



**WORLD METEOROLOGICAL ORGANIZATION
TECHNICAL DOCUMENT**

WMO/TD No. 84

TROPICAL CYCLONE
PROGRAMME
Report No. TCP-21

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

Edition 2022

**SECRETARIAT OF THE WORLD METEOROLOGICAL ORGANIZATION
GENEVA SWITZERLAND**

© World Meteorological Organization, 2022

The right of publication in print, electronic and any other form and in any language is reserved by WMO. Short extracts from WMO publications may be reproduced without authorization, provided that the complete source is clearly indicated. Editorial correspondence and requests to publish, reproduce or translate this publication in part or in whole should be addressed to:

Chair, Publications Board

World Meteorological Organization (WMO)

7 bis, avenue de la Paix

P.O. Box 2300

CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 84 03

Fax: +41 (0) 22 730 80 40

E-mail: publications@wmo.int

NOTE

The designations employed in WMO publications and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of WMO concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The mention of specific companies or products does not imply that they are endorsed or recommended by WMO in preference to others of a similar nature which are not mentioned or advertised.

The findings, interpretations and conclusions expressed in WMO publications with named authors are those of the authors alone and do not necessarily reflect those of WMO or its Members.

This publication has been issued without formal editing.

CONTENTS

| | Page |
|-----------------------------------------------------------------------------------------------------|--------|
| Chapter I General | I-1 |
| 1.1 Introduction | I-1 |
| 1.2 Terminology used in the region | I-2 |
| 1.2.1 General | I-2 |
| 1.2.2 Classification of cyclonic disturbances and tropical cyclones | I-2 |
| 1.2.3 Tropical cyclone characteristics | I-2 |
| 1.2.4 Terms related to the warning and warning system | I-2 |
| 1.3 Meaning of terms used for international exchanges | I-3 |
| 1.4 Units used | I-6 |
| 1.4.1 Units used in international exchanges | I-6 |
| 1.4.2 Units used in national bulletins | I-6 |
| 1.4.3 Units used in WWMIWS marine warnings | I-6 |
| Chapter II Tropical cyclone warnings and advisories | II-1 |
| 2.1 General | II-1 |
| 2.2 Classification of cyclonic disturbances followed by RSMC, New Delhi | II-1 |
| 2.3 Identification of tropical cyclones | II-1 |
| 2.4 Bulletins issued by RSMC, New Delhi | II-6 |
| 2.4.1 Extended range outlook | II-6 |
| 2.4.2 Tropical weather outlook | II-8 |
| 2.4.3 Pre-genesis track and intensity forecast | II-10 |
| 2.4.4 Special Tropical weather outlook | II-13 |
| 2.4.5 Tropical cyclone advisories | II-19 |
| 2.4.6 Hourly update bulletin | II-22 |
| 2.4.7 Tropical cyclone warnings for the high seas | II-23 |
| 2.4.8 Warnings and advisories for aviation | II-27 |
| 2.4.9 Tropical cyclone warnings for national purposes | II-29 |
| 2.4.10 Storm surge guidance | II-29 |
| 2.5 Graphical presentation of track and intensity | II-29 |
| 2.5.1 Cone of uncertainty | II-29 |
| 2.5.2 Quadrant wind forecast | II-30 |
| 2.5.3 TC Vital | II-33 |
| Annex II-A Classification of Tropical cyclone warning systems in the Panel countries | II-A-1 |
| Annex II-B Tropical cyclone warning systems in Bangladesh | II-B-1 |
| Annex II-C Tropical cyclone warning systems in India | II-C-1 |
| Annex II-D Tropical cyclone warning systems in Maldives | II-D-1 |
| Annex II-E Tropical cyclone warning systems in Myanmar | II-E-1 |
| Annex II-F Tropical cyclone warning systems in Oman | II-F-1 |
| Annex II-G Tropical cyclone warning systems in Pakistan | II-G-1 |
| Annex II-H Tropical cyclone warning systems in Sri Lanka | II-H-1 |
| Annex II-I Tropical cyclone warning systems in Qatar | II-I-1 |
| Annex II-J Tropical cyclone warning systems in Thailand | II-J-1 |
| Annex II-K Tropical cyclone warning systems in United Arab Emirates | II-K-1 |
| ANNEX II-B Attachment | II-B-1 |
| ANNEX II-C Attachment | II-C-1 |
| ANNEX II-F Attachment | II-F-1 |
| ANNEX II-G Attachment | II-G-1 |
| ANNEX II-H Attachment | II-H-1 |
| ANNEX II-I Attachment | II-I-1 |
| Chapter III The observing system and observing programme | III-1 |
| 3.1 Networks of surface and upper air stations | III-1 |
| 3.1.1 Observations from basic networks | III-1 |
| 3.1.2 Special observations from the WWW network | III-1 |
| 3.1.3 Special observations from stations other than those of the regional basic synoptic network | III-1 |
| 3.1.4 Upper air stations | III-11 |

