrant wind distribution based on 1200 UTC and (c) Typical Satellite imagery based on 0600 UTC of 25th October 2016

2.4.4 Hourly update bulletin

The hourly update bulletin of system before landfall has been introduced in October, 2014 since Cyclone 'Hudhud' (7-14 October, 2014). This bulletin contains location (lat/long) and intensity of the system. An example of hourly bulletin issued during VSCS Vardah is given below:

Example 5:

Hourly Update on VSCS, VARDHAH OVER THE BAY OF BENGAL
BULLETIN NO. 7

DATE: 12-12-2016

TIME OF ISSUE: 1400 IST

DATE/TIME (IN IST)	12-12-2016 (1330 IST)
LOCATION LATITUDE/LONGITUDE	13.2 °N/ 80.4 °E
DISTANCE FROM CHENNAI	22 KM EAST-NORTHEAST OF CHENNAI
CURRENT WIND SPEED NEAR CENTRE OF CYCLONE	120-130 KMPH GUSTING TO 140 KMPH
CURRENT WIND SPEED NEAR CHENNAI	90-100 KMPH AT 1330 IST
EXPECTED POINT OF LANDFALL	NEAR CHENNAI
EXPECTED TIME OF LANDFALL	BETWEEN 1400-1700 IST OF 12 TH DECEMBER
EXPECTED WIND SPEED AT THE TIME OF LANDFALL	100-110 KMPH GUSTING UPTO 120 KMPH
REMARKS	LANDFALL PROCESS HAS COMMENCED FROM 1400 IST

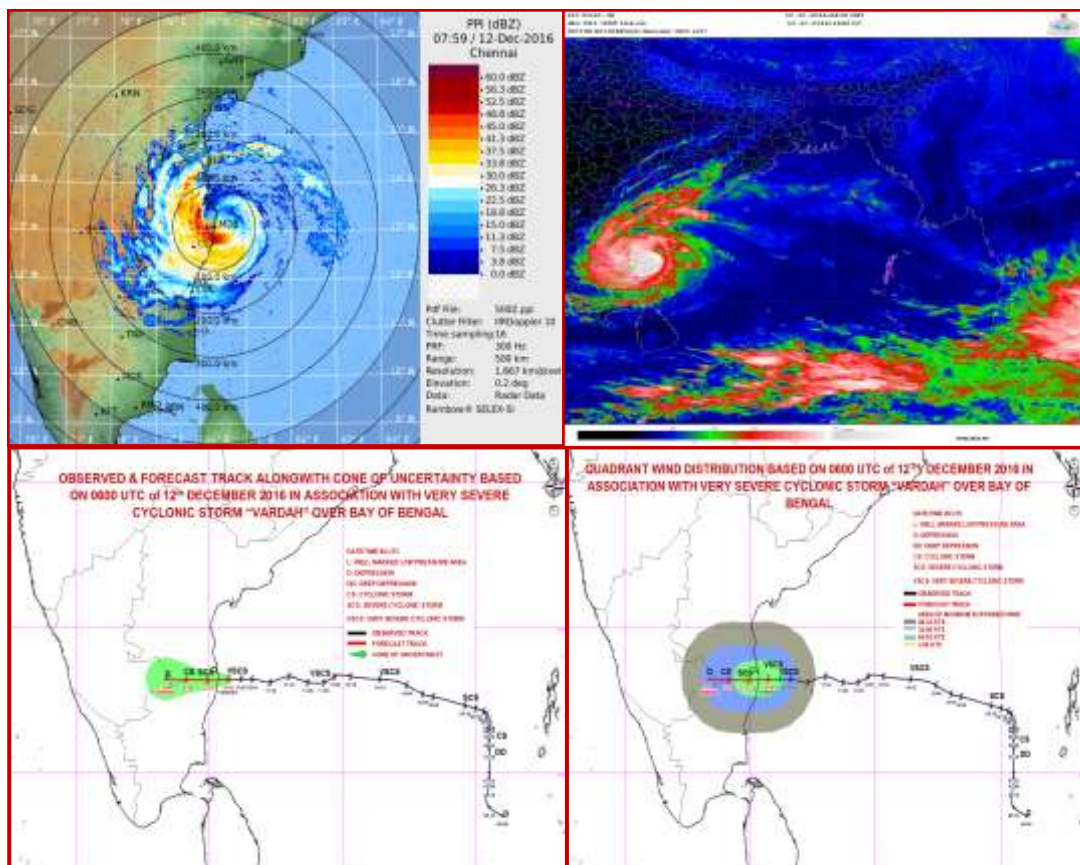


Fig. II-5: Typical DWR Chennai imagery based on 0759 UTC, (b) Satellite imagery based on 0830 UTC, (c) Observed and forecast track alongwith with cone of uncertainty & (d) Quadrant wind distribution based on 0600 UTC and of 12th December 2016

2.4.5 Tropical cyclone warnings for the high seas

The World Meteorological Organization (WMO) in its Manual on Marine Meteorological Services has recommended the issue of weather and sea bulletins for the high seas in six parts. The first part relates to tropical storm warnings in plain language. Areas of responsibility of each nation for issuing the tropical storm warnings are pre-assigned (**Fig.II-6**).

The cyclone warning centres issuing forecasts and warnings for the benefit of the ships on the high seas in the Panel countries are listed in the **Table II-2**. The area covered by these stations in their bulletins, name of the coastal radio stations with their call signs from where the tropical cyclone warnings are broadcast, are also given in **Table II-2**.

AREAS OF RESPONSIBILITY AND DESIGNATED NATIONAL METEOROLOGICAL SERVICES FOR THE ISSUE OF WARNINGS AND WEATHER AND SEA BULLETINS FOR THE GMDSS

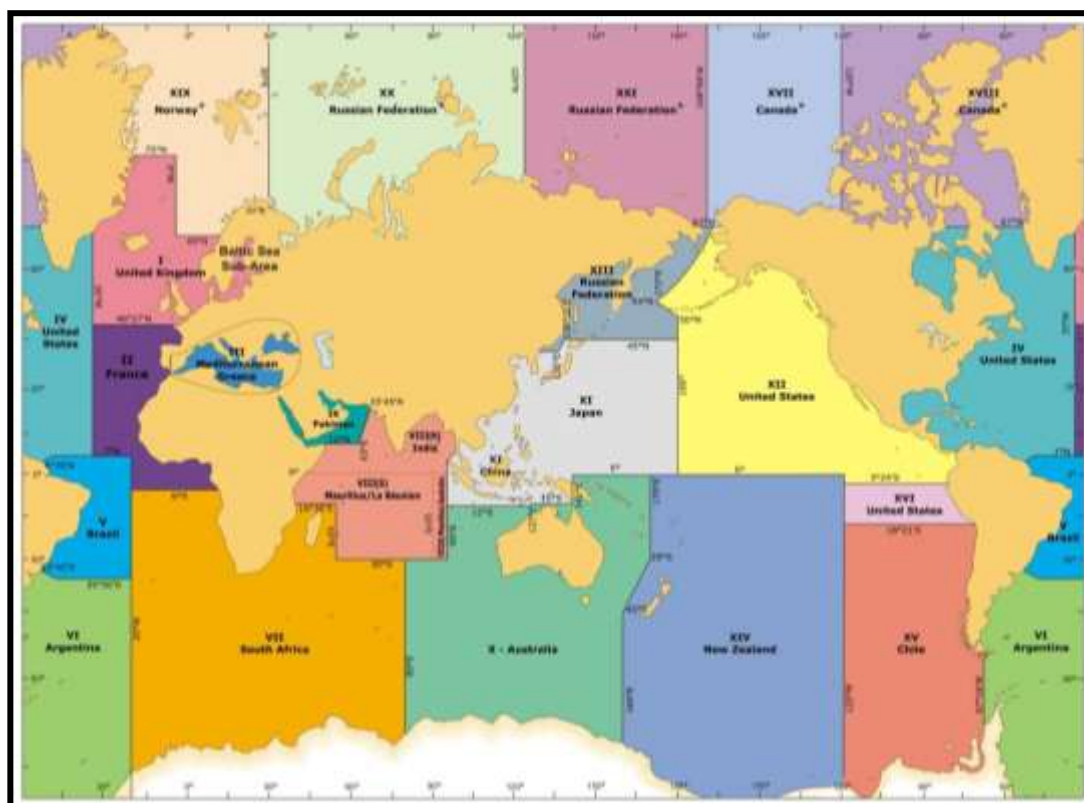


Fig. II-6.

TABLE II- 2
Stations issuing cyclone warnings for ships on the high seas

Station	Call sign of Coastal Radio Station	Area covered
Bangladesh, Chittagong	ASC	Bay of Bengal north of 18°N Lat.
India, Mumbai		Arabian Sea north of Lat. 5°N and east of Long. 60°E excluding the area north of Lat. 20°N and west of Long. 68°E. The eastern boundary of the Arabian Sea for which these bulletins are issued by Mumbai is Long. 80°E meridian excluding the Gulf of Mannar.
India, Kolkata		Bay of Bengal north of Lat. 5°N except the area between the coastline on the east and the line drawn through the points 18°N 94.5°E, 18°N 92°E, 13.5°N 92°E, 13.5°N 94°E, 10°N 94°E, 10°N 95°E and 5°N 95°E. The western boundary of the sea area for which bulletins are issued by Kolkata is up to and inclusive of the Gulf of Mannar (i.e., 77.5°E meridian).
*India, Chennai		Bay of Bengal bulletins issued by ACWC Kolkata are being broadcast through Navtex, Chennai by Narrow Band Direct Printing (NBDP)
Myanmar, Yangon	XYR	Bay of Bengal except area west of Long. 92°E and South of 10°N Lat.
Oman (Sultanate of)	A4M	Muscat Coastal Radio Station
**Pakistan, Karachi	ASK	Arabian Sea north of 20°N, Gulf of Oman and Persian Gulf (12°N-63°E)
Sri Lanka, Colombo	4PB	Indian Ocean, Arabian Sea and Bay of Bengal from the equator to 10°N between 60°E and 95°E. The area 5°N to 10°N between 60°E and 95°E is an overlap with India.
Thailand, Bangkok	HSA	Gulf of Thailand, west of southern Thailand, Strait of Malacca and South China Sea.

* Under the new Marine Meteorological Broadcast system, GMDSS (Global Marine Distress Safety System) of IMO/WMO, India issues two bulletins at 0900 and 1800 UTC everyday for broadcast through INMARSAT SAFETY SYSTEM. Additional bulletins are broadcast during Cyclone period.

** To comply IMO/WMO GMDSS and marine Meteorological Broadcast System Pakistan issues the high seas forecast / Marine bulletins for metarea-IX daily at 0700 UTC for broadcast through INMARSAT SAFETYNET SYSTEM. These bulletins are issued at 1900 UTC if so required.

Tropical cyclone warnings for the high seas contains the following informations:

- (a) Type of warning and name of the issuing centre
- (b) Name of the system and name of the basin
- (c) Date and time of reference in UTC
- (d) Type of disturbance (depression, cyclonic storm, etc.);
- (e) Location in terms of latitude and longitude or with reference to well-known landmarks and ECP
- (f) Direction and speed of movement of the disturbance
- (g) Extent of affected area in nautical miles
- (h) Wind speed or force and direction in the affected areas
- (i) Sea and swell condition in affected areas (in qualitative terms)
- (j) Other important information such as future position of disturbances

Items (a), (b), (c), (d), (e), (f), (g) and (h) listed above should always be included in the warning bulletins.

Example:

VWM 1545 UTC 14 NOVEMBER 2008 CYCLONE WARNING CENTRE KOLKATA WARNING OF TROPICAL STORM. SEVERE CYCLONIC STORM 'KHAI MUK' IN WEST CENTRAL BAY OF BENGAL CENTRED AT 1200 UTC 14 NOVEMBER 2008 WITHIN HALF A DEGREE OF LATITUDE 14.5 DEGREES NORTH LONGITUDE 83.5 DEGREES EAST REPEAT 14.5° N 83.5° E AAA PRESENT MOVEMENT NORTHWESTWARDS AAA CENTRAL PRESSURE 988 HPA (MAXIMUM SUSTAINED WIND 35 KT GUSTS 45 KT). AREAS 35 KT WIND WITHIN RADIUS 80 NM AND AREAS 30 KT WIND WITHIN 300 NM RADIUS AAA STATE OF SEA VERY ROUGH TO HIGH WITHIN 300 KM OF TROPICAL STORM CENTRE AAA SYSTEM LIKELY TO INTENSIFY AND MOVE IN A NORTHWESTERLY DIRECTION AT 10 KT AAA (NEXT BULLETIN 1845 UTC) AAA

2.4.6 Warnings and advisories for aviation

In accordance with the International Civil Aviation Organization (ICAO) Annex 3 — *Meteorological Service for International Air Navigation*/ WMO Technical Regulations [C.3.1], tropical cyclone warnings, required for the international air navigation, are issued by designated Meteorological Watch Offices (MWO) as SIGMET messages, including an outlook, giving information up to 24 hours ahead concerning the expected positions and maximum surface wind of the centre of the tropical cyclone. Each MWO provides information for one or more specified Flight Information Regions (FIRs) or Upper Information Regions (UIRs). The boundaries of the FIRs/UIRs are defined in ICAO Air Navigation Plans (ANP) for the Asia (ASIA), Middle East (MID) and Pacific (PAC) Regions.

The content and order of elements in a SIGMET message for tropical cyclone shall be in accordance with WMO Technical Regulations [C.3.1]. The data type designator to be included in the WMO abbreviated header of such messages shall be T1T 2 = WC (WMO No. 386, Manual on GTS refers).

The designated Tropical Cyclone Advisory Centre (TCAC), New Delhi shall monitor the development of tropical cyclones in its area of responsibility, in accordance with the ASIA/PAC ANP and issue advisory information concerning the positions of the centre of the cyclone, its direction and speed of movement, central pressure and maximum surface wind near the centre. These advisories are disseminated to the MWOs in the TCAC New Delhi area of responsibility, to be used in the preparation of the OUTLOOK appended to SIGMETs for tropical cyclones. In addition, the tropical cyclone advisories shall be disseminated to the other TCACs, whose areas of responsibility may be affected, to the World Area Forecast Centers (WAFC) London and Washington

and international OPNET data banks and centers operating the satellite distribution systems (SADIS and ISCS). [C.3.1]. The data type designator to be included in the WMO abbreviated header of such messages shall be T1T2 = FK (WMO-No. 386, Manual on GTS, refers).

TCAC New Delhi is issuing Tropical Cyclone Advisories for its area of responsibility, for each tropical cyclone, as necessary, in the format specified by ICAO every six hours since 2003 and alongwith graphics from 2012.

TC ADVISORY

(i) **Text message:** A text message is sent through GTS under the header BMBB01 to various users as per the following format

TC ADVISORY
DTG: 20161207/1800Z
TCAC: NEW DELHI
TC: NONAME
NR: 01
PSN: N1048 E09030
MOV: N05KT
C: 1000HPA
MAX WIND: 30KT
FCST PSN+06HR: 08/0000Z N1124 E09030
FCST MAX WIND +6HRS: 30 KT
FCST PSN+12HR: 08/0600Z N1142 E09030
FCST MAX WIND+12HR: 35KT
FCST PSN+18HR: 08/1200Z N1200 E09018
FCST MAX WIND+18HR: 40KT
FCST PSN+24HR: 08/1800Z N1218 E09006
FCST MAX WIND+24HR: 45KT
RMK: NIL
NXT MSG: 20161207/0300Z
TOO: 080130 HRS IST

(ii) **Graphical TC advisory:** The graphical advisory is sent in graphics in PNG format including text in it through GTS under the header T_PZXE89_C_DEMS. An example is shown in Fig.II-7.

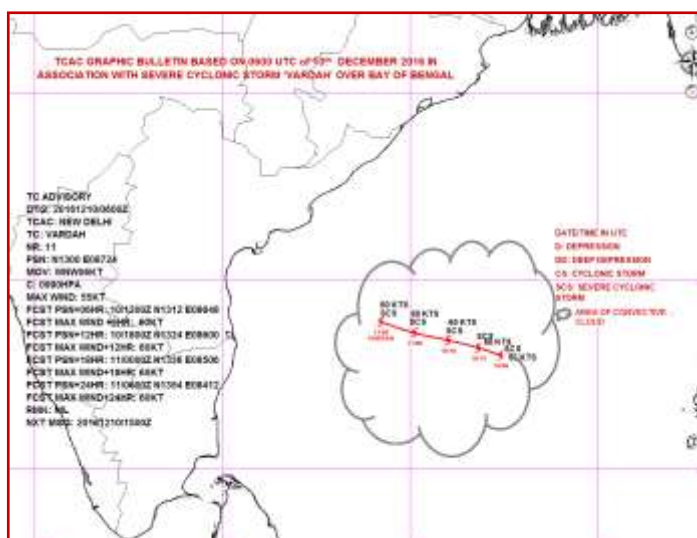


Fig. II-7

(iii) **TC advisory to ADRR Hong Kong:** TC advisory containing 24 hours forecast is also given to ADRR Hong Kong through FTP based on 00, 06, 12 and 18 UTC observation in the following format.

Example:

```
0004
VARDAH
2016120612 08.8 090.5 25 O
2016120618 09.5 090.5 25 O
2016120700 09.8 090.5 25 O
2016120706 09.8 090.5 25 O
2016120712 10.0 090.5 25 O
2016120718 10.8 090.5 30 O
2016120800 11.4 090.5 30 F
2016120806 11.7 090.5 35 F
2016120812 12.0 090.3 40 F
2016120818 12.3 090.1 45 F
```

<TC identifier>
<TC Name>

yyyymmddhh Lat. Long. Maximum Sustained Wind
and O stands for observed and F stands for
forecast

2.4.7 Tropical cyclone warnings for national purposes

Information on tropical cyclone warnings provided nationally by Panel member countries, including the port warning system, is given in Annex II- A to Annex II- I to this Chapter.

2.4.8 Storm surge guidance

Storm surge warnings will be the responsibility of the National Meteorological Services. However, storm surge guidance will be issued and incorporated in the tropical cyclone advisory bulletin by RSMC- New Delhi based on IIT, Delhi Storm Surge prediction model and INCOIS, Hyderabad Advanced CIRCulation coastal inundation model. The storm surge guidance is appended in the Tropical Cyclone Advisory bulletin for Panel member countries. The graphical product from IIT Delhi and INCOIS, Hyderabad is also uploaded in cyclone page of IMD website. An example of this product is shown in Fig. II-8. The textual message is given in bulletin.

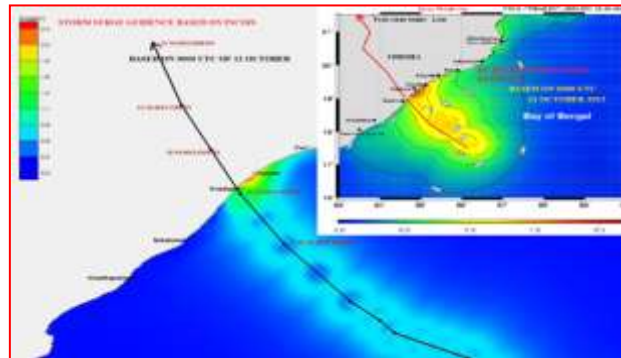


Fig. II-8 (a)

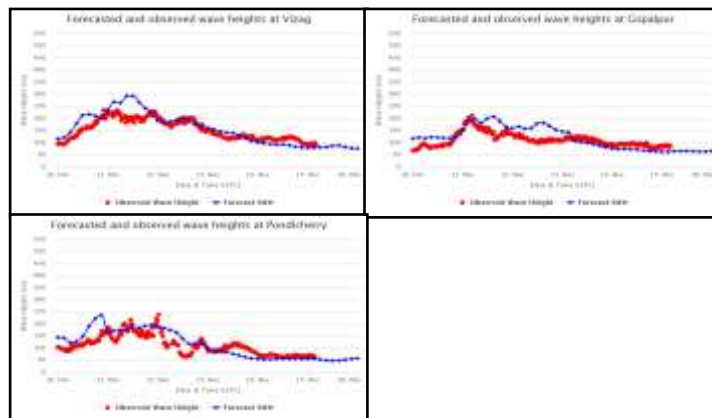


Fig. II-8 (b): Observed and forecast Wave Heights over Vishakhapatnam, Gopalpur & Pondicherry during Vardah

2.5 Graphical presentation of track and intensity

The track and intensity of the system are updated and put in cyclone page of IMD website time to time, based on the special tropical weather outlook and tropical cyclone advisory bulletin issued by RSMC, New Delhi from the stage of deep depression and based on 00, 06, 12 and 18 UTC. These are also sent by e-mail to the Panel member countries. An example of this product is shown in Fig. II-9.

2.5.1 Cone of uncertainty: The cone of uncertainty in the forecast was introduced with effect from the cyclone, 'WARD' during December, 2009 for the lead time 72 at an interval of 12 hrs. It was further revised with effect from cyclone 'VIYARU' during May, 2013 and extended upto 120 hrs for the same interval of time. It is helpful to the decision makers as it indicates the standard forecast errors in the forecast for different periods like 12, 24, 36, 48, 60, 72, 84, 96, 108, 120 hrs. The standard errors (nm) as radius of the circle around the forecast position (lat/long) so as to construct the cone of uncertainty in the track forecast are given below. It has been implemented since cyclone 'Hudhud' (7-14 October, 2015).

Lead time (hrs)	Standard error (nm) used for uncertainty forecast
00	010
12	030
24	060
36	080
48	100
60	120
72	135
84	150
96	165
108	180
120	195

An example of track forecast with cone of uncertainty is shown in Fig. II-9.

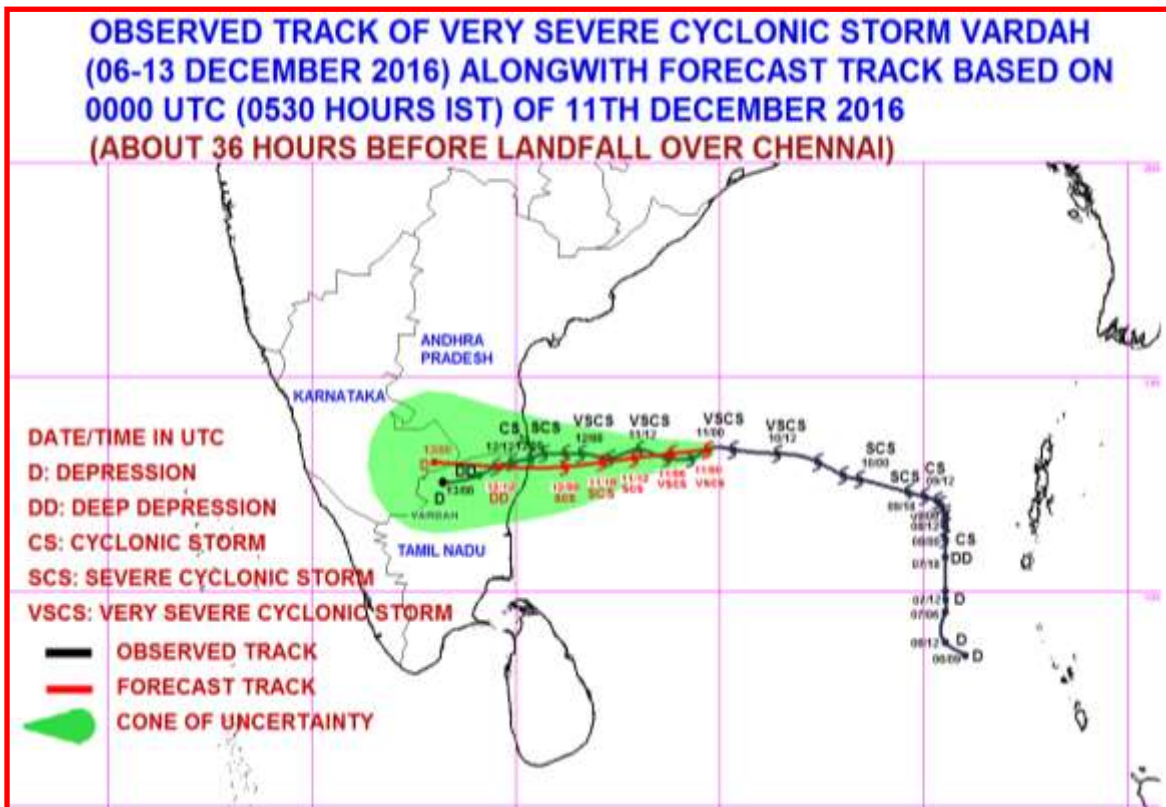


Fig.II-9 A typical example of observed and forecast track with cone of uncertainty.

2.5.2 Quadrant wind forecast:

(i) Graphical Product:

The forecast of maximum wind in four quadrants of a cyclone commenced with effect from cyclone, GIRI during October 2010. In this forecast, the radius of 28, 34, 50 and 64 knot winds was given for various forecast periods like +06, +12, +18, +24, +36, +48, +60 and +72 hrs. It was further revised with effect from cyclone 'Viyaru' during May, 2013 and extended upto 120 hrs for the same interval of time. A typical graphical presentation of this forecast is shown in Fig.II-10. This bulletin is issued from Deep Depression stage onwards based on 00, 06, 12 and 18 UTC. It is uploaded in IMD website and sent to focal points of WMO/ESCAP Panel countries by e-mail.



Fig.II-10: A typical example of observed track and forecast area of maximum sustained wind

(ii) Text Product:

The quadrant wind is also issued in text format and sent to various users through-email and GTS under the header-WTIN31. It is also sent to various NWP modeling groups including NCMRWF, IIT Delhi for vertex relocation in coded form through ftp. It is provided to IIT Delhi & INCOIS storm surge modeling group also for their use.