CONTENTS

| | Page |
|--------------------------------------------------------------------------------------------------------------------------------|-------------|
| 3.2 Observations from mobile ships | III-11 |
| 3.3 Aircraft reports | III-11 |
| 3.4 Radar observations | III-11 |
| Annex III-A Code for reporting radar observations relating to cyclonic disturbances | III-A-1 |
| Annex III-B Satellite cloud imagery monitoring facilities in the Panel countries | III-B-1 |
| Chapter IV Tropical cyclone forecasting | IV-1 |
| 4.1 Forecasting development and movement of tropical cyclones | IV-1 |
| 4.2 Prediction Model in operational use during the year 2021 | IV-1 |
| 4.3 Storm surge forecasting | IV-7 |
| 4.4 Coastal inundation forecasting | IV-7 |
| 4.5 Seasonal Prediction of cyclonic disturbances | IV-7 |
| Chapter V Communications | V-1 |
| 5.1 General | V-1 |
| 5.2 Procedures to be followed | V-1 |
| 5.2.1 Tropical cyclone warning headings | V-1 |
| 5.2.2 Telecommunication headings for the exchange of radar observations | V-2 |
| 5.2.3 Telecommunication headings for the exchange of other messages | V-2 |
| 5.2.4 Telecommunication headings for the exchange of tropical cyclone Advisories and warnings for aviation | V-2 |
| 5.3 Existing GTS circuits among the Panel countries | V-2 |
| 5.4 List of important telephone numbers and addresses connected with tropical cyclone Warnings in the Panel countries | V-2 |
| Annex V-A List of important addresses and telephone numbers connected with tropical Cyclone warnings in the Panel countries | V-A-1 |
| Chapter VI Monitoring and quality control of data | VI1 |
| 6.1 Monitoring of data | VI1 |
| 6.2 Quality control | VI1 |
| Chapter VII Archival of data | VII1 |
| 7.1 Necessity for data archival | VII1 |
| 7.2 Tropical cyclone data on landfall | VII1 |
| 7.3 Role of RSMC tropical cyclones, New Delhi in data archiving | VII1 |
| Annex VII-A Global Tropical Cyclone Track and Intensity Data Set Report Format | VII-A-1 |

I-1
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, Yemen joined in 2016 and Iran, Qatar, Saudi Arabia & United Arab Emirates joined in 2018.

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

** 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 in case of cyclogenesis occurring in deep sea. This is not applicable in case of the genesis taking place close to coast or in case of rapid intensification near the coast. In such situation, the cyclone warning can be issued directly without issuing the pre-cyclone watch or cyclone alert bulletin.

Cyclone warning*: A priority message containing tropical cyclone warning and advisories issued generally 24 hours in advance of the commencement of adverse weather in case of cyclogenesis occurring in deep sea. This is not applicable in case of the genesis taking place close to coast or in case of rapid intensification near the coast. In such situation, the cyclone warning can be issued immediately without issuing the pre-cyclone watch and alert bulletins.

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.

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).

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.

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, Iran, Maldives, Myanmar, Oman (Sultanate of), Pakistan, Qatar, Saudi Arabia, Sri Lanka, Thailand, United Arab Emirates (UAE) 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. This is 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 in case of cyclogenesis occurring in deep sea. This is not applicable in case of the genesis taking place close to coast or in case of rapid intensification near the coast. In such situation, the cyclone alert or warning can be issued directly without issuing the pre-cyclone watch.

Pre-Genesis Forecast: Pre-genesis forecast of cyclogenesis, track & intensity from the stage of low pressure area with forecast of track & intensity from depression stage upto next 72 hours, thus indicating probable date, time and location of expected cyclogenesis over the NIO.

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.

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.

TCAC Graphics Bulletin: The tropical cyclone advisory bulletin is also issued every six hourly by Tropical Cyclone Advisory Centre (TCAC), New Delhi in graphics form (PNG format) for the purpose of international civil aviation and transmitted through GTS and website.

TCAC Bulletin for Aviation Disaster Risk Reduction (ADRR): The tropical cyclone advisory bulletin in text format is issued every six hourly through ftp by Tropical Cyclone Advisory Centre (TCAC), New Delhi to WMO's ADRR centre, Hong Kong for the purpose of international civil aviation

TC Vital Bulletin for modeling group: The TC Vital Bulletin is issued every six hourly to the modeling group in text form to generate track, intensity and storm surge forecast. It contains information about the location, past movement (speed & direction), intensity of the system, size of the system, radius of maximum wind and wind distribution of 34 knots wind in four geographical quadrants around the system centre in a coded form. It is transmitted by email and through ftp to the modeling group. This information is mainly utilised for synthetic vortex generation and model initialisation as per existing conditions.

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.

WWMIWS: The IMO/WMO Worldwide Met-Ocean Information and Warning Service (WWMIWS) is the internationally coordinated service for the promulgation of meteorological warnings and forecasts to vessels undertaking international or national voyages. Tropical cyclone warnings issued for the WWMIWS are promulgated through GMDSS satellite and radio communication channels.

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.

+ 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.

1.4.3 Units used in WWMIWS marine warnings

The following units/indicators are used for marine purposes, in accordance with the WMO Manual on Marine Meteorological Services (WMO No.558):

Distance in nautical miles, the unit (nm) being stated;

Location (position) by degrees and where possible tenths of degrees of latitude and longitude, preferably expressed in numbers;

e.g. "12.2S, 168.4E"

Direction of motion to the nearest sixteen points of the compass or in degrees to the nearest ten, given in figures;

e.g. "SOUTHSOUTHEAST" or "160 DEGREES"

Speed (wind speed and direction of movement of tropical cyclones) in knots, the unit (kt) being stated;

Pressure in hectopascals (hPa), the unit being stated;

Time in Universal Time Co-ordinated (UTC), unit being stated.

TC warnings for the WWMiWS shall use the following wind warning category labels:

- Gale force wind warning (Beaufort force 8 or 9);
- Storm-force wind warning (Beaufort force 10 or 11);
- Hurricane-force wind warning (Beaufort force 12 or over).

II-1
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 rest 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 shipping (WWMIWS), and other international users, and exchanges among the Panel countries are described in this chapter. 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.

If there is migration of a cyclonic disturbance from the area under RSMC Tokyo to area under RSMC New Delhi or viceversa, following procedure will be adopted for issue of take-over message and giving name to the system:

When a tropical cyclone is expected to migrate from one RSMC (refer to as *former*) into the neighboring (refer to as *latter*) RSMC's area of service within at least 24 hours with tropical storm (TS) / cyclonic storm (CS) intensity or higher, the former RSMC will inform the latter RSMC of the possibility of cross-border migration via e-mail and through GTS. When a tropical cyclone is expected to cross the border within around 6 hours, the former RSMC will issue advisory with remark referring to the take-over according to its issuance time (00, 03, 06, 09, 12, 15, 18 and 21 UTC for RSMC New Delhi and 00, 06, 12 and 18 UTC for RSMC Tokyo). The latter RSMC uses the name given by the former RSMC for the tropical cyclone's entire lifetime. However, if a named tropical cyclone weakens to a tropical depression (TD) / deep depression (DD) or depression (D) and again develops to be a

named tropical cyclone, RSMC New Delhi will give a new name for it, while RSMC Tokyo will use the same name except when it re-develops after once transformed into an extratropical cyclone.