Example (i):

QUADRANT WIND DISTRIBUTION IN ASSOCIATION WITH “DEEP DEPRESSION” OVER BAY OF BENGAL DATE AND TIME BASED UPON WHICH FORECAST IS PREPARED:

PRESENT DATE AND TIME: 080000 UTC

PRESENT POSITION: 11.2°N/90.5° E

POSITION ACCURATE TO 50 KM

PRESENT MOVEMENT (DDD/FF) PAST SIX HOURS: 000/05 KT

PRESENT WIND DISTRIBUTION:

MAX SUSTAINED WINDS: 35 KT, GUSTS 45 KT

RADIUS OF MAXIMUM WIND 25 NM

WINDS VARY IN EACH QUADRANT

RADII ARE LARGEST RADII EXPECTED ANYWHERE IN THE QUADRANT

WIND RADII VALID OVER OPEN WATER ONLY

FORECASTS:

06 HRS, VALID AT:

080600Z 11.7°N/90.5° E

MAX SUSTAINED WINDS: 35 KT, GUSTS 45 KT

RADIUS OF 028 KT WINDS:

090 NM NORTHEAST QUADRANT
 090 NM SOUTHEAST QUADRANT
 080 NM SOUTHWEST QUADRANT
 080 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:

40 NM NORTHEAST QUADRANT
 40 NM SOUTHEAST QUADRANT
 35 NM SOUTHWEST QUADRANT
 35 NM NORTHWEST QUADRANT

12 HRS, VALID AT:

081200Z 12.0°N/90.3° E

MAX SUSTAINED WINDS: 40 KT, GUSTS 50 KT

RADIUS OF 028 KT WINDS:

090 NM NORTHEAST QUADRANT
 090 NM SOUTHEAST QUADRANT
 080 NM SOUTHWEST QUADRANT
 080 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:

40 NM NORTHEAST QUADRANT
 40 NM SOUTHEAST QUADRANT
 35 NM SOUTHWEST QUADRANT
 35 NM NORTHWEST QUADRANT

18 HRS, VALID AT:

081800Z 12.3 /90.1° E

MAX SUSTAINED WINDS: 45 KT, GUSTS 55 KT

RADIUS OF 028 KT WINDS:

100 NM NORTHEAST QUADRANT
 100 NM SOUTHEAST QUADRANT
 090 NM SOUTHWEST QUADRANT
 090 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:

50 NM NORTHEAST QUADRANT
 50 NM SOUTHEAST QUADRANT
 45 NM SOUTHWEST QUADRANT
 45NM NORTHWEST QUADRANT

24 HRS, VALID AT:

090000Z 12.6 /89.8° E

MAX SUSTAINED WINDS: 50 KT, GUSTS 60 KT

RADIUS OF 028 KT WINDS:

100 NM NORTHEAST QUADRANT
 100 NM SOUTHEAST QUADRANT
 090 NM SOUTHWEST QUADRANT
 090 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:

50 NM NORTHEAST QUADRANT
 50 NM SOUTHEAST QUADRANT
 45 NM SOUTHWEST QUADRANT
 45NM NORTHWEST QUADRANT

36 HRS, VALID AT:

091200Z 13.1 /89.2° E

MAX SUSTAINED WINDS: 55 KT, GUSTS 65 KT

RADIUS OF 028 KT WINDS:

110 NM NORTHEAST QUADRANT
 110 NM SOUTHEAST QUADRANT
 100 NM SOUTHWEST QUADRANT
 100 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:

50NM NORTHEAST QUADRANT
 50 NM SOUTHEAST QUADRANT
 45 NM SOUTHWEST QUADRANT

45NM NORTHWEST QUADRANT
RADIUS OF 050 KT WINDS:
 40NM NORTHEAST QUADRANT
 40 NM SOUTHEAST QUADRANT
 35 NM SOUTHWEST QUADRANT
 35NM NORTHWEST QUADRANT

48 HRS, VALID AT:
 100000Z 13.7 /88.1⁰ E

MAX SUSTAINED WINDS: 60 KT, GUSTS 70 KT

RADIUS OF 028 KT WINDS:
 110 NM NORTHEAST QUADRANT
 110 NM SOUTHEAST QUADRANT
 100 NM SOUTHWEST QUADRANT
 100 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:
 60NM NORTHEAST QUADRANT
 60 NM SOUTHEAST QUADRANT
 55 NM SOUTHWEST QUADRANT
 50NM NORTHWEST QUADRANT

RADIUS OF 050 KT WINDS:
 40NM NORTHEAST QUADRANT
 40 NM SOUTHEAST QUADRANT
 35 NM SOUTHWEST QUADRANT
 35NM NORTHWEST QUADRANT

60 HRS, VALID AT:
 101200Z 14.2 /86.7⁰ E

MAX SUSTAINED WINDS: 60 KT, GUSTS 70 KT

RADIUS OF 028 KT WINDS:
 120 NM NORTHEAST QUADRANT
 120 NM SOUTHEAST QUADRANT
 110 NM SOUTHWEST QUADRANT
 110 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:
 60NM NORTHEAST QUADRANT
 60 NM SOUTHEAST QUADRANT
 55 NM SOUTHWEST QUADRANT
 50NM NORTHWEST QUADRANT

RADIUS OF 050 KT WINDS:
 40NM NORTHEAST QUADRANT
 40 NM SOUTHEAST QUADRANT
 35 NM SOUTHWEST QUADRANT
 35NM NORTHWEST QUADRANT

72 HRS, VALID AT:
 110000Z 14.6 /85.2⁰ E

MAX SUSTAINED WINDS: 60 KT, GUSTS 70 KT

RADIUS OF 028 KT WINDS:
 120 NM NORTHEAST QUADRANT
 120 NM SOUTHEAST QUADRANT
 110 NM SOUTHWEST QUADRANT
 110 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:
 60NM NORTHEAST QUADRANT
 60 NM SOUTHEAST QUADRANT
 55 NM SOUTHWEST QUADRANT
 50NM NORTHWEST QUADRANT

RADIUS OF 050 KT WINDS:
 40NM NORTHEAST QUADRANT
 40 NM SOUTHEAST QUADRANT
 35 NM SOUTHWEST QUADRANT
 35NM NORTHWEST QUADRANT

84 HRS, VALID AT:

111200Z 15.0 /83.6⁰ E

MAX SUSTAINED WINDS: 55 KT, GUSTS 65 KT

RADIUS OF 028 KT WINDS:

110 NM NORTHEAST QUADRANT
110 NM SOUTHEAST QUADRANT
100 NM SOUTHWEST QUADRANT
100 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:

60NM NORTHEAST QUADRANT
60 NM SOUTHEAST QUADRANT
55 NM SOUTHWEST QUADRANT
50NM NORTHWEST QUADRANT

RADIUS OF 050 KT WINDS:

40NM NORTHEAST QUADRANT
40 NM SOUTHEAST QUADRANT
35 NM SOUTHWEST QUADRANT
35NM NORTHWEST QUADRANT

96 HRS, VALID AT:

120000Z 15.3 /82.3⁰ E

MAX SUSTAINED WINDS: 50 KT, GUSTS 60 KT

RADIUS OF 028 KT WINDS:

110 NM NORTHEAST QUADRANT
110 NM SOUTHEAST QUADRANT
100 NM SOUTHWEST QUADRANT
100 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:

50NM NORTHEAST QUADRANT
50NM SOUTHEAST QUADRANT
45 NM SOUTHWEST QUADRANT
45NM NORTHWEST QUADRANT

RADIUS OF 050 KT WINDS:

40NM NORTHEAST QUADRANT
40 NM SOUTHEAST QUADRANT
35 NM SOUTHWEST QUADRANT
35NM NORTHWEST QUADRANT

108 HRS, VALID AT:

121200Z 15.6 /80.9⁰ E

MAX SUSTAINED WINDS: 40 KT, GUSTS 50 KT

RADIUS OF 028 KT WINDS:

90 NM NORTHEAST QUADRANT
90 NM SOUTHEAST QUADRANT
80 NM SOUTHWEST QUADRANT
80 NM NORTHWEST QUADRANT

RADIUS OF 034 KT WINDS:

40NM NORTHEAST QUADRANT
40NM SOUTHEAST QUADRANT
35 NM SOUTHWEST QUADRANT
35NM NORTHWEST QUADRANT

120 HRS, VALID AT:

130000Z 15.8 /79.6⁰ E

MAX SUSTAINED WIND: 25 KT, GUSTS 35 KT

Example (ii):

TC vital sent through ftp has been introduced in 2013. The format of TC vital is sent through ftp to NWP modelers. The format of this bulletin is given below along with an example.

Format

No. of characters	Description of characters	Example
character*4 tcv_center	Hurricane Center Acronym	IMD
character*3 tcv_storm_id	Storm Identifier (02B, etc)	04B
character*9 tcv_storm_name	Storm name	VARDAH
integer tcv_century	2-digit century id (19 or 20)	20
integer tcv_yymmdd	Date of observation	161210
integer tcv_hhmm	Time of observation (UTC)	0000
integer tcv_lat	Storm Lat (X10), always >0	126 (for 12.6 ⁰ latitude)
character*1 tcv_latns	'N' or 'S'	N
integer tcv_lon	Storm Lon (*10), always >0	0884 (for 88.4 ⁰ longitude)
character*1 tcv_lonew	'E' or 'W'	E
integer tcv_stdir	Storm motion vector (in degree)	300 (Past six hours) (west-northwestwars)
integer tcv_stspd	Speed of storm movement (m/sX10)	055 (Past six hours Reported in 3 digits)
integer tcv_pcen	Min central pressure (mb)	0990 (Reported in 4 digits)
integer tcv_penv	outermost closed isobar(mb)	1006 (Reported in 4 digits)
integer tcv_penrad	rad outermost closed isobar(km)	0250 (Reported in 4 digits) (250 km)
integer tcv_vmax	max sfc wind speed (m/s)	028 (Reported in 3 digits)
integer tcv_vmaxrad	rad of max sfc wind spd (km)	040 (Reported in 4 digits) (half of average of radius of MSW)
integer tcv_r15ne	NE rad of 34 knots winds (km)	0170 (Reported in 4 digits)
integer tcv_r15se	SE rad of 34 knots winds (km)	0130 (Reported in 4 digits)
integer tcv_r15sw	SW rad of 34 knots winds (km)	0120 (Reported in 4 digits)
integer tcv_r15nw	NW rad of 34 knots winds (km)	0170 (Reported in 4 digits)
character*1 tcv_depth	Storm depth (S,M,D,X) S stands for shallow (for D), M stands for Medium (for DD), D stands for Deep (for CS and above) and X stands for missing	M

Example:

IMD 04B VARDAH 20161210 0000 126N 0884E 300 055 0990 1006 0250 028 040 0200 0180 0180 0200 D

ANNEX II-A-1

CLASSIFICATION OF TROPICAL CYCLONE WARNING SYSTEMS IN THE PANEL COUNTRIES

Existing classifications of low pressure systems (cyclonic disturbances) in the Panel countries are given below together with the WMO classifications.

***Classification of low pressure systems (cyclonic disturbances)
presently in use by Panel countries for national purposes)***

<u>Country</u>	<u>Type of Disturbance</u>	<u>Corresponding Wind Speed</u>
Bangladesh	Low pressure area	Less than 17 knots (less than 31 km/h)
	Well marked low	17- 21 knots (31-40km/h)
	Depression	22- 27 knots (41-51km/h)
	Deep Depression	28- 33 knots (52-61km/h)
	Cyclonic storm	34 -47 knots (62-88 km/h)
	Severe cyclonic storm	48- 63knots (89-117 km/h)
	Severe cyclonic storm with a core of hurricane wind	64 – 119 knots (118-221km/h)
	Super cyclonic storm	120 knots and above (222 km/h or more)
India	Low pressure area	Less than 17 knots
	Depression	17 -27 knots
	Deep Depression	28- 33 knots
	Cyclonic storm	34 -47 knots
	Severe cyclonic storm	48 -63 knots
	Very severe cyclonic storm	64 -89 knots
	Extremely severe cyclonic storm	90 -119 knots
	Super cyclonic storm	120 knots and above
Maldives	Low pressure area	Less than 17 knots
	Depression	17- 27 knots
	Deep Depression	28 -33 knots
	Cyclonic storm	34 -47knots
	Severe cyclonic storm	48 -63knots
	Very severe cyclonic storm	64 -119knots
	Super cyclonic storm	120 knots and above
Myanmar	Low pressure area	Less than 17 knots
	Depression	17- 27 knots
	Deep Depression	28 -33 knots
	Cyclonic storm	34 -47 knots
	Severe cyclonic storm	48 -63 knots
	Very severe cyclonic storm	64 -119 knots
	Super cyclonic storm	120 knots and above
Oman (Sultanate of Oman)	Low	Less than 17 knots
	Depression	17-27 knots
	Deep depression	28-33 knots
	Tropical storm	34-63 knots
	Tropical cyclone	64 knots or more
Pakistan	Depression	22- 27knots
	Deep Depression	28- 33knots
	Cyclonic storm	34 -47knots
	Severe cyclonic storm	48- 63knots
	Very severe cyclonic storm	64- 119 knots
	Super cyclonic storm	120 knots or more

ANNEX II-A-2

<u>Country</u>	<u>Type of Disturbance</u>	<u>Corresponding Wind Speed</u>
Sri Lanka	Low pressure area	Less than 17 knots
	Depression	17- 27 knots
	Deep Depression	28- 33 knots
	Cyclonic storm	34 -47 knots
	Severe cyclonic storm	48- 63 knots
	Very severe cyclonic storm	64 -119 knots
	Super cyclonic storm	120 knots and above
Thailand	Tropical depression	27 - 33 knots
	Tropical Cyclones	34 knots and more
Yemen	Low pressure area	Less than 17 knots
	Depression	17 -27 knots
	Deep Depression	28- 33 knots
	Cyclonic storm	34 -47 knots
	Severe cyclonic storm	48 -63 knots
	Very severe cyclonic storm	64 -89 knots
	Extremely severe cyclonic storm	90 -119 knots
	Super cyclonic storm	120 knots and above
WMO Classification (Vide WMO No.471)	Tropical depression	Up to 34 knots
	Moderate tropical storm	34- 47 knots
	Severe tropical storm	48 -63 knots
	Hurricane (or local synonym) Winds	64 knots and more
	Tropical disturbance of Unknown intensity	Wind speed uncertain

Tropical Cyclone Warning System in Bangladesh

Organization

The Bangladesh Meteorological Department is responsible for providing tropical cyclone warnings to Bangladesh and its coastal areas and for a designated portion of the high seas in the Bay of Bengal. Warnings and forecasts are issued under the authority of the Director, Bangladesh Meteorological Department.

The tropical storm warnings are provided from the Storm Warning Centre, Agargaon, Dhaka. This Centre is also responsible for issuing the weather warnings like "Nor'westers" (severe local storms) warning, etc.

Tracking

The tropical cyclones are tracked with the help of conventional observations, radar, satellite observations and model derived products.

Tropical cyclone warnings

Tropical cyclone warnings are provided to:

- (i) The Honorable President
- (ii) The Honorable Prime Minister
- (iii) Control room, Ministry of Food and Disaster Management (MoFDM)
- (iv) All ministries
- (v) The Sea Port Authorities at Chittagong, Mongla and Cox's Bazar
- (vi) The Cyclone Preparedness Programme (CPP), Bangladesh Red Crescent Society
- (vii) The Armed Forces division, Bangladesh Navy, Bangladesh Air Force
- (viii) Inland river ports authorities
- (ix) Airport authorities
- (x) Concerned government officials
- (xi) The general public (through Betar (Radio) Television, electronic media and mass media)
- (xii) Fishing boats and trawlers in the sea
- (xiii) Coast Guard
- (xiv) The NGOs

Stages of warnings

Warnings are issued in four stages for the government officials. The first stage called "Alert" is issued to all concerned whenever a disturbance is detected in the Bay as per Standing Orders for Disasters (SOD) of Bangladesh. In the second stage, cyclone warnings are issued in four stages as detailed below:

- (i) (a) Distant Cautionary Signal- issued if a ship might run into danger during its voyage after leaving the harbour.
(b) Distant Warning Signal issued when there is no immediate danger of the port but a ship might run into the storm after leaving the port.
- (ii) (a) Local Cautionary Signal – issued when port is threatened by squally weather from tropical disturbances or nor'westers.

(b) Local Warning Signal issued when the port is threatened by a storm, but it does not appear that the danger is as yet sufficiently great to justify extreme measures of precaution. It is issued minimum 24 hours before the landfall.
- (iii) Danger Signal issued when the port is likely to experience severe weather from a storm of slight or moderate intensity. The Signal is issued minimum 18 hours before the landfall.
- (iv) Great Danger Signal issued when the port is likely to experience severe weather from a storm of great intensity. The signal is issued minimum 10 hours before the landfall.

Format of the cyclone warning bulletin

Cyclone warning bulletins contain the following information:

- (i) Name of the storm
- (ii) Position of the storm centre
- (iii) Direction and speed of movement in knots for international use and km/h for national use.
- (iv) Distance of the storm centre from the ports.
- (v) Maximum sustained wind within the radius of maximum wind of the disturbance.
- (vi) Signals for the maritime ports.
- (vii) Areas likely to be affected specifying Police Station (Thana) of subdivision as far as possible.
- (viii) Approximate time of commencement of gale winds (speed more than 51 km/ h).
- (ix) Storm surge height in meter and areas likely to be inundated.
- (x) Advisory for fishing boats and trawlers over North Bay and Deep Sea.

Tropical cyclone warnings for the high seas

Tropical cyclone warnings for the high seas in Bangladesh are provided from the Storm Warning Centre at Dhaka and are broadcast from the coastal radio station at Chittagong (ASC). Warnings are issued for the Bay of Bengal region north of 18° N latitude.

Warnings to ports

In accordance with international procedure, ports are warned and advised to hoist "Signals" whenever adverse weather is expected over the ports for the oceanic areas, in which it is located due to the tropical cyclone. However, regional difference exists. The warning messages normally contain information on the location, intensity, direction and speed of movement of the tropical cyclone and the expected weather over the port. The tropical cyclone signals used in Bangladesh ports along with their meaning are given in Attachment to Annex II-B.

Dissemination

Warnings are disseminated through high priority landline telegrams, telefax, telephone and teleprinter. In addition, warnings are also transmitted to Betar (Radio) Bangladesh, Dhaka, Chittagong, Khulna, Rangpur, Rajshahi and Sylhet for broadcast. Alert messages are broadcast four to five times a day. "Warnings" are broadcast every hour and "Danger" and "Great Danger" messages are broadcast frequently.

Dissemination of tropical cyclone warnings

- (i) Telefax
- (ii) Telephones
- (iii) Automatic Message Switching System (AMSS)
- (iv) Bangladesh Betar (Radio)
- (v) Television
- (vi) Through print & electronic media
- (vii) W/T
- (viii) Internet, by keeping information on BMD website (<http://www.bmd.gov.bd>).

Cyclone warning system in India

The India Meteorological Department is responsible for providing tropical cyclone warnings in India. The tropical cyclone warning service is one of the most important functions of the India Meteorological Department and it was the first service undertaken by the Department in 1865 with the issue of Port Warnings for Calcutta. Thus cyclone warning service is more than 150 years old.

Organization

Tropical cyclone warnings in India are provided through three Area Cyclone Warning Centres (ACWCs) located at Kolkata, Chennai and Mumbai and three Cyclone Warning Centres at Bhubaneswar, Visakhapatnam and Ahmedabad. The entire cyclone warning work is coordinated by the Scientist-G and Head (Services) at New Delhi.

Tracking of tropical cyclones

Tracking of the tropical cyclones in India is done with the help of:

- (vii) Conventional surface and upper air observations from inland and island stations, coastal Automatic Weather Station (AWS), ships and buoy observations;
- (ii) Cyclone detection radar including Doppler Weather Radar;
- (iii) Satellite cloud pictures from the Geostationary Satellite (INSAT 3D, INSAT 3A & Kalpana1) and polar orbiting satellites.

More details on the observing system are provided in a separate chapter.

Tropical Cyclone Forecasting

Details about tropical forecasting procedures are discussed in Chapter-IV.

Tropical cyclone warnings

The bulletins and warnings issued in connection with tropical cyclones in India may be divided into the following broad categories:

- (i) Warning bulletins for shipping on the high seas.
- (ii) Warning bulletins for ships plying in the coastal waters.
- (iii) Port warnings.
- (iv) Fisheries warnings. (Fishermen & Fisheries Officials)
- (v) Four stage warnings for the State and Central Government officials.
- (vi) Warnings for recipients who are registered with the department (Designated/registered users).
- (vii) Warning for aviation.
- (viii) Warnings for the general public through All India Radio, TV (including Doordarshan), Press and other electronic media.
- (ix) Warning for Indian Navy.

Format and examples of all these bulletins are shown as Attachment to Annex II-C1

Bulletins for the high seas

These bulletins are for the shipping interests on the high seas. The area covered by these bulletins is the sea area between the Asian Coast and the line joining the points 24° N 68° E, 20° N 68° E, 20° N 60° E, 5° N 60° E, 5° N 95° E, 10° N 95° E, 10° N 94° E, 13° 30'N 94° E, 13° 30'N 92° E, 18° N 92° E and 18° N 94° 30'E. The exact area of coverage is shown below (Fig.- Annex II-C-1).

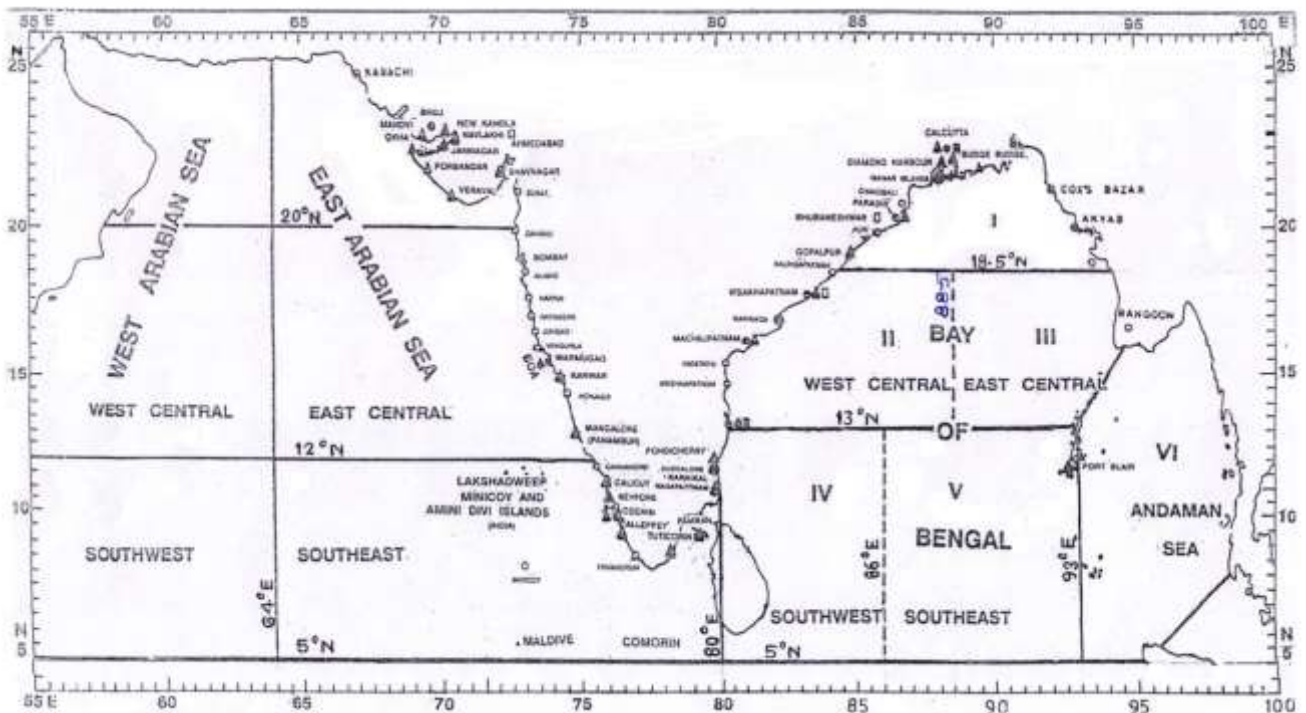


Fig. II-C-I. The exact area of coverage

These bulletins are issued by the Area Cyclone Warning Centres at Kolkata and are broadcast by the Coastal Radio Stations of the Department of Telecommunication (DoT) and "NAVTEX Chennai". These bulletins are issued by the Area Cyclone Warning Centres; Mumbai is available to the users through e-mail/fax and uploaded in the website of RMC Mumbai. The bulletins for the Arabian Sea broadcast from Mumbai Radio are issued by the Area Cyclone Warning Centre at Mumbai, whilst those for the Bay of Bengal, broadcast from Kolkata and Chennai Radio, are issued by the Area Cyclone Warning Centre at Kolkata. Under the GMDSS programme of WMO/IMO, India is issuing GMDSS bulletins for met area VIII (N) daily at 0900 UTC and 1800 UTC with additional warning during cyclone period. These bulletins consist of six parts. They are:

- Part I : Tropical Cyclone Warning in plain language.
- Part II : Synopsis of weather conditions in the forecast area in plain language.
- Part III : Forecast in plain language.
- Part IV : Analysis of the surface synoptic chart in IAC Fleet Code.
- Part V : Data of observations from ships in WMO codes.
- Part VI : Data of observations from selected land stations and upper air reports in WMO codes.

In normal undisturbed weather, two bulletins are broadcast at fixed hours known as "Daily" bulletins. In the event of disturbed weather (depression in the Bay of Bengal and the Arabian Sea), a third bulletin known as "Extra" bulletin is broadcast.

When a cyclonic storm has developed, three additional bulletins known as 'Storm' bulletins are broadcast. In addition to these six bulletins, if any unexpected development of weather warrants urgent communication to ships, a "Special" bulletin is issued which may be broadcast at any time. These bulletins are broadcast according to a schedule at fixed hours. Daily bulletins broadcast from Mumbai and Kolkata consist of all the above six parts, while those from Chennai consist only of Parts I, II and III. "Extra", "Storm" and "Special" bulletins contain only Part I.

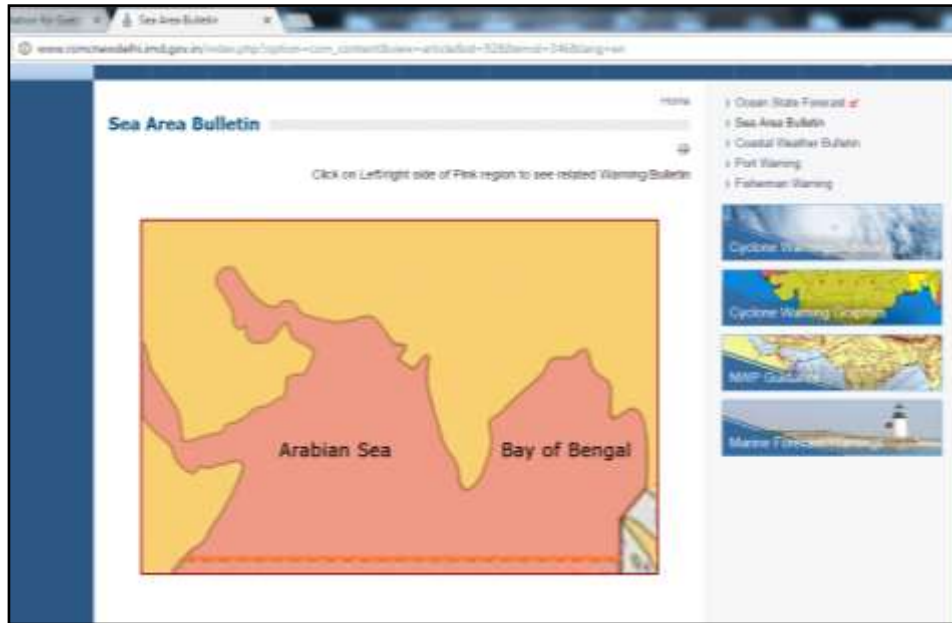


Fig. II C-2: Sample Sea Area bulletin available at RSMC New Delhi website

Coastal Weather Bulletins

These bulletins give weather information in greater detail in the coastal areas for the benefit of ships plying mainly in coastal areas. For the purpose of these bulletins, the coastal area is defined as the sea area up to 75 km off the coastline.

As in the case of sea bulletins for merchant ships, the coastal bulletins are broadcast from Navtex, Chennai. In normal weather coastal bulletins are broadcast twice daily (Daily One at 0630 UTC and Daily Two at 1830 UTC respectively). These are known as "Daily" bulletins. Whenever a depression, tropical cyclone or some other phenomenon influences the weather of the coastal strip concerned "Extra", "Storm" and "Special" bulletins for the coastal strip are also broadcast in addition to "Daily" bulletins.

Each bulletin first gives the name of the coastal strip to which it pertains followed by the details of the weather system, if any, affecting the coastal area. It also includes a forecast of wind, weather, visibility and state of sea for the coastal strip. Information on storm surges/tidal waves and areas likely to be affected are given whenever necessary. The bulletins also give information regarding storm warning signals, if any, hoisted at the ports in the coastal strip concerned.

The coastal bulletins pertaining to India coast are sent to control room of Director General of Lighthouse and Light ships (DGLL) at Mumbai through e-mail and Automated message switching System (AMSS) at IMD, Mumbai for broadcast through 11 Navtex stations along the coast. These bulletins are also uploaded on RSMC Website (www.rsmcnewdelhi.imd.gov.in). A sample is shown in Fig. II C-3.

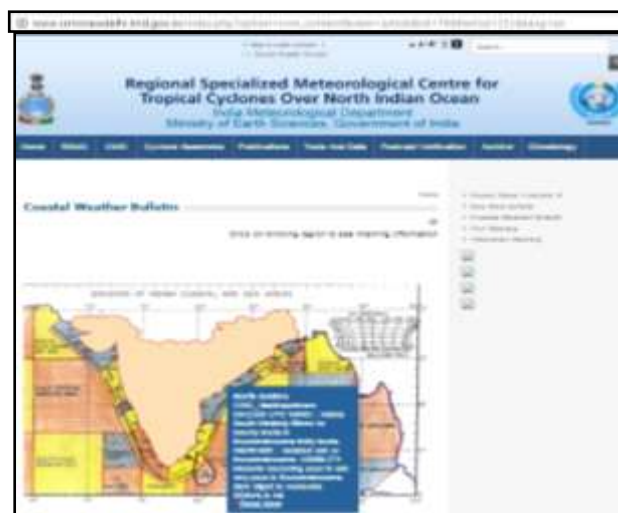


Fig. II C-3: Sample Coastal Weather bulletin available at RSMC New Delhi website

Storm warnings to ports

A visual storm warning signal system for the Bay of Bengal ports, chiefly for the port of Kolkata, has been in existence since 1865. A similar system for the ports on the west coast was started in 1880. A uniform system applicable to all Indian ports was introduced in 1898.

The India Meteorological Department issues storm warnings to port officers whose ports are likely to be affected by adverse weather. They are also advised to hoist visual storm warning signals for the benefit of ships at the port and those out at sea. The information is, in most cases, conveyed by very high priority telegrams/fax/e-mail.

The storm warning signals, which are displayed prominently on masts in ports, are in the form of cones and cylinders for day signals and red and white lamps for night signals. In addition to hoisting signals, port officers have, in most cases, arrangements for disseminating the information and warnings received by them to country crafts and sailing vessels in the harbor. These bulletins are also uploaded on RSMC Website (www.rsmcnewdelhi.imd.gov.in). A sample is shown in Fig. II C-4.

The meaning of the signals used in Indian ports is given in Attachment to Annex II-C2.



Fig. II C-4: Sample Port Warning bulletin available at RSMC New Delhi website

Fisherman Warnings

Warnings for fisherman and fishery officials are issued by Area Cyclone Warning Centres as per their area of responsibility and uploaded on RSMC website. A sample is shown in Fig. II C-5.

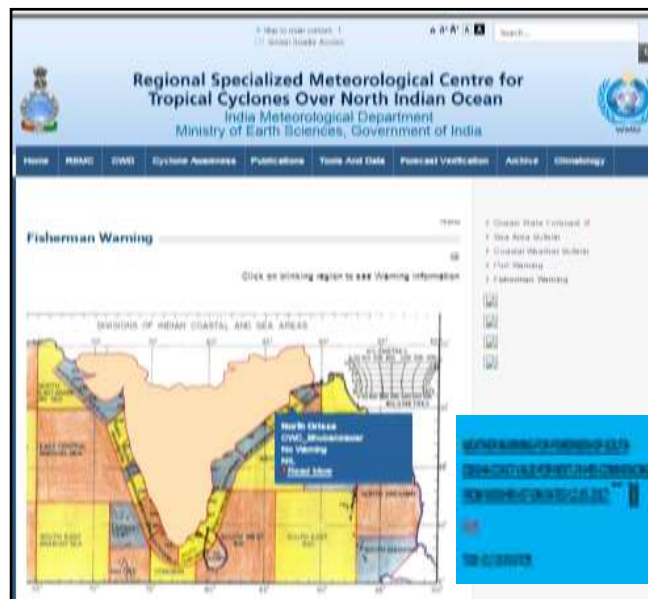


Fig. II C-5: Fisherman Warning bulletin available at RSMC New Delhi website

Tropical storm warnings to government officials (Four stage warnings)

A "pre-cyclone watch" bulletin is issued by DGM himself soon after the formation of a depression informing senior central government officials including chief secretary of coastal maritime States about likely development of a cyclonic storm, its movements, coastal belt of India likely to experience adverse weather. This bulletin is issued at least 72 hours in advance of commencement of adverse weather.

At the second stage, a "cyclone alert" is issued at least 48 hours in advance of the expected commencement of adverse weather in association with the cyclonic storm over the coastal area. The third stage of the warning, known as "cyclone warning" is issued at least 24 hours in advance of commencement of severe weather. The last stage of warning covering the post-landfall scenario is included in the cyclone warnings issued 12 hrs before the expected time of landfall and is continued till the cyclonic wind force is maintained in the core area of the cyclonic storm over land.

Post landfall outlook

Post-landfall outlook will be issued as a part of cyclone warning at least 12 hours in advance of the landfall of the system by RSMC New Delhi and the concerned ACWC. On the basis of this outlook, the concerned RMC/MC which are likely to be affected will also issue cyclone warnings for the interior area. This is the regular cyclone warning.

Dewarning Message

As and when a given coastal belt is expected to become free from the impact of TCs, a dewarning message is issued to the ports and disaster management agencies in India as a part of four stage warning system.

Tropical cyclone bulletins to All India Radio (AIR) for broadcast

In general, weather bulletins are issued by the meteorological offices to the AIR stations for broadcast in the midday transmissions. These are based on 0300 UTC charts. The areas covered by the bulletins are the areas served by the respective AIR stations (AM and FM). These bulletins include:

- (i) A summary of the past weather;
- (ii) special weather warnings for public services such as the Public Works Department, Irrigation, DoT, Railways, etc. &
- (iii) General forecast including warnings.

Points (ii) and (iii) are valid until the morning of the second day. The summary of weather includes information about tropical storms and depressions affecting the area. The centre of the system is included with reference to the nearest well known place and latitude and longitude. Warnings in bulletins once included are repeated in the subsequent daily bulletins also as long as adverse weather is anticipated. In addition, meteorological centres in the maritime states include suitable warnings for fishermen. These general bulletins are broadcast at a fixed time (midday) by the AIR stations and are intended to meet the requirements of the public in general and the needs of various categories of officials in particular.

In addition, special AIR bulletins containing cyclone alert messages issued 48 hours prior to the commencement of the adverse weather and tropical cyclone warning messages issued 24 hours prior to the commencement of the adverse weather in the coastal areas due to an approaching tropical storm are broadcast. These broadcasts are meant to alert the agencies entrusted with the responsibility of carrying out cyclone preparedness works and also the general public.

(For framing the tropical storm warning bulletins to AIR and Doordarshan abbreviated terms like "cyclone" for cyclonic storm, "severe cyclone" for the severe cyclonic storm and "super cyclone" for super cyclonic storm etc. are also used.)

The height of the storm surge is included in the bulletin in meters and it represents height above the normal tide level. The coastal districts likely to be affected by the storm are mentioned in the first sentence of the bulletins. The types of damage likely to be expected from systems of various intensities along with the suggested action are also included. For this purpose the following table is referred.

Damage Potential and Action Suggested

Category/ T.No/ Wind Speed	Structures	Communi- & Power	Road/Rail	Agriculture	Marine Interests	Coastal Zone	Overall Damage Category	Suggested Actions
Deep Depression T 2.0 52 – 61 kmph (28-33 knots)	Minor damage to loose / unsecured structures		Some breaches in Kutchra road due to flooding.	Minor damage to Banana trees and near coastal agriculture due to salt spray. Damage to ripe paddy crops.	Very rough seas. Sea waves about 4-6 m high.	Minor damage to Kutchra embank- ments.	Minor	Fishermen advised not to venture into sea.
Cyclonic Storm T 2.5-T 3.0 62 – 87 kmph (34-47 knots)	Damage to thatched huts.	Minor damage to power and communi- cation lines due to breaking of branches.	Major damage to Kutchra and minor damage to Pucca roads.	Some damage to paddy crops, banana, papaya trees and orchards.	High to very high sea waves about 6-9 m high.	Sea water inundati- on in low lying areas after erosion of Kutchra embank- ments.	Minor to moderate.	Fishermen advised not to venture into sea.
Severe Cyclonic Storm T 3.5 88-117 kmph (48-63 knots)	Major damage to thatched houses/ huts. Roof tops may blow off. Unattache- d metal sheets may fly.	Minor damage to power and communi- cation lines.	Major damage to Kutchra and some damage to Pucca roads. Flooding of escape routes.	Breaking of tree branches, uprooting of large avenue trees. Moderate damage to banana and papaya trees. Large dead limbs blown from trees.	Phenome- nal seas with wave height 9- 14 m. Movemen- t in motor boats unsafe.	Major damage to coastal crops. Storm surge upto 1.5 m (area specific) causing damage to embank- ments/ salt pans. Inundati- on upto 5 km in specific areas.	Moderate	Fishermen advised not to venture into sea. Coastal hutment dwellers advised to move to safer places. Other people in the affected areas to remain indoors.
Very Severe Cyclonic Storm T 4.0- T 4.5 118-166 kmph	Total destruction of thatched houses/ extensive	Bending/ uprooting of power and communi- cation	Major damage to Kutchra and and Pucca roads. Flooding of	Widesprea- d damage to standing crops, plantation	Phenome- nal seas with wave height more than 14 m.	Storm surge upto 2 m. Inundatio- n upto 10 km in	Large	Fishermen not to venture into sea. Evacuation from

(64-89 knots)	damage to kutcha houses. Some damage to pucca houses. Potential threat from flying objects.	poles.	escape routes. Minor disruption of railways, overhead powerlines and signalling systems.	s, orchards, falling of green coconuts and tearing of palm fronds. Blowing down of bushy trees like mango.	Visibility severely affected. Movement in motor boats and small ships unsafe.	specific areas. Small boats, country crafts may get detached from moorings.		coastal areas need to be mobilized. People advised to remain indoors. Judicious regulation of rail and road traffic needed.
Extremely Severe Cyclonic Storm T 5.0- T 6.0 167-221 kmph (90-119 knots)	Extensive damage to all types of kutcha houses, some damage to old badly managed Pucca structures. Potential threat from flying objects.	Extensive uprooting of communication and power poles.	Disruption of rail/road link at several places.	Extensive damage to standing crops, plantations, orchards. Blowing down of Palm and coconut trees. Uprooting of large bushy trees.	Phenomenal seas with wave height more than 14 m. Movement in motor boats and small ships not advisable.	Storm surge upto 2-5 m. Inundation may extend upto 10-15 km in specific areas. Large boats and ships may get torn from their moorings.	Extensive	Fishermen not to venture into sea. Evacuation from coastal areas essential. Diversion/suspension of rail and road traffic may be required.
Super Cyclonic Storm T 6.5 and above 222 kmph and more (120 knots and more)	Extensive damage to non-concrete residential and industrial buildings. Structural damage to concrete structures. Air full of large projectiles.	Uprooting of communication and power poles. Total disruption of communication and power supply.	Extensive damage to Kutcha roads and some damage to poorly repaired pucca roads. Large scale submerging of coastal roads due to flooding and sea water inundation. Total disruption of railway and road traffic due to major damages to bridges, signals and railway tracks. Washing away of rail/road links at several places.	Total destruction of standing crops/orchards. Uprooting of large trees and blowing away of palm and coconut crowns, stripping of tree barks.	Phenomenal seas with wave heights of more than 14m. All shipping activities unsafe.	Extensive damage to port installations. Storm surge more than 5m, inundation upto 40 km in specific areas and extensive beach erosion. All ships torn from their moorings. Flooding of escape routes.	Catastrophic	Fishermen not to venture into sea. Large scale evacuations needed. Total stoppage of rail and road traffic needed in vulnerable areas.

These bulletins are generally issued at the time of each sea area bulletin. The frequency of the bulletin can be raised when the tropical storm is tracked with the help of radar and previous warnings issued needs modification.

A third set of bulletins issued to AIR is the coastal weather bulletins. Whenever a cyclonic storm is likely to affect the Indian coastal areas, coastal weather bulletins issued by the India Meteorological Department are broadcast in the All India News Cycles of All India Radio from New Delhi in English, Hindi and in the regional language of the area affected. These bulletins contain information on the following:

- 1) Time of issue of bulletin in IST
- 2) Coastal strip for which bulletin issued and period of validity
- 3) Position, intensity and movement of cyclonic storm
- 4) Forecast point and time of landfall
- 5) Signals hoisted at the ports in the coastal strip
- 6) Information of storm surges/tidal waves

Dissemination of tropical cyclone warnings

The modes of telecommunication used for the dissemination of tropical cyclone warnings in India are:

- (i) Telefax
- (ii) Telephones
- (iii) Automatic Message Switching System (AMSS)
- (iv) All India Radio
- (v) Television
- (vi) FM Radio
- (vii) Community Radio
- (viii) DTH
- (ix) Cyclone Warning Dissemination System (CWDS), Digital Cyclone Warning Dissemination System (DCWDS) one way communication system
- (x) W/T (especially police W/T)
- (xi) Internet, by keeping information on IMD website (<http://www.imd.gov.in>)/RSMC website(www.rsmcnewdelhi.imd.gov.in).
- (xii) Microwave link of the railways
- (xiii) IVRS
- (xiv) e-mail
- (xv) SMS
- (xvi) GMDSS
- (xvii) NAVTEX for coastal weather bulletin
- (xviii) Social Media (Face Book and Tweeter)

It is also being planned to issue cyclone alert through Google platform from postmonsoon season of 2015

The following warnings/advisory products are given in the dynamic page of cyclone page of IMD's website/RSMC website. When one type of communication channel fails, the alternate channel is used.

The screenshot displays the website for the Regional Specialized Meteorological Centre for Tropical Cyclones Over North Indian Ocean. The header includes the organization's name and logo, along with a search bar. The navigation menu lists various sections such as Home, RSMC, CWO, Cyclone Awareness, Publications, Tools And Data, Forecast Verification, Archive, Climatology, and Contact. The main content area features a large satellite image of a cyclone, a 'Cyclone Alerts' section with a 'Register for SMS Alerts' link, and a 'Quick Links' section with various links to weather forecasts, maps, and data. The footer contains contact information, social media icons, and a copyright notice.

Cyclone warning system in Maldives

The Maldives Meteorological Service (MMS) issue tropical cyclone and severe weather warning to the public and travelers across the country.

Tracking of Tropical Cyclone

Conventional observations, such as surface, upper air observations, automatic weather stations, ship reports, and radar and satellite observations are utilized for observing, detecting and tracking tropical cyclones. Numerical Weather Prediction models produced in-house and NWP charts provided by RIMES and advisories from RSMC are also used by forecasters.

Advisories and Warnings

Advisories and Warnings are issued for:

Heavy Rain, Thunderstorms
Strong Wind, Tornado
Rough Seas, Tidal/ Swell Waves

Advisories and Warnings are sent to:

Government's Executive Management
National Disaster Management
Ministry of Defense and National Security
Maldives Police Service
Coast Guard
Aviation Sectors
Tourism, Transport, Health Sectors
Fisheries, Agriculture, Education Sectors
TV media, Print media, Radio service.

Dissemination of Warning

The National Meteorological Centre has established the following means of communication for the dissemination of the warning.

Hotlines - Dedicated point to point telephone line between stake holders and NMC
SMS text messages
Local TV Channels
Local Radio Channels
Internet (<http://www.meteorology.gov.mv>) and email
Facsimile

ANNEX II-D-2

Alert and Warning criteria

Alert Level		Description	Action
1	WHITE	<ul style="list-style-type: none"> - Mean wind speed is expected or prevailed between 23 – 30 mph. - Rainfall of more than 50 mm is expected to occur within 24 hours. - High tidal waves are expected. 	Weather Information, but no immediate threat.
2	YELLOW	<ul style="list-style-type: none"> - Mean wind speed is expected or prevailed between 30 – 40 mph. - Torrential rain is expected and if heavy rain occurred for more than 2 hours. - A severe thunderstorm is expected or experienced. - Tropical Cyclone is formed within effective areas of Maldives. - Significant tidal or swell waves expected or experienced. 	Concern authorities and people living in the area to be on alert & be ready to take action. Travel by sea not advisable.
3	RED	<ul style="list-style-type: none"> -Flash flood is expected. -A tropical Cyclone is tracked to move closer or cross Maldives islands. -Destructive tidal or swell waves or storm surge is expected or observed. 	Evacuation of population from threatened areas to safer places. Prohibition of sea transportation.
4	GREEN	The condition has improved.	Cancel warning

Cyclone warning system in Myanmar

Cyclone warning system in Myanmar

Organization

Tropical cyclone warnings in Myanmar are provided by the Department of Meteorology and Hydrology (DMH), Myanmar. Tropical cyclone warnings are provided from the Multi-Hazard Early Warning Center of DMH in Nay Pyi Taw.

Tracking of Tropical Cyclone

Conventional observations, such as surface and upper air observations, ships' reports, and radar and satellite observations are utilized for observing, detecting and tracking tropical cyclones.

Tropical cyclone warnings

The Multi-Hazard Early Warning Center of DMH in Nay Pyi Taw is responsible for providing tropical cyclone and storm surge warnings to its coastal population, the ports along the Myanmar coast and for the designated area of the high seas in the Bay of Bengal. 24x7 Storm Watch Centers: Nay Pyi Taw Multi Hazard Early Warning Centre, Yangon Forecasting office, Mingaladon International Airport Aviation Forecasting office and all coastline observatories watch the storms whenever cyclones develop in the Bay of Bengal.

Storm news and warnings are issued at frequent intervals for national and international users in various sectors. Special storm warnings accompanied with color code and possible storm affected specific areas are issued hourly to all news media. National televisions televised all hourly news continuously in footnote rolling format frequently.

The area designated for Myanmar for providing warnings is the area of the Bay of Bengal east of 92° E and north of 10° N. Warnings are broadcast through the coastal radio station at Yangon (call sign XYR).

Port warning signals and their meanings used in the ports of Myanmar are given in Attachment to Annex II-E.

Dissemination of Storm Warning

Collection and dissemination of meteorological data and warnings are done with the coordination of Myanmar Posts and Telecommunications and Department of Civil Aviation point-to-point circuit. The modes of telecommunication used for the dissemination of tropical cyclone warnings in Myanmar are:

1. Telephone
2. Facsimile
3. Local TV (3 Channel)
4. Myanmar Radio
5. FM Radio
6. DMH website- www.moezala.gov.mm
7. Single Side Band Transceiver

Tropical Cyclone Warning System in Oman

Organization

Tropical cyclone warnings in Oman are provided by the Central Forecasting Office under the Directorate General of Meteorology and Air Navigation (DGMAN) which falls under Public Authority for Civil Aviation in cooperation with the National Committee for Civil Defense (NCCD).

Tracking

The Oman Regional Model as well as other international numerical weather prediction products are used for early warning. The Tropical Cyclones are tracked with the help of surface and upper air observation, satellite imagery and aircraft observations.

The tropical cyclones are tracked with the help of conventional surface and upper air observations, satellite images particularly the Kalpana-1 INSAT 3A.

Tropical Cyclone Warning

Tropical cyclone warnings are provided for:

- (i) The high seas
- (ii) Coastal waters
- (iii) Ports
- (iv) Civilian and military aviation
- (v) Governmental officials
- (vi) General public including fishermen
- (vii) Recipients registered with the DGMAN

Warning Procedures

The Central Forecasting Office will issue tropical storm report, advisory, warnings and amendments every 12 hours or more frequently if required by changing conditions. The Advisory or warning will contain the following information

- (i) Number
- (ii) Date and time
- (iii) Name of Storm
- (iv) Classification
- (v) Position of the Tropical storm
- (vi) Intensity
- (vii) Central pressure
- (viii) Movement the direction and speed
- (ix) Wind direction and speed around the centre
- (x) Destination from a coastal point
- (xi) Outlook

In the event the storm is expected to approach the coast of Oman, the following bulletins will be issued according to the stage:

Reports

When it is expected that a depression, storm, severe storm or cyclone may approach Oman coast within 72 hours, a report will be issued and it will be renewed every other 24 hours.

Advisory

When it is expected that a depression, storm, severe storm or cyclone May approach Oman coast within 48 hours an advisory will be issued and it will be renewed every other 6 hours.

Warning

When it is expected that a depression, storm, severe storm or cyclone may approach Oman coast within 24 hours a warning will be issued and it will be renewed every other 3 hours.

Last Report

When it is expected that a depression, storm, severe storm or cyclone is dissipating a report will be issued clearing the event.

Bulletins for high sea

Tropical cyclones warnings for the high seas in Oman are provided by the Central Forecasting Office located at Muscat International Airport and broadcasted from the Muscat coastal radio station at Muscat whose call sign is A4M.

Warnings for Ports

The Central Forecasting Office issues warnings to ports whenever adverse weather is expected to affect them

The main ports are:

- 1- Mina Sultan Qaboos in Muscat
- 2- Mina Salalah
- 3- Mina Sohar
- 4- Wudam Naval Base
- 5- Khasab
- 6- Qalhat
- 7- Al-Duqm

Dissemination of the Tropical Cyclone Warnings

The modes of telecommunication used for the dissemination of tropical cyclone warnings and advisories to different categories of recipients are:

- 1- Telephones
- 2- Telefax
- 3- Internet (E-mail, web site & Facebook and Twitter Page)
- 4- Short Messages Service (SMS)
- 5- Wireless Application protocol WAP
- 6- Voice Mail Pager System
- 7- Oman Radio
- 8- Oman Television
- 9- Muscat Radio Coastal Station

Bulletins for the High Seas

Tropical cyclones warnings for the high seas in Oman are provided by the Central Forecasting Office located at Muscat international Airport and are broadcast from the Muscat Coastal Radio Station at Muscat, whose call sign is A4M.

Warnings to Ports

The Central Forecasting Office of the Meteorological Department issues storm warnings to ports whenever adverse weather is expected to affect them.

The main Ports are:

- (i) Mina Sultan Qaboos in Muscat
- (ii) Mina Salalah
- (iii) Wudam Naval Base
- (iv) Khasab
- (v) Sohar
- (vi) Qalhat
- (viii) Al-Dukm

Dissemination of Tropical Cyclone Warnings

The modes of telecommunication used for the dissemination of tropical cyclone warnings and advisories to different categories of recipients are:

- (i) Telephones
- (ii) Telefax
- (iii) Voice Mail Pager System
- (iv) Oman Radio
- (v) Oman Television
- (vi) Muscat Radio Coastal Station
- (vii) Web site: www.met.gov.om & Facebook /Twitter Page
- (viii) Email

Tropical cyclone warning system in Pakistan

Pakistan Meteorological Department is responsible for the preparation and issuance of tropical cyclone warnings in Pakistan. The tropical cyclone warnings are issued by Marine Meteorology & Tropical Cyclone Warning Centre of PMD.

Tracking of the tropical cyclones

Tracking of the tropical cyclone in Pakistan is done with the help of following:

- (i) Conventional surface and upper air observations from inland stations and ships' observations
- (ii) Model outputs and guidance from the global tropical cyclones warning centres
- (iii) The NWP products of High resolution Regional Model (implemented at PMD)
- (iv) Cyclone detection radar
- (v) Meteorological satellites data products.
- (vi) AWSs installed at coast along Sindh and Makran (Balochistan)

Tropical cyclone Watch, Alert and Warning

Tropical cyclone Watch, Alert and Warning are issued by PMD's Marine Meteorology & Tropical Cyclone Warning Centre as per following criteria:

Tropical cyclone Watch is issued when a tropical cyclone gets formed or enters the Arabian Sea north of Lat. 10°N. Tropical cyclone Watch is issued irrespective of cyclone's threat to affect Pakistan's coastal areas. The issuance of tropical cyclone Watch requires the concerned authorities to be watchful.

Tropical cyclone Alert is issued when there is likelihood that tropical cyclone may affect Pakistan's coastal areas.

Tropical cyclone Warning is issued when there is very likelihood that tropical cyclone may affect Pakistan coast. Tropical cyclone warnings are issued every three (3) or six (6) hours and/or whenever necessary and imperative.

Tropical cyclone warnings

The bulletins and warnings issued in connection with tropical cyclones in Pakistan are divided into the following broad categories:

- i. Warning bulletins for shipping on the high seas
- ii. Warning bulletins for ships plying in the coastal waters
- iii. Port warnings
- iv. Fisheries warnings
- v. Warnings for Government officials and functionaries including National Disaster Management Authority (NDMA) and Provincial Disaster Management Authorities (PDMAs) and District Management Authorities (DDMAs)
- vi. Warnings for recipients who are registered with PMD
- vii. Warnings for aviation
- viii. Warnings for the general public through electronic and print media
- ix. Warnings to CBOs, NGOs and INGOs
- x. Warning to Search and Rescue (SAR) Operations

Types of warnings

Bulletins for the high seas

These bulletins are for the shipping interests on the high seas. The area covered includes the North Arabian Sea (north of 20° N). Coverage is shown in Fig. II-1

These bulletins are issued by the PMD's Marine Meteorology -Tropical Cyclone Warning Centre, Karachi and are broadcast by the Coastal Radio Stations. These bulletins consist of three parts.

- Part I : Tropical Cyclone Warning in plain language.
- Part II : Synopsis of weather conditions in the forecast area in plain language.
- Part III : Forecast in plain language (for weather, wind, visibility and sea state etc.).

During normal undisturbed weather, two bulletins are broadcast at fixed hours known as "Daily" bulletins. In the event of disturbed weather additional bulletins are issued.

Storm warnings to ports

PMD's Marine Meteorology & Tropical Cyclone Warning Centre issues warnings to the Ports whose parts are likely to be affected by adverse weather. They are also advised to hoist the visual storm warning signals for the benefit of ships at the port and those out at sea. The information is, in most cases, conveyed by facsimile, SMS and telephone. The meaning of the port warning signals used in Pakistan ports is given in Attachment to Annex-II-G.

Dissemination of tropical cyclone warnings

The modes of telecommunication used for the dissemination of tropical cyclone warnings in Pakistan are:

- i. Coastal Radio (ASK)
- ii. Telephones
- iii. Electronic and print media
- iv. Radio Pakistan
- v. Pakistan television
- vi. Telex/Telefax
- vii. Internet, PMD's website: www.pmd.gov.pk
- viii. SMS and
- ix. FM radios

The mode of telecommunication differs for different types of messages. When one type of communication channel fails, the alternate channel is used.

Storm Surge Analysis

The storm surge analysis (using IIT_D model) is carried out on the basis of available climatological data for the guidance and awareness of public in general and concerned authorities in particular for preparedness and evacuation of coastal communities and safety of lives and properties; well in advance.

Cyclone warning system in Sri Lanka

Organization

The responsibility of the cyclone warning in Sri Lanka rests with the Department of Meteorology, Sri Lanka. Tropical cyclone warnings are provided from the National Meteorological Centre (NMC) Colombo.

Tracking

Tropical cyclones are tracked with the help of conventional observations, radar, satellite observations and aircraft reports. These are dealt with in more detail in a separate chapter.

Tropical cyclone warnings

Tropical cyclone advisories/ alerts/ warnings are issued under two criteria, viz., Distance from the Coast and Intensity of the System, each criterion having key stages.

(a). Distance Criterion

(i) When a depression or a cyclonic storm is about 550 km off the coast.

In addition to distance of storm centre from coast, this bulletin indicates forecast conditions on the (a) speed and direction of movement and (b) maximum surface wind speed likely. This bulletin is issued every twelve (12) hours and wherever imperative.

(ii) When the cyclonic storm is 300 km off the coast.

In addition to above contents, information on areas likely to be affected are provided. This bulletin is issued every six (6) hours and wherever imperative. and





(iii) When the cyclonic storm is 200 km off the coast.

If landfall is indicated, a bulletin is issued every three (3) hour and wherever imperative. This bulletin includes additional information on point of landfall, storm surges and areas likely to be inundated.

Signal No.	Colour	Description	Action required
1	White	Potential area of development	Information only, vessels at sea to be vigilant.
2	White	Cyclone has formed	Information only, vessels to avoid the area, listen to media.
3	Yellow	Weather experienced in coastal region, sea getting rough	Vessels to avoid the area, people to stay away from sea/ beach.
4	Yellow	Raining with windy (~40 knots), sea rough	Stay away from beach, vessels in danger, be inside building.
5	Yellow	Heavy rain with very strong wind (>40 knots)	Be ready to leave buildings with weak structures (in relevant areas only) and low lying (flood prone) areas, secure your home/valuables.
6	Red	Heavy rain with very strong wind >40 kts, cyclone expected to cross land	Evacuate to pre-designated safe places
7	Red	Severe weather very strong wind (>50 knots), severe cyclone expected to cross land	Evacuate to pre-designated safe places
8	Green	Cyclone warning cancellation/withdrawal bulletin	

ANNEX II-H-2

Four colour code with flags are used for easy and quick under standing

Signal No	Colours	Description	Action Required
1	white 	Potential area of possibility to development of vortex /disturbance /	Information only, Vessels at sea to be vigilant and avoid the area, Listen to media
2	Yellow 	Cyclone has formed in the vicinity, heavy rain with strong winds, rough seas (30-40 kts, 55-75kmph)	Stay away from beach/sea, vessels in danger/be inside building/ Be ready to leave weak buildings and low lying areas (flood prone areas), secure your home valuables
3	Red 	Cyclone is expected to cross land, Very heavy rain/very strong winds (v>50kts,100kmph)	Evacuate to predesignated areas
4	Green 	Cyclone warning cancellation/withdrawal bulletin	

(b). Intensity Criterion (Signal levels)

(i) When the cyclonic storm is 300 km off the coast.

In addition to above contents, information on areas likely to be affected are provided. This bulletin is issued every six (6) hours and wherever imperative and

(ii) When the cyclonic storm is 200 km off the coast and if landfall is indicated, a bulletin is issued every three (3) hour and wherever imperative. This bulletin includes additional information on point of landfall, storm surges and areas likely to be inundated.

Tropical cyclone warning

Tropical cyclone warnings for different users

- Relevant Government Officials including HE President & Prime Minister
- Disaster Management Centre (DMC)
- General Public
- Media
- The Armed Services & Police
- Local Administrations of relevant districts and
- Irrigation, Highways etc.

Specific users

- Coastal fishing
- Shipping and
- Aviation

Tropical cyclonic warnings for the high seas

For the high seas, the tropical cyclone warnings are provided from NMC Colombo and broadcast through the coastal radio station Colombo Radio (4PB). The area covered by the warnings is the Indian Ocean, Arabian Sea and the Bay of Bengal from the equator to 10⁰ N between 60⁰ E and 95⁰ E. The port warning signal used are given in Attachment to Annex II-H

Dissemination of tropical cyclone warnings

The warnings/bulletins for the high seas are disseminated through Colombo (4PB). Other general modes are:

- State and Private Radio
- State and Private Television
- Press/Print Media
- Telephones/Pager/ SMS
- Police Communication
- Tele-printer
- Telefax
- Internet SLMD website (<http://www.meteo.gov.lk>)
- Through warning towers of Disaster Management Centre

Tropical cyclone warnings in Thailand

Organization

Tropical cyclone and severe weather warnings and advisories in Thailand are provided by the Thai Meteorological Department (TMD), Thailand, from the Weather Forecast Bureau, TMD Headquarters at Bangkok to the government agencies concerned, specific users, high seas and general public throughout the country.

Tracking of Tropical Cyclones

Tracking of tropical cyclones in Thailand is done with the help of conventional surface and upper air observations, ships and buoy observations, radar and satellites observations, model outputs and guidance from the global tropical cyclones warning centers. These are dealt with in more details in a separate chapter.

Tropical Cyclones Warning Procedure

System Intensity	Action taken by TMD	Dissemination and Modes of Telecommunications
Active low trends to be storm (Less than 27 Knots)	Weather Report will be issued every 6 hours containing information on date and time, weather situation, and weather forecasting.	To high seas By broadcasting through the Bangkok coastal radio stations (HSA,) for the areas covered by the Gulf of Thailand, west of Southern Thailand, Strait of Malacca and the South China Sea. (every 3 hours)
		To coastal stations and ports By : Telephone, Facsimile, Email, SMS, Social Media (Facebook, Line), Thailand Radios/ and Thailand TVs, TMD Mobile Application, TMD Radio, TMD Website : www.tmd.go.th , http://www.metalarm.tmd.go.th (every 6 hours)
Tropical depression (27-33 Knots)	Comprehensive Warning/ Advisory will be issued every 6 hours containing : (i) Issuing number (ii) Date and time (iii) Classification by intensity (iv) Position of the tropical storm (v) Central pressure (vi) Movement the direction and speed (vii) Wind direction and maximum wind near the centre (viii) Destination from a coastal point	To high seas By broadcasting through the Bangkok coastal radio stations (HSA,) for the areas covered by the Gulf of Thailand, west of Southern Thailand, Strait of Malacca and the South China Sea. (every 3 hours)
		To coastal stations and ports By : Telephone, Facsimile, Email, SMS, Social Media (Facebook, Line), Thailand Radios/ and Thailand TVs, TMD Mobile Application, TMD Radio, TMD Website : www.tmd.go.th , http://www.metalarm.tmd.go.th (every 6 hours)
		Port warning signals used in Thailand Ports are given in Attachment to Annex II-I. To government agencies concerned namely : <ul style="list-style-type: none"> • Department of Disaster Prevention and Mitigation (DDPM) • Port Authority of Thailand (PAT) • Marine Department (MD) • National Disaster Warning Center (NDWC) • Governors of risk provinces To specific users (aviation, fishery, etc.), media and general public By : Telephone, Facsimile, Email, SMS, Social Media (Facebook, Line), Thailand Radios/ and Thailand TVs, TMD Mobile Application, TMD Radio, TMD Website : www.tmd.go.th , http://www.metalarm.tmd.go.th (every 6 hours)
Tropical Cyclones (34 knots)	Comprehensive Warning/ Advisory will be issued every 3 hours containing :	To high seas By broadcasting through the Bangkok coastal radio stations (HSA,) for the areas covered by the Gulf of Thailand, west of

and more)	(i) Issuing number (ii) Date and time (iii) Name of storm (iv) Classification by intensity (v) Position of the tropical storm (vi) Central pressure (vii) Movement the direction and speed (viii) Wind direction and maximum wind near the centre (ix) Destination from a coastal point	Southern Thailand, Strait of Malacca and the South China Sea. (every 3 hours)
		<p style="text-align: center;">To coastal stations and ports</p> By : Telephone, Facsimile, Email, SMS, Social Media (Facebook, Line), Thailand Radios/ and Thailand TVs, TMD Mobile Application, TMD Radio, TMD Website : www.tmd.go.th , http://www.metalarm.tmd.go.th (every 3 hours) Port warning signals used in Thailand Ports are given in Attachment to Annex II-I.
		<p style="text-align: center;">To government agencies concerned namely :</p> <ul style="list-style-type: none"> • Department of Disaster Prevention and Mitigation (DDPM) • Port Authority of Thailand (PAT) • Marine Department (MD) • National Disaster Warning Center (NDWC) • Governors of risk provinces <p style="text-align: center;">To specific users (aviation, fishery, etc.), media and general public</p> By : Telephone, Facsimile, Email, SMS, Social Media (Facebook, Line), Thailand Radios/ and Thailand TVs, TMD Mobile Application, TMD Radio, TMD Website : www.tmd.go.th , http://www.metalarm.tmd.go.th (every 3 hours)

Day Signals*	Specifications	Night Signals*	Remarks
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Bangladesh (8.XI.1976)**Signals Meant for Maritime Ports**

16a	I. <u>Distant Cautionary Signal Number One</u>	3b)	
	There is a region of squally weather in which a storm may be forming (well marked low or depression with surface winds up to 61 km/h. (33 knots))	)	)	These signals indicate that ships may be exposed to danger after leaving the harbour
10a	II. <u>Distant Warning Signal Number Two</u>	2b)	
	A storm has formed (cyclonic storm with surface winds 62-88 kmph. (34-47 knots))))	
3a	III. <u>Local Cautionary Signal Number Three</u>	5b)	
	The port is threatened by squally weather (cyclonic circulation with surface winds 40-50 km/h. (22-27 knots)) or squalls due Nor'Westerly)	)	)	These signals indicate that the port itself and the ships in it are in danger
2a	IV. <u>Local Warning Signal Number Four</u>	4b)	
	The port is threatened by a storm, but it does not appear that the danger is as yet sufficiently great to justify extreme measures of precaution (cyclonic circulation with surface winds 51-61 km/h. (28-33 knots))))	
17a	V. <u>Danger Signal Number Five</u>	16b)	
	The port will experience severe weather that the port itself and the ship in it and in coast to the south of the port (to the east of the port in the case of Mangla) cyclonic storm with surface winds 62-88 km/h. (34-47 knots)	)	)	These signals indicate that the port itself and the ships in it are in danger

* The national systems of visual storm warning signals (day signals and night signals) are reproduced in WMO Publication - WMO-No. 9, TD. 4, Volume D, Part D - Visual Storm Warning Signals Annexes II and III respectively.

Day Signals*	Specifications	Night Signals*	Remarks
<u>Bangladesh</u> - continued			
18a	VI. <u>Danger Signal Number Six</u>	17b)
	The port will experience severe weather from a storm, of slight or moderate intensity that is expected to cross the coast to the north of the port (to the west of the port in the case of Mangla) (wind speed same as in Signal No. V)))))))
19a	VII. <u>Danger Signal Number Seven</u>	18b)
	The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross over or near to the port (wind speed as in Signal No. V)))))
20a	VIII. <u>Great Danger Signal Number Eight</u>	19b)
	The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the south of the port (to the east of the port in the case of Mangla) (severe cyclonic storm with surface winds 89-118 km/h. (48-63 knots) or severe cyclonic storm of hurricane intensity with winds 119 km/h. (64 knots) or above)		) These signals indicate) that the port itself and) the ships in it are in) danger))))))
21a	IX. <u>Great Danger Signal Number Nine</u>	20b)
	The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the north of the port (to the east of the port in the case of Mangla) (wind speed same as in Signal No. VIII))))))))

* See footnote on page 1 of Attachment to Annex II-B

Day Signals*	Specifications	Night Signals*	Remarks
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Bangladesh - continued

22a	X. <u>Great Danger Signal Number Ten</u> The port will experience severe weather from a storm of great intensity that is expected to cross the coast over or near to the port (wind speed same as in Signal No. VIII)	21b)) these signals indicate) that the port itself and) the ships in it are in) danger
23a	XI. <u>Failure of Communications</u> Communications with the Meteorological Warning Centre have broken down and the local officer considers that there is danger of bad weather	7b)))))

Signals Meant for River Ports

24a	(I) <u>Cautionary Signal Number One</u> Your area is threatened by squally winds of transient nature (Nor'Wester squalls) of wind speed not exceeding 60 km/h. (32 knots). Look out for further development	5b	) ) these signals are used) for the river ports, river) and police stations in) Bangladesh
1a	(II) <u>Warning Signal Number Two</u> "A storm (of depression intensity, associated sustained winds not more than 61 km/h. (33 knots) or Nor'Wester squall (of wind speed 61 km/h. (33 knots) or high is likely to strike you (vessels of 65 feet and under in length are to seek shelter immediately)	7b	) ) these signals are) used for the river) ports, river and) police stations in) Bangladesh))
2a	(III) <u>Danger Signal Number Three</u> A storm (of gale force, associated sustained winds 62-88 km/h. (34-47 knots)) will soon strike you. All vessels are to seek shelter immediately	2b)))))

*See footnote on page 1 of Attachment to Annex II-B

Day Signals*	Specifications	Night Signals*	Remarks
<u>Bangladesh</u> - continued			
10a	(IV) <u>Great Danger Signal Number Four</u> A violent storm (of whole gale) force and above, associated sustained wind speed exceeding 88 km/h. (47 knots)) will soon strike you. All vessels continue taking shelter immediately	31b))))))))	

In the existing Tropical Cyclone Signal System in Bangladesh, two different types of Signal Numbers, one for maritime and one for river ports are being used for the same cyclone in the sea and its adjoining river ports. This often leads to create confusion among the general public and those who are related with disaster management activities. This confusion has also been observed during the recent cyclone SIDR. Therefore, to avoid any further confusion, unification and standardization of the signals has been made by the Government of the People's Republic of Bangladesh, which is yet to be implemented. Prior to the execution of the new signals, sufficient awareness needs to be raised for the general public, maritime and river port authorities and for the disaster management sector. Once this is done and the Government feels that it is appropriate to implement the new signals, the Panel will be informed accordingly.

Bulletins issued by India for Indian coast

1. State/Central Govt. Officials/Vital installations / Registered User Cyclone Alert/ Cyclone Warning Bulletin No.

FORMAT:

Date and Time of Issue:

(i) Information on cyclone : The cyclonic storm lay over..... Bay of Bengal/Arabian Sea Center km. (Direction) of place.

(ii) Forecast

Further intensification:
Direction of Movement:
Expected landfall area:
Expected time of landfall:

(iii) Weather Warning

- (a) Rainfall in Districts (Names)
- (b) Gales reaching in Districts (Names)
- (c) Gale force winds reaching 35 knots in Districts
- (d) Tidal waves in coastal areas of Districts (Names)
- (e) Sea condition:
- (f) Damage (As per IMD instruction) Districts (Names)
- (g) Likely impacts as per IMD Monograph on "Damage Potential of Tropical [Depending on Intensity of Storm (T-No)]
 - (a) Fishermen not to venture into open sea.
 - (b) Evacuation of people from low lying areas to safer places/Cyclone Shelters.
 - (c) General public in the threat area advised to be indoors.
 - (d) Rail & road transport to be regulated.

2. Port Warning

FORMAT:

Port Warning No. Date and Time for Issue

(i) Information on cyclone: The cyclonic storm lay over Bay of Bengal/Arabian Sea near Lat. ___/Long. ___ at a distance _____ km. from _____ at _____ IST _____ Estimated Central Pressure _____ hPa.

(ii) Forecast :

Further intensification:
Direction of Movement:
Expected Landfall Area :
Expected Time of Landfall :

(iii) Advice for hoisting Storm Warning Signals:

(iv) Likely impacts and actions: Depending on intensity of the storm as per IMD Monograph on "Damage Potential of Tropical Cyclones"

3. Cyclone Warning Bulletin for AIR/Press / Public:

FORMAT:

Cyclone Alert / Warning Bulletin No. _____ issued by _____ at _____ Hrs. IST on _____ (Date) for repeated broadcast at hourly / half hourly intervals. Cyclone Alert / Warning for _____ Districts. Cyclone centred at _____ hrs. IST of _____ (date) about _____ km. _____ of (direction) _____ (Place). Expected to intensify further and move in a _____ direction and cross _____ coast near / between _____ (Place) _____ (day/time). Under its influence heavy to very heavy rain likely cause floods in _____ districts commencing from _____ (time/day). Gales speed reaching _____ kmph causing _____ damage _____ in districts commencing from _____ (Date/Time) Gale force winds reaching 70 kmph likely extend into _____ Districts, causing damage _____ in _____ districts. Tidal wave of _____ m likely inundate low lying area of _____ Districts at the time of crossing coast. Fishermen advised not to venture out. Public advised to cooperate with the State authorities in disaster management efforts.

4. Fisheries Warning

FORMAT:

Fisheries warning No. _____
Date and Time of Issue _____

- (i) Information on Cyclone: Cyclonic Storm lay over _____ Bay of Bengal / Arabian Sea at a distance _____ km. _____ from _____ at _____ time (IST) on _____ (date)
- (ii) Forecast: Further intensification Direction of Movement _____

Expected landfall area Expected time of landfall

(iii) Warnings: Wind Sea Condition Tidal Waves

(iv) Storm Warning Signals at ports

Advice and Action: i) Fishermen not to venture into open seas ii) Fishermen at Sea not to come to the ports (names) _____ in coast.

5. Post Landfall Outlook

FORMAT:

EVEN AFTER LANDFALL, THE SYSTEM IS LIKELY TO MAINTAIN ITS INTENSITY FOR HOURS AND WEAKEN GRADUALLY AAA UNDER ITS INFLUENCE RAINS AT MOST/MANY PLACES WITH HEAVY TO VERY HEAVY FALLS AT LIKELY COMMENCE/CONTINUE IN (COASTAL DISTRICTS) FROM (TIME)..... (DAY) (DATES) CAUSING INUNDATION OF LOW-LYING AREAS AAA GALE WINDS/SQUALLY WINDS SPEED REACHING KMPH LIKELY COMMENCE/CONTINUE IN(COASTAL DISTRICTS) FROM(TIME)ON.....(DAY)..... (DATE) CAUSING DAMAGES TO (PROPERTY AS INDICATED IN IMD MONOGRAPH ON "DAMAGE POTENTIAL OF TROPICAL CYCLONE") AND (VEGETATION) AND GENERAL DISRUPTION OF COMMUNICATION AND POWER SUPPLY FOR

2. AS THE CYCLONE MOVES INLAND INTERIOR DISTRICTS MAY ALSO EXPERIENCE HEAVY/VERY HEAVY RAIN ACCOMPANIED WITH GALE WITH SPEEDREACHING KMPH COMMENCING FROM (TIME) ON (DAY) (DATE) FOR HRS, CAUSING FLOODING OF LOW LYING AREAS AND DAMAGE TO PROPERTY AS INDICATED IN IMD MONOGRAPH ON "DAMAGE POTENTIAL OF TROPICAL CYCLONE"

(AS PER IMD INSTRUCTION)

PEOPLE ARE ADVISED TO REMAIN INDOORS/IN SAFE PLACES AND COOPERATE WITH STATE GOVERNMENT OFFICIALS AND DISASTER MANAGEMENT AGENCIES.

Example: (CYCLONE WARNING FOR INDIAN COAST) issued from Cyclone Warning Division, IMD, New Delhi

Sub: Very Severe Cyclonic Storm, VARDHA over westcentral and adjoining southwest Bay of Bengal:

Cyclone Warning for South Andhra Pradesh and north Tamil Nadu Coasts: Orange Message

The very severe cyclonic storm, **VARDHA** over westcentral and adjoining southwest Bay of Bengal moved west-southwestwards during past 06 hrs with a speed of 18 kmph and lay centred at 1130 hrs IST of today, the 11th December, 2016 over westcentral and adjoining southwest Bay of Bengal near Latitude 13.1°N and Longitude 83.7°E, about 420 km east-southeast of Nellore, 440 km south-southeast of Machilipatnam and 370 km east of Chennai. The system is very likely to move nearly west-southwestwards and weaken gradually from today evening onwards while moving towards north Tamilnadu and adjoining south Andhra Pradesh coast. It is very likely to cross north Tamilnadu and south Andhra Pradesh coast, close to Chennai as a cyclonic storm with a wind speed of 80 to 90 kmph gusting to 100 kmph by 12th December 2016 afternoon.

Forecast track and intensity of the system are given in the table below:

Date/time(IST)	Position (lat. °N/ long. °E)	Maximum sustained surface wind speed (kmph)	Category of cyclonic Disturbance
11-12-2016/1130	13.1/83.7	125-135 gusting to 150	Very Severe Cyclonic Storm
11-12-2016/1730	13.0/82.9	120-130 gusting to 145	Very Severe Cyclonic Storm
11-12-2016/2330	12.9/82.0	110-120 gusting to 130	Severe Cyclonic Storm
12-12-2016/0530	12.9/81.2	090-100 gusting to 110	Severe Cyclonic Storm
12-12-2016/1130	12.9/80.4	080-090 gusting to 100	Cyclonic Storm
12-12-2016/2330	12.8/78.8	055-065 gusting to 075	Deep Depression
13-12-2016/1130	12.8/77.2	025-035 gusting to 045	Well Marked Low

Warning:

- (i) **Heavy Rainfall Warning:** Rainfall at most places with isolated heavy to very heavy falls over south coastal Andhra Pradesh, north coastal Tamil Nadu and Puducherry is very likely to commence from 11th December evening for subsequent 36 hrs. The rainfall intensity will increase gradually becoming heavy to very heavy rainfall (7-19 cm) at a few places and isolated extremely heavy rainfall (≥ 20 cm) over Chennai, Thiruvallur and Kanchipuram districts of Tamil Nadu and Nellore and Prakasam districts of Andhra Pradesh on 12th December
- (ii) **Wind warning:** Squally winds speed reaching 40-50 kmph gusting to 60 kmph would prevail along and off Andhra Pradesh and adjoining north Tamil Nadu coasts commencing from 11th December night. It will gradually increase becoming 80-90 kmph gusting to 100 kmph during the time of landfall along and off Chennai, Thiruvallur and Kanchipuram districts of Tamil Nadu, Puducherry and Nellore and Prakasam districts of Andhra Pradesh.
- (iii) **Sea condition:** Sea condition would be rough to very rough along & off Andhra Pradesh and north Tamil Nadu coasts commencing from 11th December night. Sea

condition along and off these coasts will become high to phenomenal from 12th December morning.

- (iv) **Storm surge** : The tidal wave of about one meter height above the astronomical tide is very likely to inundate the low lying areas of Chennai, Thiruvallur and Kanchipuram districts of Tamil Nadu and Nellore districts of Andhra Pradesh during the time of landfall.
- (v) **Damage Expected:** Damage to thatched huts. Minor damage to power & communication lines due to breaking of branches. Major damage to Kutcha and minor damage to Pucca roads. Damage to paddy crops, banana, papaya trees and orchards over Chennai, Thiruvallur and Kanchipuram districts of Tamil Nadu; Ongole & Nellore districts of Andhra Pradesh and Puducherry.
- (vi) **Action Suggested:** Fishermen are advised not to venture into sea along and off south Andhra Pradesh, north Tamil Nadu and Puducherry coasts. During next 48 hrs

Next bulletin will be issued at 1730 hrs IST of 11th December 2016

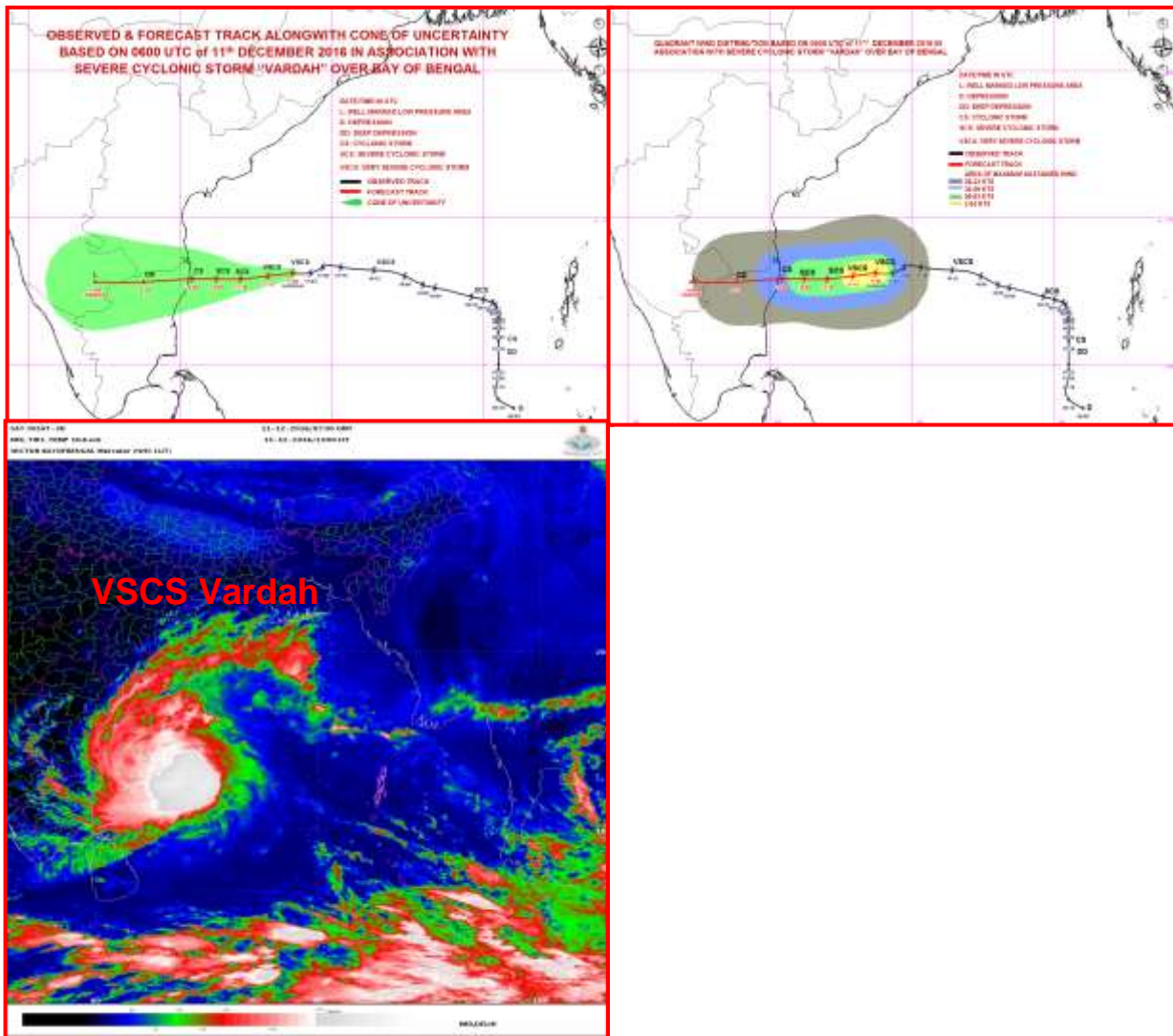


Fig. Observed & forecast track of VSCS Vardah based on 0600 UTC and tyoical satellite imagery based on 0730 UTC of 11th December

India Port warnings largely used

Day Signals*	Specifications	Night Signals*	Remarks
16a I.	<u>Distant Cautionary Signal Number One</u> There is a region of squally weather in which a storm may be forming (well marked low or depression with surface winds up to 61 km/h. (33 knots))	3b )	) These signals indicate) that ships may be) exposed to danger after) leaving the harbour
10a II.	<u>Distant Warning Signal Number Two</u> A storm has formed (cyclonic storm with surface winds 63-87 km/h. (34-47 knots))	2b))
3a* III.	<u>Local Cautionary Signal Number Three</u> The port is threatened by squally weather (cyclonic circulation with surface winds 40-50 km/h. (22-27 knots)) or squalls due Nor'Westers)	5b )	) These signals indicate) that the port itself and) the ships in it are in) danger
2a* IV.	<u>Local Warning Signal Number Four</u> The port is threatened by a storm, but it does not appear that the danger is as yet sufficiently great to justify extreme measures of precaution (cyclonic circulation with surface winds 52-61 km/h. (28-33 knots))	4b))
17a V.	<u>Danger Signal Number Five</u> The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast keeping the port to the left of its course (to the east of the port in the case of Mangla) (cyclonic storm with surface winds 63-87 km/h. (34-47 knots))	16b )	) These signals indicate) that the port itself and) the ships in it are in) danger
8a VI.	<u>Danger signal number Six</u> Port will experience severe weather from a cyclone expected to move keeping the port to the right of its track	17b )	) These signals indicate) that the port itself) and the ships in it are) in danger
19a* VII.	<u>Danger signal number Seven</u> Port will experience severe weather from a cyclone expected to move over or close to the port	18b )	) This signal is also hoisted when) a storm is expected to skirt) the coast without (actually)) crossing it
20a VIII.	<u>Great Danger Signal number Eight</u> Port will experience severe weather from a severe cyclone expected to move keeping the port to the left of its track	19b )	) These signals indicate) that the port itself) and the ships in it are) in danger

21a	IX.	<u>Great Danger Signal number Nine</u> Port will experience severe weather from a severe cyclone expected to move keeping the port to the right of its track	20b	) These signals indicate) that the port itself) and the ships in it are) in danger
22a*	X.	<u>Great Danger Signal number Ten</u> Port will experience severe weather from a severe cyclone expected to move over or close to the port	21b	) This signal is also hoisted) when a storm is expected) to skirt the coast without) (actually) crossing it
23a*	XI.	<u>Failure of Communication</u> Communications with the meteorological warning centre have broken down, and the local office considers there is a danger of bad weather	7b))))

Brief System

In the brief system only one of the five signals marked by an asterisk of the general system is hoisted, and the Port Officers are kept informed of the prospects of local bad weather associated with any disturbance in the sea, for the general information of shipping.

Extended System

Special section signals, in addition to those of the general system, are exhibited at certain ports in the Bay of Bengal belonging to the extended system.

If the port itself is threatened, the appropriate local signals of the general system are hoisted. But, if there is an area of squally weather or a storm that does not threaten the port, the distant cautionary or distant warning signal of the general system is hoisted, and one or more of the locality signals (described in the next paragraph) are hoisted under the distant signals, to indicate the position of the disturbance in the Bay.

The following shapes, when hung below a distant cautionary or warning signal, become locality signals, indicating the six divisions into which the Bay of Bengal has been divided for this purpose). If, however, the centre of the storm is near the boundary of a division, the hoisting of two locality signals is requested, the first indicating the division in which the centre is thought to be situated and the second the division nearest to the first.

In the event of a storm centre being near the corner where three divisions meet, the hoisting of three locality signals is requested, the first indicating the division in which the storm is estimated to be centred, the second the nearest adjoining division, and the third the remaining division.

Signal	3a	10a	24a	16a	2a	23a
Section	I	II	III	IV	V	VI

* See footnote on page 1 of Attachment to Annex II-B

1) The divisions are as indicated on the chart given on page II A6. Thus, if there is squally weather in Section I of the Bay, the signal 25a would be hoisted at the various ports, and if a storm has formed in Section II, the signal 11a would be hoisted at all ports which were not directly threatened. As already stated, the ports directly threatened would hoist one or other of the local signals. The Meteorological Department endeavours to keep the number of locality signals on each hoist as small as possible, and generally the number of only that section in which the centre of the storm is situated is given in the Warning bulletin.

Day Signals*	Specifications	Night Signals*	Remarks
<u>Myanmar</u> (21.II.1977)			
<u>General System</u>			
16a	There is a region of squally weather in which a storm may be forming	3b	Distant cautionary signal
10a	A storm has formed	2b	Distant warning signal
3a	The port is threatened by squally weather	5b*	Local cautionary signal
2a*	The port is threatened by a storm, but it does not appear that the danger is as yet sufficiently great to justify extreme measures of precaution	4b*	Local warning signal. The existence of a storm can often be determined before its direction of motion can be fixed. In this case all those ports which the storm could possibly strike are warned by this signal
17a	The port will experience severe weather from a storm, of slight or moderate intensity, that is expected to cross the coast to the south of the port (or to the east in the case of Yangon, Pathein and Diamond Island)	16b	Local danger signal
18a	The port will experience severe weather from a storm, of slight or moderate intensity, that is expected to cross the coast to the north of the port (or to the west in the case of Yangon and Moulmein)	17b	Local danger signal
19a*	The port will experience severe weather from a storm, of slight or moderate intensity, that is expected to cross over or near to the port	18b*	Local danger signal
20a	The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the south of the port (or to the east in the case of Yangon, Pathein and Diamond Island)	19b	Local great danger signal

* See footnote on page 1 of Attachment to Annex II-B

Day Signals*	Specifications	Night Signals*	Remarks
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Myanmar - continued

21a	The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the north of the port (or to the west in the case of Yangon and Moulmein)	20b	Local great danger signal
22a*	The port will experience severe weather from a storm of great intensity that is expected to cross over or near to the port	21b*	Local great danger signal
23a*	Communications with the meteorological warning centre have broken down, and the local officer considers that there is a danger of bad weather	7b*	Local failure of communications signal

Brief System

In the brief system only one of the five signals marked by an asterisk of the general system is hoisted, and the Port Officers are kept informed of the prospects of local bad weather associated with any disturbance in the sea, for the general information of shipping.

Extended System

Special signals, in addition to those of the general system, are exhibited at certain ports in the Bay of Bengal belonging to the extended system.

If the port itself is threatened, the appropriate local signals of the general system are hoisted. But, if there is an area of squally weather or a storm that does not threaten the port, the distant cautionary or distant warning signal of the general system is hoisted, and one or more of the locality signals (described in the next paragraph) are hoisted under the distant signals, to indicate the position of the disturbance in the Bay.

The following shapes, when hung below a distant cautionary or warning signal, become locality signals, indicating the six divisions into which the Bay of Bengal has been divided for this purpose 1) . If, however, the centre of the storm is near the boundary of a division, the hoisting of two locality signals is requested, the first indicating the division in which the centre is thought to be situated and the second the division nearest to the first.

In the event of a storm centre being near the corner where three divisions meet, the hoisting of three locality signals is requested, the first indicating the division in which the storm is estimated to be centred, the second

the nearest adjoining division, and the third the remaining division.

Signal	3a	10a	24a	16a	2a	23a
Section	I	II	III	IV	V	VI

* See footnote on page 1 of Attachment to Annex II-B

Attachment to ANNEX II-E-3

1) The divisions are as indicated on the chart given on page 26 Thus, if there is squally weather in Section I of the Bay, the signal 25a would be hoisted at the various ports, and if a storm has formed in Section II, the signal 11a would be hoisted at all ports which were not directly threatened. As already stated, the ports directly threatened would hoist one or other of the local signals. The Department of Meteorology and Hydrology endeavours to keep the number of locality signals on each hoist as small as possible, and generally the number of only that section in which the centre of the storm is situated is given in the Warning bulletin.

Attachment to ANNEX II-G-1

Day Signals*	Specifications	Night Signals*	Remarks
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Pakistan - (10.VI.1984) Port warnings largely used

16a	There is a region of squally weather in which a storm may be forming	3b)))) These signals) indicate that) ships may be) exposed to danger) after leaving the) harbour
10a	A storm has formed	2b)
3a	Port is threatened by squally weather	5b	) These signals) indicate that the) port itself and) the ships in it) are in danger
2a	Port is threatened by a storm, but it does not appear that danger justifies extreme measures of precaution	4b))))
17a	Severe weather from a storm of slight or moderate intensity, expected to cross the coast to south or east of port	16b))))
18a	Severe weather from a storm of slight or moderate intensity, expected to cross the coast to north or west of port	17b	) These signals) indicate that the) port itself and) the ships in it) are in danger
19a	Severe weather from a storm of slight or moderate intensity, expected to cross over or near to the port	18b))))
20a	Severe weather from a storm of great intensity, expected to cross the coast to south or east of port	19b))))

See footnote on page 1 of Attachment to Annex II-B

Day Signals*	Specifications	Night Signals*	Remarks
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Pakistan - continued

21a	Severe weather from a storm of great intensity, expected to cross the coast to north or west of port	20b)) These signals) indicate that the) port itself and) the ships in it) are in danger
22a	Severe weather from a storm of great intensity, expected to cross over or near to the port	21b)))
23a	Communications with the meteorological -- warning centre have broken down, and the local office considers there is a danger of bad weather	7b	) These signals) indicate that the) port itself and) the ships in it) are in danger

Sri Lanka (20.II.1978) Port Warnings

Day Signals*	Specifications	Night Signals*	Remarks
16a	There is a region of squally weather in which a storm may be forming	3b	These signals indicate that ships may be exposed to danger after leaving the harbour
10a	A storm has formed	2b	These signals indicate that ships may be exposed to danger after leaving the harbour
3a	The port is threatened by squally weather	5b	These signals indicate that the port itself and the ships in it are in danger
2a	The port is threatened by a storm, but it does not appear that the danger is as yet sufficiently great to justify extreme measures of precaution	4b	These signals indicate that the port itself and the ships in it are in danger
17a	The port will experience severe weather from a storm of slight or moderate and intensity that is expected to cross coast keeping the port to the left of its course	16b	These signals indicate that the port itself and the ships in it are in danger
8a	Port will experience severe weather from a cyclone expected	17b	These signals indicate that the port itself and the ships in it are in danger
19a	Port will experience severe weather from a cyclone expected to move over the coast without (actually) crossing it	18b	This signal is also hoisted when a storm is expected to skirt or close to the port
20a	Port will experience severe weather from a severe cyclone expected to expected to cross the coast to the South of Port	19b	These signals indicate that the port itself and the ships in it are in danger
21a	Port will experience severe weather from a severe cyclone expected to expected to cross the coast to the South or east of Port	20b	These signals indicate that the port itself and the ships in it are in danger
22a	Port will experience severe weather from a severe cyclone expected to expected to cross over or near the Port	21b	These signals indicate that the port itself and the ships in it are in danger
23a	Communications with the meteorological warning centre have broken down, and the local officer considers that there is a danger of bad weather	7b	Local failure of communications signals

Thailand (11.IV.1984)

Day Signals*	Specifications	Night Signals*	Remarks
Signals indicating the intensity of storms			
35a	Tropical depression or storm with wind speeds near centre not exceeding 33 knots	1.	Signals indicating the occurrence of storms in the Gulf of Thailand and adjacent seas to be displayed at Port Area (Bangkok) and at Bangkok Harbour Limit I (Pong Pachjmit Fort, Pagklongsarn, Dhonburi)
36a	Tropical storm or storm with wind speeds near centre from 34 knots and over but not exceeding 63 knots		
56a	Typhoon or cyclone or storm with wind speeds near centre 64 knots or more	2	Signals indicating the intensity and locality of storms will be hoisted on the same yard-arm with the pennant indicating the intensity and the flag indicating the locality of the storm. The flag is always hoisted below the pennant

* See footnote on page 1 of Attachment to Annex II-B

Day Signals*	Specifications	Night Signals*	Remarks
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Thailand - continued**Signals indicating the locality of storms**

- 37a Area 1 : Gulf of Thailand east coast to Lat. 5°N and Long. 105°E
- 38a Area 2 : Gulf of Thailand west coast to Lat. 5°N
- 43a Area 3: Andaman Sea bounded by west coast of southern Myanmar, west coast of southern Thailand, Long. 97°E, Lat. 5°N and Lat. 14°N
- 51a Area 4 : South China Sea bounded by southern Viet Nam coast, Lat. 12°N, Lat. 5°N, Long. 105°E and Long. 112°E

Note: In normal weather conditions (no tropical depression, storm or typhoon) the white pennant with red circle (52a) will be displayed at the upper yard-arm at Bangkok Harbour Limit I (Pong Pachjmit Fort, Pagklongsarn, Dhonburi).

* See footnote on page 1 of Attachment to Annex II-B

THE OBSERVING SYSTEM AND OBSERVING PROGRAMME

3.1 Networks of surface and upper air stations

3.1.1 *Observations from basic network*

The list of implemented regional basic synoptic networks of surface and upper air stations of the Panel countries is given in **Table III-1**. The network of stations adopted for regional exchange by the World Weather Watch is considered adequate for routine tracking of weather systems. However, in the cyclone season, particularly when a tropical depression or storm exists in the region, special efforts will be made by the national meteorological services to improve the collection and distribution of surface synoptic reports from the coastal stations.

3.1.2 *Special observations from the WWW network*

National meteorological services will endeavor to arrange for additional observations in areas coming within the circulation of a tropical cyclone. These stations will make round the clock three hourly or hourly observations when the system is of tropical storm intensity and close to the coast and the observations will be passed on real time to the Panel countries.

3.1.3 *Special observations from stations other than those of the regional basic synoptic network*

National Meteorological Services (NMS) have established a large number of meteorological observing stations, in addition to those in the regional basic synoptic network, observations from which are received by the NMS. When there is a tropical cyclone in the Bay of Bengal or in the Arabian Sea, observations from these stations, particularly from coastal stations, will be exchanged on real time basis on priority. If the observations are not received during a tropical cyclone situation a request for them could be sent to the NMS concerned. A list of these stations is given in **Table III-2 & III-3**.

III-2
**TABLE III-1: List of implemented regional
 basic synoptic network stations**

Name of Station	Surface								Radiowind				Radiosonde			
	1	2							3				4			
	00	03	06	09	12	15	18	21	00	06	12	18	00	12		
41240 KHASAB		X	X	X	X	X	X									
242 DIBA*	X	X	X	X	X	X	X	X								
244 BURAIMI	X	X	X	X	X	X	X	X								
246 SOHAR MAJIS		X	X	X	X	X	X	X	X							
253 RUSTAQ	X	X	X	X	X	X	X	X								
254 SAIQ	.	X	X	X	X											
255 NIZWA*			X	X	X											
256 SEEB INT. AIRPORT	X	X	X	X	X	X	X	X	X							
257 SAMAIL	X	X	X	X	X	X	X	X								
258 MINA SULTAN QABOOS	X	X	X	X	X	X	X	X								
262 FAHUD	X	X	X	X	X	X	X	X								
263 BAHLA	X	X	X	X	X	X	X	X								
264 ADAM	X	X	X	X	X	X	X	X								
265 IBRA	X	X	X	X	X	X	X	X								
267 QALHAT	X	X	X	X	X	X	X	X								
268 SUR	X	X	X	X	X	X	X	X								
275 QARN ALAM	X	X	X	X	X	X	X	X								
288 MASIRAH	X	X	X	X	X	X	X	X								
304 MARMUL	X	X	X	X	X	X	X	X								
312 MINA SALALAH	X	X	X	X	X	X	X	X								
314 THUMRAIT	X	X	X	X	X	X	X	X								
315 QAIROON HAIRITI		X	X	X	X	X	X	X	X							
316 SALALAH	X	X	X	X	X	X	X	X	X							
515 DROSH		X	X	X	X	X	X	X	X							
530 PESHAWAR	X	X	X	X	X	X	X	X	X	X						
560 PARACHINAR	X	X	X	X	X	X	X	X								
571 ISLAMABAD AIRPORT	X	X	X	X	X	X	X	X								
594 SARGODHA	X	X	X	X	X	X	X	X	X	X						
598 JHELUM	X	X	X	X	X	X	X	X	X	X						
620 ZHOB	X	X	X	X	X	X	X	X								
624 DERA ISMAIL KHAN	X	X	X	X	X	X	X	X	X	X						
641 LAHORE CITY		X	X	X	X	X	X	X	X	X						
660 QUETTA AIRPORT		X	X	X	X	X	X	X	X							
675 MULTAN	X	X	X	X	X	X	X	X	X	X						
685 BAR KHAN	X	X	X	X	X	X	X	X	X	X						
710 NOKKUNDI		X	X	X	X	X	X	X	X							
712 DAL BANDIN	X	X	X	X	X	X	X	X	X	X						
715 JACOBABAD	X	X	X	X	X	X	X	X	X	X						
718 KHANPUR	X	X	X	X	X	X	X	X								
739 PANJGUR	X	X	X	X	X	X	X	X								
744 KHUZDAR	X	X	X	X	X	X	X	X	X	X						
749 NAWABSHAH	X	X	X	X	X	X	X	X	X	X						
756 JIWANI	X	X	X	X	X	X	X	X	X	X						
757 GWADAR	X	X	X	X	X	X	X	X	X							
759 PASNI	X	X	X	X	X	X	X	X	X	X						
764 HYDERABAD	X	X	X	X	X	X	X	X	X	X						
768 CHHOR		X	X	X	X	X	X	X	X	X						
780 KARACHI AIRPORT	X	X	X	X	X	X	X	X	X	X						

* During the period of tropical cyclone

III-3

Name of station 1	Surface 2								Radiowind 3				Radiosonde 4	
	00	03	06	09	12	15	18	21	00	06	12	18	00	12
	41859 RANGPUR	X	X	X	X	X	X	X	X	X	X	X	X	
883 BOGRA	X	X	X	X	X	X	X	X	X	X	X	X	X	
886 MYMENSINGH	X	X	X	X	X	X	X	X						
891 SYLHET	X	X	X	X	X	X	X	X	X	X	X	X		
907 ISHURDI	X	X	X	X	X	X	X	X	X	X	X	X		
923 DHAKA	X	X	X	X	X	X	X	X	X	X	X	X	X	
936 JESSORE	X	X	X	X	X	X	X	X	X	X	X	X		
943 FENI	X	X	X	X	X	X	X	X	X	X	X	X		
950 BARISAL	X	X	X	X	X	X	X	X	X	X	X	X		
953 MAIJDI COURT	X	X	X	X	X	X	X	X						
963 HATIYA	X	X	X	X	X	X	X	X						
964 SANDWIP	X	X	X	X	X	X	X	X						
977 CHITTAGONG (AMBAGAN)		.	.	.	.	.	.	.	X	X	X	X	X	
978 CHITTAGONG (PATENGA)	X	X	X	X	X	X	X	X						
984 KHEPUPARA		X	X	X	X	X	X	X	X					
989 KUTUBDIA	X	X	X	X	X	X	X	X						
992 COX'S BAZAR	X	X	X	X	X	X	X	X	X	X	X	X		

III-4

Name of station 1	Surface 2								Radiowind 3				Radiosonde 4	
	00	03	06	09	12	15	18	21	00	06	12	18	00	12
	42027 SRINAGAR	X	X	X	X	X	X	X	X	X	X		X	X	X
42071 AMRITSAR	X	X	X	X	X	X	X	X	X	X				
42101 PATIALA	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42111 DEHRADUN	X	X	X	X	X	X	X	X						
42131 HISSAR	X	X	X	X	X	X	X	X						
42165 BIKANER	X	X	X	X	X	X	X	X						
42182 NEW DELHI	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42189 BAREILLY	X	X	X	X	X	X	X	X						
42260 AGRA	X	X	X	X	X	X	X	X						
42309 NORTH LAKHIMPUR		X	X	X	X	X								
42314 DIBRUGARH/MOHANBARI	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42328 JAISALMER	X	X	X	X	X	X	X	X						
42339 JODHPUR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42348 JAIPUR/SANGANER	X	X	X	X	X	X	X	X	X		X			
42361 GWALIOR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42369 LUCKNOW/AMAUSI	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42379 GORAKHPUR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42397 SILIGURI	X	X	X	X	X	X	X	X						
42410 GUWAHATI	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42415 TEZPUR	X	X	X	X	X	X	X	X						
42452 KOTA AERODROME	X	X	X	X	X	X	X	X						
42475 ALLAHABAD/ BAMHRAULI	X	X	X	X	X	X	X	X						
42492 PATNA	X	X	X	X	X	X	X	X					X	X
42559 GUNA	X	X	X	X	X	X	X	X						
42571 SATNA	X	X	X	X	X	X	X	X						
42587 DALTONGANJ		X	X	X	X									
42591 GAYA	X	X	X	X	X	X	X	X	X		X	X		
42623 IMPHAL TULIHAL	X	X	X	X	X	X	X	X	X	X	X	X		
42634 BHUJ-RUDRAMATA	X	X	X	X	X	X	X	X						
42779 PENDRA	X	X	X	X	X	X	X	X						
42798 JAMSHEDPUR	X	X	X	X	X	X	X	X	X		X			
42809 KOLKATA / DUMDUM	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42840 SURAT	X	X	X	X	X	X	X	X						
42867 NAGPUR /SONEGAON	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42875 RAIPUR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42886 JHARSUGUDA	X	X	X	X	X	X	X	X	X					
42895 BALASORE	X	X	X	X	X	X	X	X						
42909 VERAVAL	X	X	X	X	X	X	X	X						
42921 NASIK CITY	X	X	X	X	X	X	X	X						
42933 AKOLA	X	X	X	X	X	X	X	X						
42971 BHUBANESWAR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42977 SANDHEADS		X			X									

III-5

Name of Station 1	Surface 2								Radiowind 3				Radiosonde 4	
	00	03	06	09	12	15	18	21	00	06	12	18	00	12
	43003	MUMBAI (SANTACRUZ)	X	X	X	X	X	X	X	X	X	X	X	X	X
43014	AURANGABAD CHIKALTHANA	X	X	X	X	X	X	X	X	X	X	X	X	X
43041	JAGDALPUR	X	X	X	X	X	X	X	X	X	X	X	X	X
43063	PUNE	X	X	X	X	X	X	X	X	X	X	X	X	X
43086	RAMGUNDAM	X	X	X	X	X	X	X	X	X	X	X	X	X
43110	RATNAGIRI	X	X	X	X	X	X	X	X	X	X	X	X	X
43117	SHOLAPUR	X	X	X	X	X	X	X	X	X	X	X	X	X
43128	HYDERABAD AIRPORT	X	X	X	X	X	X	X	X	X	X	X	X	X
43150	VISHAKHAPATNAM/ WALTAIR	X	X	X	X	X	X	X	X	X	X	X	X	X
43185	MACHILIPATNAM (FRANCHPET)	X	X	X	X	X	X	X	X	X	X	X	X	X
43189	KAKINADA	X	X	X	X	X	X	X	X	X	X	X	X	X
43192	GOA/PANJIM	X	X	X	X	X	X	X	X	X	X	X	X	X
43198	BELGAUM/SAMBRE	X	X	X	X	X	X	X	X	X	X	X	X	X
43201	GADAG	X	X	X	X	X	X	X	X	X	X	X	X	X
43213	KURNOOL	X	X	X	X	X	X	X	X	X	X	X	X	X
43226	HONAVAR	X	X	X	X	X	X	X	X	X	X	X	X	X
43233	CHITRADURGA	X	X	X	X	X	X	X	X	X	X	X	X	X
43237	ANANTAPUR	X	X	X	X	X	X	X	X	X	X	X	X	X
43245	NELLORE	X	X	X	X	X	X	X	X	X	X	X	X	X
43279	CHENNAI/MEENAMBAKKAM	X	X	X	X	X	X	X	X	X	X	X	X	X
43284	MANGALORE/BAJPE	X	X	X	X	X	X	X	X	X	X	X	X	X
43285	MANGALORE/PANAMBUR	X	X	X	X	X	X	X	X	X	X	X	X	X
43295	BANGALORE	X	X	X	X	X	X	X	X	X	X	X	X	X
42830	PORBANDAR	X	X	X	X	X	X	X	X	X	X	X	X	X
43049	GOPALPUR	X	X	X	X	X	X	X	X	X	X	X	X	X
43221	ONGOLE	X	X	X	X	X	X	X	X	X	X	X	X	X
43348	ADIRAMPATTINAM	X			X									

III-6

Name of Station	Surface								Radiowind				Radiosonde		
	1	2								3				4	
		00	03	06	09	12	15	18	21	00	06	12	18	00	12
43311	AMINI DIVI	X	X	X	X	X	X	X	X	X	X	X	X	X	
43314	KOZHIKODE	X	X	X	X	X	X	X	X	X	X	X	X	X	
43321	COIMBATORE/PEELAMEDU	X	X	X	X	X	X	X	X	X	X	X	X	X	
43329	CUDDALORE	X	X	X	X	X	X	X	X	X	X	X	X	X	
43333	PORT BLAIR	X	X	X	X	X	X	X	X	X	X	X	X	X	
43344	TIRUCHIRAPALLI	X	X	X	X	X	X	X	X	X	X	X	X	X	
43346	KARAIKAL	X	X	X	X	X	X	X	X	X	X	X	X	X	
43353	KOCHI WILLINGTON	X	X	X	X	X	X	X	X	X	X	X	X	X	
43369	MINICOY	X	X	X	X	X	X	X	X	X	X	X	X	X	
43371	THIRUVANANTHAPURAM	X	X	X	X	X	X	X	X	X	X	X	X	X	
43418	TRINCOMALEE	X	X	X	X	X	X	X	X	X	X	X	X	X	
43421	ANURADHAPURA	X	X	X	X	X	X	X	X	X	X	X	X	X	
43424	PUTTALAM	X	X	X	X	X	X	X	X	X	X	X	X	X	
43436	BATTICALOA	X	X	X	X	X	X	X	X	X	X	X	X	X	
43450	KATUNAYAKE	X	X	X	X	X	X	X	X	X	X	X	X	X	
43466	COLOMBO	X	X	X	X	X	X	X	X	X	X	X	X	X	
43473	NUWARA ELIYA	X	X	X	X	X	X	X	X	X	X	X	X	X	
43486	RATNAPURA	X	X	X	X	X	X	X	X	X	X	X	X	X	
43495	GALLE	X	X	X	X	X	X	X	X	X	X	X	X	X	
43497	HAMBANTOTA	X	X	X	X	X	X	X	X	X	X	X	X	X	
43533	HANIMADHOO	X	X	X	X	X	X	X	X	X	X	X	X	X	
43555	MALE	X	X	X	X	X	X	X	X	X	X	X	X	X	
43577	KADHDHOO	X	X	X	X	X	X	X	X	X	X	X	X	X	
43588	KADEHDHOO	X	X	X	X	X	X	X	X	X	X	X	X	X	
43599	GAN	X	X	X	X	X	X	X	X	X	X	X	X	X	
48001	PUTAO	X	X	X	X	X	X	X	X	X	X	X	X	X	
48004	HKAMTI	X	X	X	X	X	X	X	X	X	X	X	X	X	
48008	MYITKYINA	X	X	X	X	X	X	X	X	X	X	X	X	X	
48010	HOMALIN	X	X	X	X	X	X	X	X	X	X	X	X	X	
48017	PINLEBU	X	X	X	X	X	X	X	X	X	X	X	X	X	
48018	KATHA	X	X	X	X	X	X	X	X	X	X	X	X	X	
48019	BHAMO	X	X	X	X	X	X	X	X	X	X	X	X	X	
48020	MAWLAIK	X	X	X	X	X	X	X	X	X	X	X	X	X	
48024	KALEMYO	X	X	X	X	X	X	X	X	X	X	X	X	X	
48025	KALEWA	X	X	X	X	X	X	X	X	X	X	X	X	X	
48030	HAKHA	X	X	X	X	X	X	X	X	X	X	X	X	X	
48031	FALAM	X	X	X	X	X	X	X	X	X	X	X	X	X	
48033	SHWEBO	X	X	X	X	X	X	X	X	X	X	X	X	X	
48034	MOGOKE	X	X	X	X	X	X	X	X	X	X	X	X	X	
48035	LASHIO	X	X	X	X	X	X	X	X	X	X	X	X	X	
48036	GANGAW	X	X	X	X	X	X	X	X	X	X	X	X	X	
48037	MONYWA	X	X	X	X	X	X	X	X	X	X	X	X	X	
48039	SAGAING	X	X	X	X	X	X	X	X	X	X	X	X	X	
48040	HSIPAW	X	X	X	X	X	X	X	X	X	X	X	X	X	
48042	MANDALAY	X	X	X	X	X	X	X	X	X	X	X	X	X	
48043	PYINOOLOWIN	X	X	X	X	X	X	X	X	X	X	X	X	X	
48045	MINDAT	X	X	X	X	X	X	X	X	X	X	X	X	X	
48047	MYINGYAN	X	X	-	-	X	X	X	X	X	X	X	X	X	
48048	NYUNG-U	X	X	X	X	X	X	X	X	X	X	X	X	X	
48051	KYAUKTAW	X	X	X	X	X	X	X	X	X	X	X	X	X	
48052	CHAUK	X	X	X	X	X	X	X	X	X	X	X	X	X	
48053	MEIKTILA	X	X	X	X	X	X	X	X	X	X	X	X	X	
48055	NAMSAM	X	X	X	X	X	X	X	X	X	X	X	X	X	

III-7

Name of Station	Surface				Radiowind				Radiosonde					
	1	2				3				4				
		00	03	06	09	12	15	18	21	00	06	12	18	00	12
48057 TAUNGGYI	X	X	X	X	X									
48058 LOILEM	X	X	X	X	X									
48060 KENGTUNG	X	X	X	X	X			X						
48062 SITTWE	X	X	X	X	X			X						
48064 MINBU	X	X	X	X	X									
48065 MAGWAY	X	X	X	X	X									
48067 YAMETHIN	X	X	X	X	X									
48068 PINLAUNG	X	X	X	X	X									
48070 MONGHSAT	X	X	X	X	X									
48071 KYAUKPYU	X	X	X	X	X			X						
48072 MANAUNG	X	X	X	X	X									
48074 PYINMANA	X	X	X	X	X									
48075 LOIKAW	X	X	X	X	X									
48077 PROME	X	X	X	X	X									
48078 TOUNGOO	X	X	X	X	X									
48080 SANDOWAY	X	X	X	X	X			X						
48085 GWA	X	X	X	X	X									
48087 HINTHADA	X	X	X	X	X									
48088 THARWADY	X	X	X	X	X									
48089 SHWEGYIN	X	X	X	X	X									
48092 HMAWBI	X	X	X	X	X									
48093 BAGO	X	X	X	X	X			X						
48094 PATHEIN	X	X	X	X	X			X						
48095 MAUBIN	X	X	X	X	X									
48096 MINGALADON	X	X	X	X	X			X						
48097 YANGON	X	X	X	X	X			X		X		X		
48098 THAON	X	X	X	X	X									
48099 HPAAN	X	X	X	X	X			X						
48101 PYAPON	X	X	X	X	X									
48103 MAWLAMYINE	X	X	X	X	X									
48107 YE	X	X	X	X	X									
48108 DAWEI	X	X	X	X	X			X						
48109 COCO ISLAND	X	X	X	X	X			X						
48110 MERGUI	X	X	X	X	X			X						
48112 KAWTHOUNG	X	X	X	X	X			X						
48300 MAE HONG SON	X	X	X	X	X	X	X	X						
48303 CHIANG RAI	X	X	X	X	X	X	X	X						
48327 CHIANG MAI	X	X	X	X	X	X	X	X	X	X	X			X
48328 LAMPANG	X	X	X	X	X	X	X	X						
48330 PHRAE	X	X	X	X	X	X	X	X						
48331 NAN	X	X	X	X	X	X	X	X						
48351 UTTARADIT	X	X	X	X	X	X	X	X						
48353 LOEI	X	X	X	X	X	X	X	X						
48354 UDON THANI	X	X	X	X	X	X	X	X						
48356 SAKON NAKHON	X	X	X	X	X	X	X	X						
48375 MAE SOT	X	X	X	X	X	X	X	X						
48376 TAK	X	X	X	X	X	X	X	X						
48377 BHUMIBOL DAM	X	X	X	X	X	X	X	X						
48378 PHITSANULOK	X	X	X	X	X	X	X	X						
48379 PHETCHABUN	X	X	X	X	X	X	X	X						
48381 KHON KAEN	X	X	X	X	X	X	X	X						
48400 NAKHON SAWAN	X	X	X	X	X	X	X	X						
48407 UBON RATCHATHANI	X	X	X	X	X	X	X	X		X	X			X
48431 NAKHON RATCHASIMA	X	X	X	X	X	X	X	X						

III-8

Name of Station		Surface								Radiowind				Radiosonde	
1		2								3				4	
		00	03	06	09	12	15	18	21	00	06	12	18	00	12
48432	SURIN	X	X	X	X	X	X	X	X						
48453	BANGKOK	X	X	X	X	X	X	X	X	X	X	X			X
48456	DON MUANG	X	X	X	X	X	X	X	X						
48462	ARANYAPRATHET	X	X	X	X	X	X	X	X						
48475	HUA HIN	X	X	X	X	X	X	X	X						
48477	SATTAHIP	X	X	X	X	X	X	X	X						
48480	CHANTHABURI	X	X	X	X	X	X	X	X	X		X			
48500	PRACHUAP KHIRIKHAN	X	X	X	X	X	X	X	X	X		X			
48517	CHUMPHON	X	X	X	X	X	X	X	X						
48532	RANONG	X	X	X	X	X	X	X	X						
48551	SURAT THANI	X	X	X	X	X	X	X	X	X	X	X	X		
48565	PHUKET AIRPORT	X	X	X	X	X	X	X	X						X
48567	TRANG	X	X	X	X	X	X	X	X						
48568	SONGKHLA	X	X	X	X	X	X	X	X		X	X			X
48569	HAT YAI	X	X	X	X	X	X	X	X						
48583	NARATHIWAT	X	X	X	X	X	X	X	X						

TABLE III-2: List of stations other than those in the WWW network from which special observations are available in cyclone situations

Country: Bangladesh

Name of Station	Surface								Radiowind				Radiosonde		
	1	2								3				4	
		00	03	06	09	12	15	18	21	00	06	12	18	00	12
41858 SAYEDPUR	X	X	X	X	X	X	X	X							
41859 RANGPUR		X	X	X	X	X	X	X		X	X	X	X		
41863 DINAJPUR	X	X	X	X	X	X	X	X							
41883 BOGRA		X	X	X	X	X	X	X		X	X	X	X	X	
41886 MYMENSINGH	X	X	X	X	X	X	X	X							
41891 SYLHET		X	X	X	X	X	X	X		X	X	X	X		
41895 RAJSHAHI		X	X	X	X	X	X	X							
41909 TANGAIL		X	X	X	X	X	X	X							
41907 ISHURDI		X	X	X	X	X	X	X		X	X	X	X		
41915 SRIMONGAL	X	X	X	X	X	X	X	X							
41923 DHAKA		X	X	X	X	X	X	X		X	X	X	X	X	
41926 CHUADANGA	X	X	X	X	X	X	X	X							
41929 FARIDPUR	X	X	X	X	X	X	X	X							
41933 COMILLA		X	X	X	X	X	X	X							
41936 JESSORE		X	X	X	X	X	X	X		X	X	X	X		
41939 MADARIPUR	X	X	X	X	X	X	X	X							
41941 CHANDPUR		X	X	X	X	X	X	X							
41943 FENI		X	X	X	X	X	X	X		X	X	X	X		
41946 SATKHIRA		X	X	X	X	X	X	X							
41947 KHULNA		X	X	X	X	X	X	X							
41950 BARISAL		X	X	X	X	X	X	X		X	X	X	X		
41951 BHOLA		X	X	X	X	X	X	X							
41953 MAJDI COURT		X	X	X	X	X	X	X							
41958 MONGLA	X	X	X	X	X	X	X	X							
41960 PATUAKHALI		X	X	X	X	X	X	X							
41963 HATIYA		X	X	X	X	X	X	X							
41964 SANDWIP		X	X	X	X	X	X	X							
41965 SITAKUNDA		X	X	X	X	X	X	X							
41966 RANGAMATI		X	X	X	X	X	X	X							
41977 CHITTAGONG (AMBAGAN)			.	.	.	.	.	.		X	X	X	X	X
41978 CHITTAGONG (PATENGA)		X	X	X	X	X	X	X							
41984 KHEPUPARA		X	X	X	X	X	X	X							
41989 KUTUBDIA		X	X	X	X	X	X	X							
41992 COX'S BAZAR		X	X	X	X	X	X	X		X	X	X	X		
41998 TEKNAF		X	X	X	X	X	X	X							
43413 MANNAR		X	X	X	X	X	X	X							
43475 POTTUVIL		X	X	X	X	X	X	X							

TABLE III-3
Buoys over north India Ocean

Buoy's ID	Surface								Radiowind				Radiosonde	
	2								3				4	
	00	03	06	09	12	15	18	21	00	06	12	18	00	12
Indian Buoys														
AD02 (ARB)	X	X	X	X	X			X						
AD03 (ARB)	X	X		X	X	X	X	X						
AD04 (ARB)	X	X		X	X	X	X	X						
AD05 (ARB)	X	X	X	X	X	X	X	X						
CB02 (ARB)	X	X		X	X			X	X					
CB03 (ARB)	X	X		X	X			X	X					
SW02 (ARB)	X	X		X	X			X	X					
BD02 (BOB)	X	X	X	X	X	X	X	X	X					
BD07 (BOB)	X	X	X	X	X	X	X	X	X					
BD08 (BOB)	X	X	X	X	X	X	X	X	X					
BD10 (BOB)	X	X		X	X	X	X	X	X					
BD11 (BOB)	X	X	X	X	X	X	X	X	X					
BD12 (BOB)	X	X		X	X	X	X	X	X					
BD13 (BOB)	X	X		X	X			X	X					
CB01 (BOB)	X	X		X	X			X	X					
Oman Buoys														
23053 Buoy (MINA SALALAH) ¹	X	X	X	X	X	X	X	X	X					

¹ Temporarily discontinued

3.1.4 *Upper air stations*

Additional upper wind observations will be made as appropriate whenever a tropical cyclone is centered within 500 nautical miles of the station. The minimum required is two observations per day, but for a better understanding of the ambient wind field three or even four flights on some days will be made when possible. All these additional upper air observations will be distributed among the Panel countries.

3.2 **Observations from mobile ships**

Efforts will be made to obtain the maximum number of ships' observations from the cyclone field by the NMSs and to pass on these observations to RSMC New Delhi. Whenever there is a tropical cyclone in the Bay of Bengal or in the Arabian Sea, additional ships' reports at frequent intervals will be requested by the storm warning centre/meteorological office concerned.

3.3 **Aircraft reports**

All reports from aircraft in flight in the area will be passed on real time to RSMC, New Delhi and to other Panel countries. In case the national meteorological service collecting the report deems it to be of interest in the analysis or forecasting of a tropical cyclone situation, it will be prefixed with an agreed high priority symbol.

3.4 **Radar observations**

As long as a tropical cyclone remains within range of one of the cyclone detection radars in the region, the meteorological centre concerned will keep the system under continuous surveillance and will transmit the radar observations through GTS to RSMC New Delhi and other Panel countries. These reports will be made in accordance with a reestablished schedule, preferably on a regular three hourly basis.

The report will be in the RADOB code (FM20VRADOB) or the code given in **Annex IIIA** and will be transmitted twice to ensure reception of the complete message. The radar imageries will be exchanged through website or e-mail.

In case the report is in plain language, the full range of information available at the radar station will be given. The message will therefore include, where available, the confirmation of the determination of the centre; the shape, definition, size and character tendency of the eye, the distance between the end of the outermost band and the centre of the cyclone and the direction and speed of movement with a statement of the interval of time over which the movement was calculated.

A list of the cyclone detection radar stations in the Panel area is given in **Table III-4**.

TABLE III-4
WEATHER RADAR STATIONS KEEPING WATCH
OVER THE ARABIAN SEA AND THE BAY OF BENGAL

Country	Station	N	E	Type	Op. since
Bangladesh	41992 Cox's Bazar	21°20'	92°17'	Doppler	1970
	41984 Khepupara	21°59'	90°14'	Doppler	1982
	41923 Dhaka	23°46'	90°23'	10 cm	1970
	41859 Rangpur	25°44'	89°14'	10 cm	1999
India	42807 Kolkata	22°34'	88°21'	10 cm / DWR	1973 2002
	42976 Paradip	20°16'	86°39'	10 cm	1973
	43149 Visakhapatnam	17°45'	83°21'	10 cm	1970
				DWR	2006
	43185 Machilipatnam	16°11'	81°09'	10 cm/ DWR	1981 2004
				DWR	2004
	-- Sriharikota	13°40'	80°14'	DWR	2004
	43278 Chennai	12°59'	80°15'	10 cm	1973
				DWR	2002
	43346 Karaikal	10°54'	79°50'	10 cm	1989
				DWR	2016
	43353 Kochi	09°56'	76°16'	10 cm	1987
				DWR	2016
	43192 Goa	15°29'	73°49'	10 cm	2002
DWR				2016	
43057 Mumbai	18°54'	72°49'	10 cm	1989	
			DWR	2016	
42634 Bhuj	23°15'	69°48'	10 cm	1987	
			DWR	2016	
Maldives	43555 Male	04°09'	73°11'	10 cm(DWR)	2008
Myanmar	48071 Kyaukpyu	19°23'	93°33'	10 cm	1979(Not operational)
Pakistan	41780 Karachi	24°54'	67°08'	5.6 cm	1991
Thailand	48455 Bangkok	13° 55'	100°36'	10 cm(DWR)	1992
	48475 Hau Hin	12°35'	99°57'	10 cm(DWR)	1995
	48517 Chumphon	10°29'	99°11'	5.6 cm(DWR)	2008
	48551 Surat Thani	09°08'	99°9'	10 cm (DWR)	1993
	48565 Phuket	08°08'	98°19'	5.6 cm(DWR)	2006
	48569 HAT Yai	06°56'	100°23'	5.6 cm(DWR)	2004
	48563 Krabi	08°06'	98°58'	5.6 cm(DWR)	2006
	48568 Songkhla	07°26'	100°27'	5.6 cm(DWR)	2011
	48583 Narathiwat	06°25'	101°45'	5.6 cm(DWR) (Dual.Pol.)	2014

CODE FOR REPORTING RADAR OBSERVATIONS RELATING TO CYCLONIC DISTURBANCES

Part "A" (to be reported when centre of the storm can be determined).

CYREP FFAA STATION llll YYGGg 4R wLaLaLa 1LoLoLoLo EYE or SPIRAL
6CSDT Pdsdfsfs

Explanatory Notes

CYREP FFAA : Radar Report giving centre of a cyclone

STATION : Name of station in plain language

llll : Station Index Number

YY : UTC date

GGg : Time of observation in hours and tens of minutes UTC

4 : Indicator figure

1 : Quadrant of globe '1' for our area as per WMO definition

Rw : Wavelength of radar

3 for 3 cm radar, 5 for 5.6 cm radar, 8 for 10 cm radar

LaLaLa : Latitude } In tenths of a degree.

Tenths are

} obtained by dividing the number of minutes

LoLoLoLo : Longitude } by six and discarding the remainder.

EYE or : Either the word "EYE" or the word "SPIRAL" will be reported,

SPIRAL but not both.

The word "EYE" will be reported if a partial or complete eye is seen by the radar.

If a double walled eye is seen "DOUBLE EYE" will be reported instead of "EYE".

If the storm centre is estimated using only spiral bands the word "SPIRAL" will be reported.

6 : Indicator figure to show that eye characteristics and/or confidence of fix follow.

C : Confidence of fix (Vide Table 1).

S : Shape of eye and length of arc of eyewall seen (Vide Table 2).

D : Diameter or length of major axis of the eye (Vide Table 3).

T : Tendency of the eye determined over the period since the last observation (Vide Table 4).

NOTE: S, D and T will be reported as solidus (/) if the storm centre is fixed from spiral bands only.

P: Period over which the movement of the storm centre has been determined (Vide Table 5).

dsds: Direction in tens of degree towards which the storm centre is moving.

fsfs: Speed of movement of storm centre in kilometres per hour.

If movement over a period of 3 hours or more cannot be estimated, the group pdsdfsfs will be dropped.

NOTE: The radar meteorologist may at his discretion add any other operationally useful information not covered above, in plain language at the end of Part A of the message.

TABLE 1
Confidence of Fix (C)

Code Figure	Category	Radar echo pattern	Likely accuracy about
1.	Very poor	Spiral bands, ill defined or too few or too short	100 km
2.	Poor	Centre estimated from well defined spiral bands ----- eye not visible	50 km
3.	Fair	Partial eye wall seen	30 km
4.	Good	Closed or nearly closed eye whose geometric centres can be located with confidence	10 km

NOTE: The accuracy and criteria as given above are only illustrative and not definitive.

TABLE 2

Shape of eye and length of arc of eyewall seen (S)		
Code Figure	Length of arc	Shape
0	-----	Ill-defined
1	Less than 180 ⁰	{ Shape other than
2	More than 180 ⁰	{ circular or elliptical
3	Closed	{
4	Less than 180 ⁰	{
5	More than 180 ⁰	{ Elliptical
6	Closed	{
7	Less than 180 ⁰	{
8	More than 180 ⁰	{ Circular
9	Closed	{

TABLE 3

D- Diameter or length of major axis of the eye of the tropical cyclone			
Code Figure		Code Figure	
0	less than 10 km	6	60 to 69 km
1	10 to 19 km	7	70 to 79 km
2	20 to 29 km	8	80 to 89 km
3	30 to 39 km	9	90 km and greater
4	40 to 49 km	/	undetermined
5	50 to 59 km		

TABLE 4

T- Tendency of the eye, determined over the period since the last observation

Code Figure	
0	Eye has first become visible since the last observation.
1	No significant change in the characteristics or size of the eye.
2	Eye has become smaller with no other significant change in characteristics.
3	Eye has become larger with no other significant change in characteristics.
4	Eye has become less distinct with no significant change in size.
5	Eye has become less distinct and decreased in size.
6	Eye has become less distinct and increased in size.
7	Eye has become more distinct with no significant change in size.
8	Eye has become more distinct and decreased in size.
9	Eye has become more distinct and increased in size.
/	Change in character and size of eye cannot be determined.

TABLE 5

Code Figure	Period
7	During the preceding 3 hours
8	During the preceding 6 hours
9	During a period of more than 6 hours

(to be reported whenever any radar echo is seen)

RAREP FFBB Iliii YYGGg CHARACTER (b1b1b1/r1r1r1 -----bnbnbn/rnrnrn) INTENSITY TENDENCY
dsdsfsfs ALTD (bbb/HtHt/rrr)

- NOTE:** 1. Part B will normally be reported only at synoptic hours. In the case of any break in observations or rapid development, additional Part B messages may be transmitted as necessary.
2. Part A messages are to be prepared and transmitted as close to the observation time as possible. Part B can be transmitted separately, after Part A has been sent. When Part A and Part B are transmitted together, the code groups RAREP, Iliii, YYGGg need not be included in Part B.

Character:

- EYE :** An echo identified definitely as the eye wall of a tropical cyclone.
- SPRL BND :** A continuous or broken curved line of echoes recognizable as a spiral band associated with a cyclonic system.
- SQL LN :** This pattern should normally have a length to width ratio of about 10 to 1 and length about 60 km or more.
- BRKN LN :** A broken line of echoes.
- SLD :** An area fully covered with echoes.
- BRKN :** An area 4/8 to 7/8 covered with echoes.
- SCT :** An area 1/8 to 4/8 covered with echoes.
- WDLY SCT :** An area less than 1/8 covered with echoes.
- ISLTD :** Isolated solid mass of echo.
- ECHO ALDFT :** Echo seen only at elevations higher than half the beam width.
- bbb :** Azimuth in three digits (degrees) of points on the periphery of an echo area.
- rrr :** Range (three digits) in units of kilometers.

NOTE:

- (1) The groups within the brackets () may be reported as many times as necessary.
- (2) In the case of line echoes, in spiral bands and eye wall, as many bbb/rrr points along the line as necessary may be given to define the shape of the line. The points should preferably be given along the line in the anticlockwise direction.
- (3) In the case of areas, as many bbb/rrr points as necessary to define the shape may preferably be given in the anticlockwise order starting from the northernmost point. The first point should be repeated as the last point to indicate that it is a closed area.

ANNEX III-A-4

(4) In any one RAREP message, the character of echoes will be reported in the order given in the group description above.

(5) If an echo system with a distinct characteristic is partly or wholly embedded in another, the two systems should be reported in separate groups. For example, a SPRL BND, or BRKNLN (which may be distinguished as such by using the attenuator or isoecho system) embedded in a larger area of echoes will be reported as SPRL BND or BRKN LN in addition to the area reported separately.

(6) The number of features or groups should be as few as possible, and should be just sufficient to convey an overall picture of the system.

Intensity:

Code	dBZ	For radars having facility for quantitative measurement	
		Approximate rainfall rate mm/hr	Other radars
WK	23 to 32	less than 4	Qualitatively
MDT	33 to 42	4 to 15	determined as in
STG	43 to 52	16 to 63	Weather Radar
VRY STG	53 or more	64 and above	Manual

- NOTE: (1) The intensity of the strongest echo in the group is to be reported.
 (2) The rainfall rates indicated are based on the relationship $Z = 200R^{1.6}$ and may be taken only as a rough guide.
 (3) Intensity is to be reported only of echoes within 200 km range

Tendency:

INCG : Increasing
 DCG : Decreasing
 NO CHG : No change

In view of the difficulties in finding out the tendency of echoes of large areal extent as in a depression or cyclone, tendency should be reported only in case of isolated cells or groups of cells or a line mainly for aviation purposes. The radar meteorologist will take into consideration the change in height, area, length and intensity of echoes over a period of time in judging the tendency.

dsds : Direction in tens of degrees towards which the echo or group of echoes is moving.
 fsfs : Speed in kmph of the echo or group of echoes.

Doppler Weather Radar (DWR):

Doppler Weather Radars provide vital information on radial velocity within tropical cyclone which is not available in conventional radars. Conventional radar provides information on reflectivity and range only, whereas a DWR provides velocity and spectral width data along with various meteorological, hydrological and aviation products which are very useful for forecasters in estimating the storm's center, its intensity and predicting its future movement. The DWR generates these products through a variety of software algorithms.

NOTE: (1) In case of a group of echoes or of a line, only the overall movement of the group of echoes will be reported.

(2) The movement will be observed over a period of, say 30 to 60 minutes.

ALTD: Indicator for echo height information.

HtHt : Height of top of echo above mean sea level in kilometers.

NOTE: (1) Reports of heights should be restricted to a maximum range of 200 km from the station.

(2) In the case of echoes of large areas, the height group may be repeated as necessary for including a number of prominent echoes.

The radar meteorologist will have discretion to report any other special phenomena such as Bright Band and Anomalous Propagation in plain language at the end of the message.

Parts A and B both shall be used whenever the echo pattern observed is recognized as relating to tropical cyclone. Part B only will be used for reporting echoes other than connected with tropical cyclone.

The products available from DWR of IMD which are available in IMD website include PPI (Z), PPI (V), MAX(Z), VVP2, SR1 and PAC . In the IMD website these products are uploaded at 10 minutes interval when a cyclone comes within a coastal Radar range and could be used by member countries.

Hourly radar bulletin is issued by DWR stations in India during the cyclone period. An example of the bulletin is given below:

CYCLONE REPORT

1. Name of the station	: DWR Chennai
2. Date and Time (UTC) of observation	: 20161212_0500 UTC
3. Name of the cyclone	: Vardah
4. Information about eye of cyclone	: Yes
a. Is the eye Visible (Yes/No)	: Yes
b. Shape of the eye	: Irregular
c. Diameter of eye (km)	: 34.44 km
d. Estimation of centre of cyclone based on Eye/Spiral band observation	: 12.18525N 80.834E
e. Echo top (height 20 dBz) of rain bearing clouds around the cyclone within 100 km radius	: 10.28 km
f. (i) Maximum radar reflectivity (dBz) of rain bearing clouds around the cyclone within 100km radius	: 63.0 dBz, 36.2 km range, 101 deg-Az, 5.02 km height
(ii) Maximum reflectivity at any other area Spiral/streamers etc.	:
g. (i) Maximum radial velocity in eyewall/spiral band region (mps) Its height (km) and its position (Azimuth and distance from Radar)	: 51 m/s at 0.493 km height
(ii) Maximum velocity in any other area (spiral/streamers/rain shields etc.)	:
5. Tendency of cyclone	
a. Intensity (Increasing/Decreasing)	:
b. Duration for which the information on movement of the system pertains to	: 1 hours
c. Direction of movement	: WSW
d. Estimated speed of movement	: 23.6 km/hr
6. Any other feature (s)	: Leading for landfall closer to in next few hours

Satellite cloud imagery monitoring facilities in the Panel countries**Bangladesh**

Bangladesh Meteorological Department (BMD) has the facilities of NOAA HRPT and MTSAT LRIT & HRIT cloud imageries from NOAA and MTSAT satellites respectively. The satellite imageries of all channels are updated on BMD website (<http://www.bmd.gov.bd>) regularly.

India

At present IMD is receiving and processing meteorological data from three Indian satellites namely Kalpana-1, INSAT-3D & INSAT-3DR. Kalpana-1 was launched on 12th September, 2002 and is currently located at 72.5°E. INSAT-3D launched on 26 July 2013 is positioned at 82°E and INSAT 3DR launched on 8 September, 2016 is located at 74°E . Kalpana-1 has payload of Very High Resolution Radiometer (VHRR) for imaging the earth in three channels viz. Visible (0.55-0.75 μm), Infra-Red (10.5-12.5 μm) and Water vapour (5.7-7.1 μm) having resolution of 2X2 km in visible and 8X8 km in Water vapour (WV) and Infra-red (IR) channels. INSAT-3D and INSAT-3DR have an advanced imager with six imagery channels {Visible (0.55-0.75 μm), Short wave Infra-Red (SWIR) (1.55-1.70 μm), Medium Infra-Red (MIR) (3.80-4.00 μm), Thermal Infra-Red-1(TIR-1) (10.2-11.3 μm), TIR-2 (11.5-12.5 μm), & WV (6.50-7.10 μm)} and a nineteen channel sounder (18 IR & 1 Visible) for derivation of atmospheric temperature and moisture profiles. It provides 1 km. resolution imagery in visible band, 4 km resolution in IR band and 8 km in WV channel.

At Present about 48 nos. of satellite images are taken daily from Kalpana-1, INSAT-3D and INSAT-3DR. Half hourly satellite imageries are also obtained from all the six imager channels and hourly images from the sounder channels of INSAT-3D satellite. All the received data from the satellite are processed and archived in National Satellite Data Center (NSDC), New Delhi. INSAT-3D Meteorological Data Processing System (IMDPS) is processing meteorological data from INSAT-3D and supports all operational activities of the Satellite Meteorology Division on round the clock basis. Cloud Imagery Data are processed and transmitted to forecasting offices of the IMD as well as to the other users in India and foreign countries.

The following products derived from the satellite are useful for monitoring of tropical cyclones

1. Enhanced grey scale imagery of cyclone.
2. Enhanced coloured imagery of cyclone.
3. Lower level Vorticity
4. Upper level Divergence.
5. Lower level convergence.
6. Vertical wind shear.
7. Wind shear tendency.
8. Outgoing Long wave Radiation (OLR) at 0.25X0.250 resolution
9. Quantitative Precipitation Estimation (QPE) at 10 /10 resolution
10. Sea Surface Temperature (SST) at 10 /10 resolution
11. Cloud Motion Vector (CMV)
12. Water Vapour Wind (WVW)
13. Upper Tropospheric Humidity (UTH)
14. Temperature, Humidity profile
15. Value added parameters from sounder products
 - a. Geo-potential Height
 - b. Layer Precipitable Water
 - c. Total Precipitable Water
 - d. Lifted Index
 - e. Dry Microburst Index
 - f. Maximum Vertical Theta-E Differential
 - g. Wind Index

At present Dvorak technique is used but manually applied. Recently efforts have been made for automation of this technique. Automated Dvorak technique version (8.2.1) is running in experimental mode at

Satellite Application Unit, Satellite Meteorology Division. Satellite Application Unit is also using Microwave imageries operationally from NOAA, Metop's DMSP satellites for locating the tropical systems. Satellite Application Unit issues three hourly bulletins in general and hourly and half hourly bulletins in case of tropical cyclones and other severe weather events.

With the Web Archival System developed at IMD, KALPANA-1/INSAT-3A/ INSAT-3D & INSAT-3DR products & imageries are archived. The automatic script is being used to keep and update the images/products on the website for 6 months. These are available to all users

A GIS based quick visualization and analysis tool for satellite data on real time basis, namely Real time Analysis of Product & Information Dissemination (RAPID) has been launched.

The satellite imageries of all channels are updated every half hourly on IMD website. The images displayed are full frame, Asia Mercator Sector and Northwest sector. Animation of last 24 hours/ 72 hours/ Infrared images are also put on IMD website (www.imd.gov.in) for users and public.

Satellite Derived Products

The computer system (IMDPS) commissioned in year 2000, is used for processing data from INSAT series of satellite. Apart from generating cloud imagery, the following products are derived from satellite data; and the same are also archived.

- (i) Atmospheric Motion Vector (CMVs) and water vapour winds based on three consecutive KALPANA-I images at 00, 06 ,12 &15 UTC are being disseminated over the GTS and website.
- (ii) Sea Surface Temperature (SSTs) eight times a day as well as, daily mean for each $1^{\circ} \times 1^{\circ}$ latitude/ longitude grid (free from cloud contamination) using KALPANA-I data.
- (iii) Outgoing Long wave Radiation (OLR) on daily / weekly / monthly basis over $0.25^{\circ} \times 0.25^{\circ}$ latitude/longitude grid
- (iv) Quantitative Precipitation Estimates (QPE) on daily / weekly / monthly basis over $1^{\circ} \times 1^{\circ}$ attitude/ longitude grid, using the standard temperature threshold technique of Arkin.
- (iv) The cloud motion vectors derived from INSAT satellites and hydro-estimator are displayed on IMD website daily. In addition to this QPE, OLR and SST are also displayed on IMD website daily.
- (v) Relative vorticity, vertical wind shear of horizontal wind, low level convergence, upper level divergence are available every hourly on IMD and RSMC website.
- (vi) Cyclone specific enhanced colored and gray scale imageries are also available on IMD and RSMC website.

In recent years India has launched the following Satellite which will be useful in the monitoring and prediction of tropical cyclone.

(a) RISAT-1:

Radar Satellite-1 (RISAT-1) is a state of the art Microwave Remote Sensing Satellite carrying a Synthetic Aperture Radar (SAR) Payload operating in C-band (5.35 GHz), which enables imaging of the surface features during both day and night under all weather conditions. Active Microwave Remote Sensing provides cloud penetration and day-night imaging capability. These unique characteristics of C-band (5.35GHz) Synthetic Aperture Radar enable applications in management of natural disasters like flood and cyclone. The data from this satellite are available for operation use from later part of 2012

Cyclone Warning Dissemination System (CWDS) through INSAT

Cyclone Warning Dissemination System (CWDS) is a dependable scheme for transmission of cyclone alert/warning message directly to the area likely to be affected by the cyclone using the S-band broadcast capabilities on board the Indian National Satellite (INSAT) .The system enables the cyclone warning center of IMD to directly and selectively address a particular area likely to be affected by cyclones. 251 Analogue CWDS receiver and 101 Digital CWDS receivers have already been installed in the coastal areas on India. Since the existing 252 Cyclone Warning Dissemination System (CWDS) stations and 101 digital CWDS have become obsolete and many of these systems have stopped working and were beyond repair, IMD and ISRO jointly decided to replace all these CWDS systems by new 500 numbers of Direct Telecom Hub (DTH) based Disaster Warning Dissemination Systems (DWDS) for issuing warning to cyclone prone areas. Till date 178 numbers of DTH based DWDS systems has been installed in Tamil Nadu, Pondicherry and Andhra Pradesh.

The DTH based DWDS system can disseminate the warning messages in real time to multiple receiving locations spread over large coastal areas. This service is unique in the world and will help the public in general and the administration, in particular, during the cyclone.

Automatic Weather Stations (AWS)

Data from the AWS is being received round the clock at the Receiving Earth Station, Pune through the geostationary satellite KALPANA-I, and utilizing Pseudo-Random burst Sequence (PRBS) technique of transmission.

The raw data received from all AWS is processed at the Earth Station and the synoptic data in WMO synop Mobile FM-14 Ext format is transmitted to Global Telecommunication system (GTS) by AMSS Mumbai every hour. The processed data is archived at earth station, Pune. Procedures for quality checking and archival of AWS data at National Data Centre (NDC), Pune have also commenced. Current AWS data is available in IMD Pune website www.imdpune.gov.in / RSMC website under **Data & Tool**

Maldives

Digital Meteorological Data Dissemination (DMDD) system donated by India Meteorological Department (IMD) receives WMO coded GTS data, half hourly cloud imagery from KALPANA and Fax charts in LRIT/HRIT format transmitted by IMD and display on a high resolution color monitor. Images can be further enhanced using different image processing functions and can be focused more on the area of interest. This system has the capability to plot the received met data by values or contours on a specific image. With all these features it helps forecasters to do more precise predictions.

However, this system is facing signal loss therefore nothing has been received during 2012 and 2013.

The High Resolution Satellite Image Receiving System GEOSAT 500 has stopped functioning since 2010 due to expiring of service agreement with manufacture.

An integrated satellite receiving system generously donated by China Meteorological Agency was installed on 25 October 2012. This **CMACAST** system receives Satellite imageries from FY2E and FY2D series of Chinese geostationary satellites at an interval of 30 minutes. Surface synoptic data, Upper air sounding data, NWP of ECMWF, T213: NWP of CMA global model, NWP accumulation precip from Germany model and Japan model. Another component of this system is the application software MICAPS (meteorological data analyzing system) which enables to display satellite pictures, surface & upper air data and NWP products and overlay different products and analysis of various weather phenomena. This SYSTEM is satisfactorily operational.

Myanmar

The Department of Meteorology and Hydrology in Myanmar is receiving satellite imageries from MTSAT ground receiver, Feng Yun Cast ground receiver and also from US polar-orbiting satellites (NOAA series of the USA).

An integrated satellite receiving system generously donated by China Meteorological Agency was installed on March 2012. This **CMACAST** system receives Satellite imageries from FY2E and FY2D series of Chinese geostationary satellites at an interval of 30 minutes. Surface synoptic data, Upper air sounding data, NWP of ECMWF, T213: NWP of CMA global model, NWP accumulation precipitation from Germany model and Japan model. Another component of this system is the application software MICAPS (meteorological data analyzing system) which enables to display satellite pictures, surface & upper air data and NWP products and overlay different products and analysis of various weather phenomena.

Oman (Sultanate of Oman)

The Meteorological Department has the following satellite ground receiving stations:

- (i) APT and WEFAX system based at Muscat International Airport.
- (ii) APT and WEFAX system based at Muscat Airport.
- (iii) HRPT system at Muscat International Airport.
- (iv) PDUS at Muscat International Airport.
- (v) S-VISSR at Muscat International Airport.

All the above mentioned systems receive their data from the EUMETSAT Geostationary Satellite and NOAA Polar Orbiting Satellites.

Apart from generating cloud imagery, several products are derived from the satellite data. Some of these products are:

- (i) Sounding based on TOVS [on experimental basis]
- (ii) Sea surface temperature
- (iii) Precipitation estimates
- (iv) Cloud tops
- (v) Fire detection [on experimental basis]
- (vi) Pollution [on experimental basis]
- (vi) Vegetation Index - NDVI [on experimental basis]

Pakistan

Satellite Ground Stations operated by PMD

1. HRPT at Islamabad and Quetta and
2. FY-2E/D (CMA cast-satellite receiving products, cloud imageries, winds and vorticity etc) at Islamabad and Karachi Airport.
3. Other satellite imageries available thru internet are accessed too.

Sri Lanka

Satellite imageries and products are received from Himawari 8 and FY 2D/E through the real time receiving systems .

METEOSAT-7/ MTSAT/ INSAT imageries are accessed through Internet regularly

Thailand

The Meteorological Department in Thailand is receiving satellite imagery from Himawari 8,. FY-2, FY-3 TIROS (NOAA15, 16, 18, 19), and Terra/Aqua Direct Broadcast (MODIS) satellites.

CHAPTER IV

TROPICAL CYCLONE FORECASTING

4.1 Forecasting development and movement of tropical cyclones

The final responsibility for analysis and forecasting of genesis, intensification and movement of tropical cyclones in the region will be with the National Meteorological Service of each of the Members. However, in addition to the exchange of observational data needed for analysis and forecasting, the following special arrangements for the exchange of processed products and advisories have been made.

- (i)
 - (a) Processed products will be provided by RSMC tropical cyclones, New Delhi. A list of output products broadcast from RSMC tropical cyclones, New Delhi for international purposes is given in Table IV.1. A list of other products broadcast through facsimile from RSMC tropical cyclones, New Delhi for national purposes is given in Annex IV-A.
 - (b) RSMC tropical cyclones, New Delhi will issue a tropical weather outlook once daily throughout the year for the benefit of the Member countries. It is being transmitted on the GTS at 06 UTC. The outlook covering the Bay of Bengal and the Arabian Sea indicates possible development of tropical depressions over the sea. An additional outlook will be transmitted again over the GTS at 1700 UTC when a Depression is located and expected to intensify into a cyclonic storm.
- (ii) In case there is a tropical cyclone in the Panel region, RSMC tropical cyclones, New Delhi will also issue the following:
 - (a) Tropical cyclone advisories, details of which have been given in earlier chapters.
 - (b) Tropical Cyclone Advisory Centre (TCAC) New Delhi will issue Tropical Cyclone Advisory bulletins for the international air navigation to Meteorological Watch Offices (MWOs) in area of responsibility at least for every six hours.
- (ii) The satellite tropical disturbance summary issued from Washington will be exchanged through the GTS.
- (iii) National Meteorological Services may like to use climatological charts of average vector motions for the track prediction. The track prediction based on climatological charts are usually most useful (minimum error) when tropical storms are to the south of subtropical anticyclones. Such charts for the region for each month and for each season are available in IMD and RSMC, New Delhi website in the form of cyclone Web Atlas.

4.2 Prediction Models in operational use during the year 2017

4.2.1 Global Forecast System

The Global Forecast System (GFS), adopted from National Centre for Environmental Prediction (NCEP) was implemented at India Meteorological Department (IMD), New Delhi on IBM based High Power Computing Systems (HPCS) at T1534 (~ 12 km in horizontal over the tropics) with ENKF based Grid point Statistical Interpolation (GSI) scheme as the global data assimilation for the forecast up to 10 days. The model is run twice in a day (00 UTC and 12 UTC). The real-time outputs are made available to the national web site of IMD (<http://www.imd.gov.in/section/nhac/dynamic/nwp/welcome.htm>).

IMD also makes use of NWP products prepared by some other operational NWP Centers like, ECMWF (European Center for Medium Range Weather Forecasting), GFS (NCEP), JMA (Japan Meteorological Agency), UKMO etc..

4.2.2 Regional Forecast System

IMD operationally runs three regional models WRFDA-WRFARW (v3.6), and HWRF for short-range prediction during cyclone condition.

4.2.2.1. Non-hydrostatic mesoscale modeling system WRFDA-WRF-ARW

The mesoscale forecast system Weather Research and Forecast WRFDA (version 3.6) with 3DVAR data assimilation is being operated daily twice to generate mesoscale analysis at 9 km horizontal resolution using IMD GFS-T574L64 analysis as first guess and forecasts as boundary condition. Using analysis and updated boundary conditions from the WRFDA, the WRF (ARW) is run for the forecast up to 3 days with double nested configuration with horizontal resolution of 9 km and 3 km and 45 Eta levels in the vertical. The model mother domain covers the area between lat. 23°S to 46°N long 40°E to 120°E and child covers whole India. The performance of the model is found to be reasonably skilful for cyclone genesis and track prediction. At ten other regional Centers, very high resolution mesoscale models (WRF at 3 km resolution) are also operational with their respective regional setup/configurations.

4.2.2.2 Hurricane WRF Model (HWRF)

Recently under Indo-US joint collaborative program, IMD adapted Hurricane-WRF model for Tropical Cyclone track and intensity forecast for North Indian Ocean region for its operational requirements. The basic version of the model HWRFV (3.7+) which was operational at EMC, NCEP, USA was ported on IITM ADITYA HPCS machine with nested domain of 27 km, 9 km and 3 km horizontal resolution and 61 vertical levels with outer domain covering the area of 216X432, 106X204 and innermost domain 198X354 with Center of the system adjusted to the Center of the observed cyclonic storm. The outer domain covers most of the North Indian and the inner domain mainly covering the cyclonic vortex which moves along the movement of the system. The model has special features such as vortex initialization, coupled with Ocean model to take into account the changes in SST during the model integration, tracker and diagnostic software to provide the graphic and text information on track and intensity prediction for real-time operational requirement. Model has full physics configuration with cloud microphysics of eta-HWRF scheme (Rogers et al., 2001), radiation physics for short wave and long wave (GFDL schemes), surface layer (GFDL) and surface physics (GFDL slab model), planetary boundary layer physics (Hong and Pan, 1996) and cumulus physics (New simplified Arakawa-Schubert - Han and Pan, 2011).

As part of model validation, case studies were undertaken to test the ability of the model for the Cyclonic storms formed during the year 2010 and model forecasts are produced up to 5 days during the 2011 cyclone season as an experimental forecast in real-time. In these runs only the atmospheric model (HWRF) was tested. The Ocean Model (POM-TC) and Ocean coupler requires the customization of Ocean Model for Indian Seas. In this regards, IMD is working in collaboration with INCOIS, Hyderabad which is running the Ocean Models (POM)/Hybrid co-ordinate ocean model (HYCOM) to support in porting the Ocean Model with Indian Ocean climatology and real time data of SST over Indian Seas. The model is run on real time six hourly basis (started from cyclone season 2016) based on 00, 06, 12 and 18 UTC initial conditions to provide 6 hourly track and intensity forecasts along with surface wind and rain swaths valid up to 126 hours. The model uses IMD GFS-T1534L64 analysis/forecast as first guess. The model is run with a resolution of 18km, 6km, and 2km from post monsoon season in 2016.

4.2.3. Genesis Potential Parameter (GPP)

A cyclone genesis parameter, termed the genesis potential parameter (GPP), for the North Indian Sea is developed (Kotal et al, 2009). The parameter is defined as the product of four variables, namely vorticity at 850 hPa, middle tropospheric relative humidity, middle tropospheric instability, and the inverse of vertical wind shear. The parameter is operationally used for distinction between non-developing and developing systems at their early development stages. The composite GPP value is found to be around three to five times greater for developing systems than for non-developing systems. The analysis of the parameter at early development stage of a cyclonic storm found to provide a useful predictive signal for intensification of the system.

The grid point analysis and forecast of the genesis parameter up to seven days is also generated on real time (available at <http://www.imd.gov.in/section/nhac/dynamic/Analysis.htm>). Higher value of the GPP over a region indicates higher potential of genesis over the region. Region with GPP value equal or greater than 30 is found to be high potential zone for cyclogenesis. The analysis of the parameter and its effectiveness during cyclonic disturbances in 2012 affirm its usefulness as a predictive signal (4-5 days in advance) for cyclogenesis over the North Indian Ocean.

4.2.4. Statistical Dynamical model for Cyclone Intensity Prediction (SCIP)

A statistical-dynamical model (SCIP) (Kotal et al, 2008) has been implemented for real time forecasting of 12 hourly intensity up to 120 hours. The model parameters are derived based on model analysis fields of past cyclones. The parameters selected as predictors are: Initial storm intensity, Intensity changes during past 12 hours, Storm motion speed, Initial storm latitude position, Vertical wind shear averaged along the storm track,

Vorticity at 850 hPa, Divergence at 200 hPa and Sea Surface Temperature (SST). For the real-time forecasting, model parameters are derived based on the forecast fields of IMD-GFS model. The method is found to be provided useful guidance for the operational cyclone forecasting.

4.2.5. Multi-model ensemble (MME) technique (IMD-GFS, NCEP-GFS, UKMO, ECMWF, JMA)

The multi model ensemble (MME) technique (Kotal and Roy Bhowmik, 2011) is based on a statistical linear regression approach. The predictors selected for the ensemble technique are forecasts latitude and longitude positions at 12-hour interval up to 120-hour of five operational NWP models. In the MME method, forecast latitude and longitude position of the member models are linearly regressed against the observed (track) latitude and longitude position for each forecast time at 12-hours intervals for the forecast up to 120-hour. The 12 hourly predicted cyclone tracks are then determined from the respective mean sea level pressure fields using a cyclone tracking software. Multiple linear regression technique is used to generate weights (regression coefficients) for each model for each forecast hour (12hr, 24hr, 36 hr, 48hr, 60hr, 72hr, 84hr, 96hr, 108hr and 120 hrs) based on the past data. These coefficients are then used as weights for the ensemble forecasts. 12-hourly forecast latitude (LAT^f) and longitude (LON^f) positions are defined by multiple linear regression technique. A collective bias correction is applied in the MME by applying multiple linear regression based minimization principle for the member models GFS(IMD), GFS(NCEP), ECMWF, UKMO and JMA. ECMWF data are available at 24h intervals. Therefore, 12h, 36h, 60h, 84h, 108h forecast positions of ECMWF are computed based on linear interpolation. All these NWP products are routinely made available in real time on the IMD web site: www.rsmcnewdelhi.imd.gov.in.

4.2.6. Rapid Intensification (RI) Index

A rapid intensification index (RII) is developed for tropical cyclones over the Bay of Bengal (Kotal and Roy Bhowmik, 2013). The RII uses large-scale characteristics of tropical cyclones to estimate the probability of rapid intensification (RI) over the subsequent 24-h. The RI is defined as an increase of intensity 30 kt (15.4 ms^{-1}) during 24-h. The RII technique is developed by combining threshold (index) values of the eight variables for which statistically significant differences are found between the RI and non-RI cases. The variables are: Storm latitude position, previous 12-h intensity change, initial storm intensity, vorticity at 850 hPa, divergence at 200 hPa, vertical wind shear, lower tropospheric relative humidity and storm motion speed. The probability of RI is found to be increases from 0% to 100% when the total number of indices satisfied increases from zero to eight. The forecasts are made available in real time from 2013.

4.2.7. Tropical Cyclone Ensemble Forecast based on Global Models Ensemble (TIGGE) Data

As part of WMO Program to provide a guidance of tropical cyclone (TC) forecasts in near real-time for the WMO/ESCAP panel Member Countries based on the TIGGE Cyclone XML (CXML) data, IMD implemented JMA supported software for real-time TC forecast over North Indian Ocean (NIO) during 2011.

The Ensemble and deterministic forecast products from ECMWF (50+1 Members), NCEP (20+1 Members), UKMO (23+1 Members) and MSC (20+1 Members) are available near real-time for NIO region for named TCs. These Products includes: Deterministic and Ensemble TC track forecasts, Strike Probability Maps, Strike probability of cities within the range of 120 kms 4 days in advance. The JMA provided software to prepare Web page to provide guidance of tropical cyclone forecasts in near real-time for the WMO/ESCAP panel Members. The forecast products are made available in real time.

4.2.8. NCMRWF and IITM GEFS

Global models are also run at NCMRWF. These include GFS and unified model adapted from UK Meteorological Office. Apart from the observations that are used in the earlier system, the new observations assimilated at NCMRWF include (i) Precipitation rates from SSM/I and TRMM (ii) GPSRO occultation (iii) AIRS and AMSRE radiances (iv) MODIS winds. Additionally ASCAT ocean surface winds and INSAT-3D AMVs are also assimilated. NCUM (N768/L70) model features a horizontal resolution of 17km and 70 vertical levels. It uses 4D-Var assimilation and features no cyclone initialization/relocation. NCUM is a grid point model which has a Non-hydrostatic dynamics with a deep atmosphere suitable for all scales. It has semi-implicit time integration with 3D semi-Lagrangian advection, terrain following height coordinates and high order advection. It features mass-flux for shallow convection with convective momentum transport, non-local mixing and entrainment for boundary layer. NCMRWF Ensemble Prediction System (NEPS) is a global medium range probabilistic forecasting system adapted from UK MET Office. The configuration consists of four cycles of assimilation corresponding to 00Z, 06Z, 12Z 18Z and 10-day forecasts are made using the 00Z initial condition. The N400L70 forecast model consists of 800x600 grid points on the horizontal surface and has 70 vertical levels. Horizontal resolution of the model is approximately 33 km in the midlatitudes. The 10 day control forecast run starts with N768L70 analysis of the deterministic assimilation forecast system and 44 ensemble members start from different perturbed initial conditions consistent with the uncertainty in initial conditions. The initial perturbations are generated using

Ensemble Transform Kalman Filter (ETKF) method (Bishop et al., 2001). An important component common to both the deterministic and ensemble model is that they do not use any TC relocation in the analysis.

- At IMD the Global ensemble forecasting system (GEFS) configuration consists of four cycles corresponding to 00Z, 06Z, 12Z 18Z and 10-day forecasts are made using the 00Z initial condition. It is operational at IMD since May, 2017
- A T190L28 control that is started with T574L64 analysis and run out to 10 days
- 20 perturbed forecasts each run out to 10 days at T190L28 horizontal and vertical resolution. The initial perturbations are generated using Ensemble Transform with Rescaling (ETR) method.

4.2.8.1. The Ensemble Mean and Spread

The ensemble spread is a measure of the difference between the members and is represented by the standard deviation (SD) *with respect to the ensemble mean (EM)*. On average, small (*high*) spread indicates a high (*low*) forecast accuracy.

- The ensemble spread is flow-dependent and varies for different parameters.
- It usually increases with the forecast range, but there can be cases when the spread is larger at shorter forecast ranges than at longer ranges. This might happen when the initial days are characterized by strong synoptic systems with complex structures but are followed by large-scale "fair weather" high pressure systems.

4.2.8.2. Probabilistic forecasts of quantitative precipitation

- In these charts, the probability that 24-hour precipitation amounts over a 2.5x2.5 lat-long grid box will exceed certain threshold values is given. The forecast probability is estimated directly from the 20-member global ensemble.
- At each grid point the number of ensemble members having a 24-hour precipitation amount within a specified range (e.g. 1-2cm, 2-5cm etc) is counted (M) and the probability is expressed as $100*(M/20)$.

4.3 Storm surge forecasting

Storm surge forecasting will be the responsibility of the National Meteorological Services. However, storm surge guidance will be issued and incorporated in the Tropical Cyclone Advisory bulletin by RSMC- New Delhi based on IIT, Delhi Storm Surge prediction model.

4.4 Coastal inundation forecasting

The coastal inundation forecast by RSMC, New Delhi commenced from 2013 experimentally with cyclone Phailin. This forecast is provided to disaster managers. It is mainly based on coastal inundation model run by Indian National Centre for Ocean Information Services (INCOIS) Hyderabad. This ADCIRC model is adapted from USA. An example of this model product is shown below

4.5 Seasonal Prediction of cyclonic disturbances

Seasonal prediction of cyclonic disturbances is being issued experimentally for the post monsoon season (Oct.-Dec.) since 2014. This contains information about the frequency of cyclonic disturbances (depression and above) over the Bay of Bengal and number of cyclonic disturbance days over the north Indian Ocean.

Processed products updated and uploaded on IMD's website (www.imd.gov.in) on real time basis by RSMC –Tropical Cyclones New Delhi for national/international purposes.

(A) WEATHER CHARTS

Model	Products
GFS	Analysis and forecast up to 240 hrs
WRF-VAR (AWR) Analysis 27 km	Analysis and forecast up to 72 hrs
WRF-VAR (AWR) Analysis 9 km	Analysis and forecast up to 72 hrs
Extended Range Forecast	Temperature anomaly and mean rainfall forecast up to four weeks
Other products	Weekly Upper Level Mean Winds Weekly Upper Level Wind Anomalies Monthly Upper Level Mean Winds Monthly Upper Level Wind Anomalies
HWRP	Analyses and forecasts upto five days
EPS	Forecast Track and strike probability upto five days
NCMRWF : GEFS	EPS products, forecast track and strike probability upto five days.
NCUM	Analysis and forecast up to 168 hrs.

(B) DOPPLER RADAR PRODUCTS

- MAX(Z) Product
- Plan Position Indicator(Z)
- Volume Velocity processing(2)
- Plan Position Indicator(V)
- Surface Rainfall Intensity
- Precipitation Accumulation (PAC) 24 hrs at 0300 UTC

(C) INSAT IMAGES & INSAT PRODUCTS

(i) INSAT IMAGES

(a) FULL DISC

- Visible Channel
- Infra-red Channel
- Colour Composite
- Water Vapour Channel

(b) SECTOR

- Visible Channel
- Infra-red Channel
- Colour Composite
- Water Vapour Channel
- Enhanced IR Channel
- Enhanced Visible Channel

(c) NORTH WEST SECTOR

- Visible Channel
- Infra-red Channel
- Colour Composite
- Water Vapour Channel

(d) NORTH EAST SECTOR

- Visible Channel
- Infra-red Channel
- Colour Composite
- Water Vapour Channel

(e) Cyclone specific images

- Enhanced grey scale image
- Enhanced colour image

(ii) PRODUCTS

- Daily Average WV image from Kalpana-1
- Daily Average IR image from Kalpana-1
- Cloud Motion Vectors (CMV)
- Water Vapour Winds (WVW)
- Cloud Top Temperature Image
- Cloud Top Temperature Image (Below -40°C)
- G.P.S. Precipitable Water Data
- Insat - 3A CCD Image
- Normalised Difference Vegetative Index
- Upper Tropospheric Humidity (UTH)
- Map of Daily UTH
- Map of Weekly UTH
- Sea Surface Temperature (SST)
- Map of Weekly SST
- Map of Daily SST
- Outgoing Long wave Radiation (OLR)
- Latitude-Time Diagram of daily OLR from 1 January 2010
- Latitude-Time Diagram of daily OLR from 1 January 2009
- Latitude-Time Diagram of daily OLR for the Year 2009
- Latitude-Time Diagram of daily OLR (Monsoon season 2009
- Latitude-Time Diagram of daily OLR(Monsoon Season 2008)
- Map of Daily Mean OLR
- Map of Weekly Mean OLR
- Map of Monthly Mean OLR
- Map of Seasonal Mean OLR
- Quantitative Precipitation Estimate (QPE)
- Map of Daily QPE
- Map of Weekly QPE
- Map of Monthly QPE
- Map of Seasonal QPE

NOAA METOP IMAGES (Microwave channel)

V-1
CHAPTER V
COMMUNICATIONS

5.1 General

The basic communication network for the exchange of data, forecast, warnings and observations will be the Global Telecommunication System (GTS). Tropical cyclone advisories and warnings (SIGMETs) for aviation shall be transmitted by means of the Aeronautical Fixed Service (AFS), according to the provision of ICAO Annex 3/WMO No. 49, Technical Regulations [C.3.1], and ICAO ASIA/PAC and MID ANP FASIDs.

Processed products of RSMC tropical cyclones, New Delhi are distributed in chart form through Satellite broadcast as well as through ftp server on Internet.

In the GTS a regional arrangement exists for the exchange of raw and processed data, forecasts, warnings and addressed messages. Normally message-switching computers in GTS transmit the data on a first in-first out basis. However, priority can be assigned to certain messages on the basis of abbreviated headings. Such messages are given preference over other messages in transmission on the circuits.

The messages for which high priorities are to be assigned are:

- (i) all radar observations in cyclonic storm situations;
- (ii) composite ships' surface and upper-air observations from the tropical cyclone field;
- (iii) tropical cyclone warnings;
- (iv) tropical weather outlook;
- (v) tropical cyclone advisories; and
- (vi) satellite bulletins from RSMC tropical cyclones, New Delhi.

To exchange these messages on priority basis among the Panel countries the abbreviated headings as decided in consultation with RTH New Delhi will be used.

5.2 Procedures to be followed

WMO headings.

Station location indicators.

International block and station index numbers will be used to send surface and upper-air observations.

5.2.1 *Tropical cyclone warning headings*

The headings used for the exchange of tropical cyclone warnings by the Panel countries are given in Table V1. Member countries will request RTH New Delhi to assign priority to these headings if not already provided.

5.2.2 *Telecommunication headings for the exchange of radar observations*

The telecommunication headings used for the exchange of radar observations are listed in Table V2.

5.2.3 Telecommunication headings for the exchange of other messages

The telecommunication headings (which will be the priority headings) for the exchange of tropical weather outlook, tropical storm advisories and satellite bulletins as decided in consultation with the RTH New Delhi are listed in Table V3.

5.2.4 Telecommunication headings for the exchange of tropical cyclone advisories and warnings for aviation

The telecommunication headings for the exchange of tropical cyclone advisories and warnings for aviation are given in Table V4.

5.3 Existing GTS circuits among the Panel countries

1. New Delhi -Bangkok	Upgraded to 64 Kbps TCP/IP WMO FTP circuit.
2. New Delhi- Colombo (Sri Lanka)	Upgraded to internet.
3. New Delhi Dhaka(Bangladesh)	64 kbps TCP/IP WMO Socket circuit, satellite (since March 2007)
4. New Delhi- Karachi(Pakistan)	Upgraded to 64 kbps.
5. New Delhi -Malé(Maldives)	Upgraded to Internet w.e.f. February,2004.
6. New Delhi -Yangon(Myanmar)	Upgraded to internet.
7. New Delhi -Muscat	Upgraded to 64 kbps TCP/IP WMO Socket circuit.
8. New Delhi.-Jeddah	Upgraded to internet.
9. New Delhi – Yemen	No direct connectivity.
10. Bangkok - NayPyiTaw(Myanmar)	Internet
11. Bangkok - Jeddah	64 Kbps TCP/IP WMO FTP circuit

5.4 List of important telephone numbers and addresses connected with tropical cyclone warnings in the Panel countries

A list containing addresses of the tropical cyclone warning centres of the Panel countries, together with their telephone numbers, is given in Annex V-A.

5.5 Global Maritime disturbances Safety System (GMDSS)

GMDSS is a satellite based broadcast system intended for the benefit of ships at high seas. EGC (Enhanced Group Call) Safety Net System of the INMARSAT (International Maritime Satellite Organization) together with NAVTEX and MSI (Maritime Safety Information) broadcast form integral parts of the GMDSS. Under this ocean going vessels would receive:

- a) Meteorological forecasts and warnings;
- b) Navigational aid and warnings; and
- c) Helps in search and rescue operations. WMO has suggested date of full implementation of the system as 1st February, 1999. IMD is broadcasting two GMDSS bulletins at 0900 and 1800 UTC everyday with effect from 1st October, 1998 and additional warnings during the cyclone season.

5.6 India Meteorological Department is hosting its own website www.imd.gov.in and www.rsmcnewdelhi.imd.gov.in which also provides information pertaining to WX Charts, Forecasts, Warnings, Satellite Imageries, Hydrological and Seismological and other weather related topics are updated on regular basis.

5.7 Regional Meteorological Centres located at Delhi, Chennai, Nagpur and Mumbai are hosting their own websites.

TABLE V-1
ABBREVIATED HEADINGS FOR EXCHANGE OF
TROPICAL CYCLONE WARNINGS FOR THE HIGH SEAS

	<u>Country</u>	<u>GTS Abbreviated Headings</u>	<u>Priority</u>
1.	Bangladesh	WTBW20 VGDC	Highest
2.	India	WTIN20 DEMS	Highest
3.	Maldives	WTMV20 VRMM	Highest
4.	Myanmar	WTBM20 and WOBM20 VBRR	Highest
5.	Oman (Sultanate of Oman)	WTOM20 and WSOM20 OOMS	Highest
6.	Pakistan	WWPK20 OPKC	Highest
7.	Sri Lanka	WTSB40 VCCC	Highest
8.	Thailand	WTTH20 VTBB	Highest
9.	Yemen	WTYE20 OYSN	Highest

TABLE V-2**Communication headings for the exchange of radar observations**

<u>Country</u>	<u>Abbreviated heading</u>
1. Bangladesh	SDBW20 VGDC
2. India	SDIN90 VABB (Mumbai-Karachi) SDIN90 VECC (Kolkata-Dhaka and Bangkok) SDIN90 VOMM (Chennai-Bangkok, Dhaka and Colombo)
3. Maldives	SDMV20 VRMM
4. Myanmar	SDBM20 VBRR
5. Pakistan	SDPK20 OPKC SDPK40 OPKC
6. Thailand	SDTH20 VTBB
7. Sri Lanka	SDSB20 VCCC

TABLE V-3**GTS headings for the exchange of tropical weather outlook, tropical storm advisory and satellite bulletin**

<u>Country</u>	<u>Abbreviated heading</u>																		
	<table border="1"> <thead> <tr> <th><u>Tropical weather outlook</u></th> <th><u>Tropical storm advisory</u></th> </tr> </thead> <tbody> <tr> <td>Bangladesh</td> <td>BMAA01 VGDC</td> </tr> <tr> <td>India</td> <td>BMAA01 VBRR</td> </tr> <tr> <td>Pakistan</td> <td>BMAA01 OPKC</td> </tr> <tr> <td></td> <td>BMAA01 VCCC</td> </tr> <tr> <td></td> <td>BMAA01 VTBB</td> </tr> <tr> <td></td> <td>BMAA01 VRMM</td> </tr> <tr> <td></td> <td>BMAA01 OOMS</td> </tr> <tr> <td></td> <td>BMAA01 OYSN</td> </tr> </tbody> </table>	<u>Tropical weather outlook</u>	<u>Tropical storm advisory</u>	Bangladesh	BMAA01 VGDC	India	BMAA01 VBRR	Pakistan	BMAA01 OPKC		BMAA01 VCCC		BMAA01 VTBB		BMAA01 VRMM		BMAA01 OOMS		BMAA01 OYSN
<u>Tropical weather outlook</u>	<u>Tropical storm advisory</u>																		
Bangladesh	BMAA01 VGDC																		
India	BMAA01 VBRR																		
Pakistan	BMAA01 OPKC																		
	BMAA01 VCCC																		
	BMAA01 VTBB																		
	BMAA01 VRMM																		
	BMAA01 OOMS																		
	BMAA01 OYSN																		

Satellite bulletins generated by RTH, New Delhi

TCIN20 DEMS (Sat bulletins based on INSAT pictures)-	For International
TCIN50 DEMS (Sat bulletins based on INSAT pictures)	For National
TCIN51 DEMS (Intense precipitation advisory bulletins)	
ATIN50 DEMS (For all CDRs during cyclone period)	

TABLE V-4

WMO headings for the exchange of Tropical Cyclone Advisories for aviation and SIGMETs**I. TC Advisories**

	<u>Country</u>	<u>Abbreviated heading</u>	<u>Area</u>
1.	India	FKIN21 VIDP FKIN20 VIDP	Bay of Bengal Arabian Sea

II. SIGMETs for tropical cyclones

	<u>Country</u>	<u>Abbreviated heading</u>	<u>Area</u>
1.	Bangladesh	WCBWxx VGDC	Dhaka
2.	India	WCINxx VECC WCINxx VOMM WCINxx VABB	Kolkata Chennai Mumbai
3.	Maldives	WCMV31 VRMM	Malé
4.	Myanmar	WCBMxx VYYY	Yangon
5.	Oman (Sultanate of Oman)	WCOMxx OOMS	Muscat
6.	Pakistan	WCPKxx OPKC	Karachi
7.	Sri Lanka	WCSB31 VCCC	Colombo
8.	Thailand	WCTH31 VTBB	Bangkok
9.	Yemen	-	-

Notes:

1. TCAC New Delhi shall send the TC advisories to the MWOs through AFTN. In addition to the MWOs listed above, the advisories have been sent to all MWOs in the area of responsibility of TCAC New Delhi according to ICAO ASIA/PAC and MID Regions FASIDs.
2. TCAC New Delhi have send the TC advisories to Singapore OPMET Data Bank – AFTN address WSSSYMYX.
3. The MWOs listed above have send their SIGMETs for tropical cyclones through AFTN to the MWOs responsible for the adjacent FIRs and to Singapore OPMET Data Bank – AFTN address WSSSYMYX.

ANNEX V-A-1

**LIST OF IMPORTANT ADDRESSES AND TELEPHONE NUMBERS
CONNECTED
WITH TROPICAL CYCLONE WARNINGS IN THE PANEL COUNTRIES**

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India Meteorological Department (IMD)
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ANNEX V-A-2

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CHAPTER VI

MONITORING AND QUALITY CONTROL OF DATA

6.1 Monitoring of data

It will be the responsibility of the National Meteorological Services to monitor the data, advisories and forecasts received by them in accordance with the specified arrangements. Each tropical cyclone warning centre will review from time to time the inflow of data to the centre and also the transmission to neighbouring services of the messages they are responsible for sending out.

To be sure of reception of important data in the case of cyclonic storm situations, cyclone warning centres of the Member countries will transmit addressed messages to RSMC tropical cyclones, New Delhi four times a day which will include important surface, upper-air and ships' observations.

The National Meteorological Services will inform RSMC tropical cyclones, New Delhi of any shortcomings in the flow of data (raw and processed) and also indicate any requirements over and above those already agreed upon for tropical cyclone warning purposes.

6.2 Quality control

National Meteorological Services will make extra efforts to make sure that all observational data passed on GTS, particularly during disturbed weather, have been checked for errors and that corrections are made if needed. They will impress upon their observing stations the need for accuracy of data, particularly in tropical cyclone situations and the difficulties that may be caused in the decision process by an incorrectly recorded or transmitted observation.

In case of doubt as to the correctness of any observation or part thereof, an addressed message will be sent to the national service and to RSMC tropical cyclones, New Delhi requesting confirmation.

CHAPTER VII

ARCHIVAL OF DATA

7.1 Necessity for data archival

In view of the development of computer facilities in the region, it is expected that the research efforts on tropical cyclones will substantially increase. In addition to dynamic modeling of tropical cyclones on the new generation computer being acquired by national authorities, it is expected that the synoptic oriented investigations and research as well as verification programmes will be undertaken in the region.

It is, therefore, necessary to create data sets as detailed and as complete as possible for all the future cyclones.

7.2 Tropical cyclone data on landfall

There is a dearth of information on actual conditions of tropical cyclones and an endeavor is therefore required to be made to utilize whatever information is obtained to the maximum extent possible. In particular, the Panel countries are interested in verifying forecast and estimated conditions against the actual.

Panel countries will take appropriate steps to ensure that after a tropical cyclone makes a landfall all the available data pertaining to that tropical cyclone are collected and archived. Data on the actual condition of winds, storm surge, surface pressure and rainfall from stations near the point of landfall will be sent to RSMC tropical cyclones, New Delhi. If the landfall is in a country other than India, its meteorological service will send a brief summary of information to RSMC tropical cyclones, New Delhi for inclusion in the RSMC New Delhi tropical cyclone report.

In the case of a tropical cyclone making a landfall on the coast of a country, which is not a member of the Panel, RSMC Tropical Cyclones, New Delhi will collect the information for inclusion in the RSMC, New Delhi tropical cyclones report.

7.3 Role of RSMC-tropical cyclones, New Delhi in data archival

For each tropical cyclone occurrence in the area, initially RSMC tropical cyclones New Delhi will compile the following data sets:

- (i) Daily synoptic charts covering the area 45° N to 30° S and 30° E to 120° E for the surface and upper-air charts for the levels 700, 500 and 200 hPa for 00 UTC and 12 UTC.
- (ii) All upper-air data from stations within 15 degrees of the tropical cyclone field.
- (iii) The tracks of tropical cyclones for the Panel regions prepared by the India Meteorological Department.
- (i) An e-Atlas on Cyclones and Depressions (C&D's) having many salient features as generation of Tracks, several types of C&D's statistics have been developed and also circulated to Panel Member countries for their use.
- (ii) The online version of e-Atlas is available at IMD Website at Cyclone Page under the URL: www.rmchennaieatlas.tn.nic.in.
- (iii) All the annual reports on cyclonic disturbances are available for the period of 1990 onwards in the RSMC, New Delhi website.

For the purpose of making these archives the National Meteorological Services will supply New Delhi with relevant information requested by RSMC tropical cyclones, New Delhi. On request by a Panel country, the RSMC tropical cyclones, New Delhi will make arrangements to supply these data sets to the Panel Member concerned on a copying cost basis.

VII-2

In accordance with the directive of the WMO Executive Council (ECXLV), Geneva, July 1993) an international format for the archiving of tropical cyclone data is to be used by all RSMCs with activity specialization in tropical cyclones.

The Tropical Cyclone Programme (TCP) office of the WMO Secretariat has the responsibility for the maintenance of the format, including assignment of the source codes to appropriate organizations, and authorizing additions and changes.

In the international format given below, the Dvorak T number (Position 3536) and Dvorak CI number (position 3738) will be the ones determined at the centre submitting the data, in the case of the Panel on Tropical Cyclones, by RSMC New Delhi.

Complete historic data in the format given in Annex VII-A will be made available for research applications. RSMC New Delhi will provide such data, to the Director of the National Climatic Data Centre (NCDC), USA in this format through WMO.

GLOBAL TROPICAL CYCLONE TRACK AND INTENSITY DATA SET REPORT FORMAT

Position Content

1-9

Cyclone identification code composed by 2 digit numbers in order within the cyclone season, area code and year code. 01 SWI2000 shows the 1st system observed in Southwest Indian Ocean basin during the 2000/2001 season. Area codes are as follows:

ARB = Arabian Sea
 ATL = Atlantic Ocean
 AUB = Australian Region (Brisbane)
 AUD = Australian Region (Darwin)
 AUP = Australian Region (Perth)
 BOB = Bay of Bengal
 CNP = Central North Pacific Ocean
 ENP = Eastern North Pacific Ocean
 ZEA = New Zealand Region
 SWI = Southwest Indian Ocean
 SWP = Southwest Pacific Ocean
 WNP = Western North Pacific Ocean and South China Sea

10-19 Storm Name

20-23 Year

24-25 Month (0112)

26-27 Day (0131)

28-29 Hour-universal times (at least every 6 hourly position 00Z, 06Z, 12Z and 18Z)

30 Latitude indicator:

1 =North latitude;

2=South latitude

31-33 Latitude (degrees and tenths)

34-35 Check sum (sum of all digits in the latitude)

36 Longitude indicator:

1 =West longitude;

2=East longitude

37-40 Longitude (degrees and tenths)

41-42 Check sum (sum of all digits in the longitude)

43 position confidence*

1 = good (<30nm; <55km)

2 = fair (3060nm; 55-110km)

3 = poor (>60nm; >110km)

9 = unknown

Note* Confidence in the center position: Degree of confidence in the center position of a tropical cyclone expressed as the radius of the smallest circle within which the center may be located by the analysis. "position good" implies a radius of less than 30 nm, 55 km; "position fair", a radius of 30 to 60 nm, 55 to 110km; and "position poor", radius of greater than 60 nm, 110km.

44-45 Dvorak T number (99 for no report)

46-47 Dvorak CI number (99 for no report)

48-50 Maximum average wind speed (whole values) (999 for no report).

51 Units 1 =kt, 2=m/s, 3=km per hour.

52-53 Time interval for averaging wind speed (minutes for measured or derived wind speed, 99 if unknown or estimated).

54-56 Maximum Wind Gust (999 for no report)

57 Gust Period (seconds, 9 for unknown)

58 Quality code for wind reports:

1 =Aircraft or Dropsonde observation

2=Over water observation (e.g. buoy)

3=Over land observation

4=Dvorak estimate

5=Other

59-62 Central pressure (nearest hectoPascal) (9999 if unknown or unavailable)

63 Quality code for pressure report (same code as for winds)

ANNEX VII-A-2

- 64 Units of length: 1 =nm, 2=km
65-67 Radius of maximum winds (999 for no report)
68 Quality code for RMW:
1 =Aircraft observation
2=Radars with well defined eye
3=Satellite with well defined eye
4=Radars or satellite, poorly defined eye
5=Other estimate
69-71 Threshold value for wind speed (gale force preferred, 999 for no report)
72-75 Radius in Sector 1: 315 45
76-79 Radius in Sector 2: 45 135
80-83 Radius in Sector 3: 135 225
84-87 Radius in Sector 4: 225 315
88 Quality code for wind threshold
1=Aircraft observations
2=Surface observations
3=Estimate from outer closed isobar
4=Other estimate
89-91 Second threshold value for wind speed (999 for no report)
92-95 Radius in Sector 1: 315 45
96-99 Radius in Sector 2: 45 135
100-103 Radius in Sector 3: 135 225
104-107 Radius in Sector 4: 225 315
108 Quality code for wind threshold (code as for row 88)
10910 Cyclone type:
01 = tropics; disturbance (no closed isobars)
02= <34 knot winds, <17m/s winds and at least one closed isobar
03= 34-63 knots, 17 32m/s
04= >63 knots, >32m/s
05= extra tropical
06= dissipating
07= subtropical cyclone (non frontal, low pressure system that comprises I initially baroclinic circulation developing over subtropical water)
08= overland
09= unknown
111-112 Source code (2 digit code to represent the country or organization that provided the data to NCDC USA.
WMO Secretariat is authorized to assign number to additional participating centers, organizations)
01 RSMC Miami Hurricane Center
02 RSMC Tokyo Typhoon Center
03 RSMC Tropical Cyclones New Delhi
04 RSMC La Reunion Tropical Cyclone Centre
05 Australian Bureau of Meteorology
06 Meteorological Service of New Zealand Ltd.
07 RSMC Nandi Tropical Cyclone Centre
08** Joint Typhoon Warning Center, Honolulu
09** Madagascar Meteorological Service
10 ** Mauritius Meteorological Service
11 ** Meteorological Service, New Caledonia
12 Central Pacific Hurricane Center, Honolulu
Note**: no longer used
Headings 1-19 Cyclone identification code and name;
20-29 Date time group;
30-43 Best track positions;
44-110 Intensity, Size and Type;
111-112 Source code.