Table II-1: New list of tropical cyclone names adopted by WMO/ESCAP Panel Member Countries in April 2020 for naming of tropical cyclones over North Indian Ocean including Bay of Bengal and Arabian Sea (First name was used in June, 2021)

| WMO/ESCAP Panel Member countries | Column 1 | | Column 2 | | Column 3 | | Column 4 | |
|-------------------------------------------|----------|----------|----------|----------|----------|-----------|----------|----------|
| | Name | Pron' | Name | Pron' | Name | Pron' | Name | Pron' |
| Bangladesh | Nisarga | Nisarga | Biparjoy | Biporjoy | Arnab | Ornab | Upakul | Upokul |
| India | Gati | Gati | Tej | Tej | Murasu | Murasu | Aag | Aag |
| Iran | Nivar | Nivar | Hamoon | Hamoon | Akvan | Akvan | Sepand | Sepand |
| Maldives | Burevi | Burevi | Midhili | Midhili | Kaani | Kaani | Odi | Odi |
| Myanmar | Tauktae | Tau'Te | Michaung | Migjaum | Ngamann | Ngaman | Kyarthit | Kjathi |
| Oman | Yaas | Yass | Remal | Re-Mal | Sail | Sail | Naseem | Naseem |
| Pakistan | Gulab | Gul-Aab | Asna | As-Na | Sahab | Sa-Hab | Afshan | Af-Shan |
| Qatar | Shaheen | Shaheen | Dana | Dana | Lulu | Lulu | Mouj | Mouj |
| Saudi Arabia | Jawad | Jowad | Fengal | Feinjal | Ghazeer | Razeer | Asif | Aasif |
| Sri Lanka | Asani | Asani | Shakhti | Shakhti | Gigum | Gigum | Gagana | Gagana |
| Thailand | Sitrang | Si-Trang | Montha | Mon-Tha | Thianyot | Thian-Yot | Bulan | Bu-Lan |
| United Arab Emirates | Mandous | Man-Dous | Senyar | Sen-Yaar | Afoor | Aa-Foor | Nahhaam | Nah-Haam |
| Yemen | Mocha | Mokha | Ditwah | Ditwah | Diksam | Diksam | Sira | Sira |

(contd.)

The names already used from the list till September 2022 are shown in red colour.

| WMO/ESCAP Panel Member countries | Column 5 | | Column 6 | | Column 7 | | Column 8 | |
|-------------------------------------------|----------|------------|----------|-----------|----------|----------|----------|------------|
| | Name | Pron' | Name | Pron' | Name | Pron' | Name | Pron' |
| Bangladesh | Barshon | Borshon | Rajani | Rojoni | Nishith | Nishith | Urmi | Urmi |
| India | Vyom | Vyom | Jhar | Jhor | Probah | Probaho | Neer | Neer |
| Iran | Booran | Booran | Anahita | Anahita | Azar | Azar | Pooyan | Pooyan |
| Maldives | Kenau | Kenau | Endheri | Endheri | Riyau | Riyau | Guruva | Guruva |
| Myanmar | Sapakyee | Zabagji | Wetwun | We'wum | Mwaihout | Mwei'hau | Kywe | Kjwe |
| Oman | Muzn | Muzn | Sadeem | Sadeem | Dima | Dima | Manjour | Manjour |
| Pakistan | Manahil | Ma-Na-Hil | Shujana | Shu-Ja-Na | Parwaz | Par-Waaz | Zannata | Zan Naa Ta |
| Qatar | Suhail | Es'hail | Sadaf | Sadaf | Reem | Reem | Rayhan | Rayhan |
| Saudi Arabia | Sidrah | Sadrah | Hareed | Haareed | Faid | Faid | Kaseer | Kusaer |
| Sri Lanka | Verambha | Ve-Ram-Bha | Garjana | Garjana | Neeba | Neeba | Ninnada | Nin-Na-Da |
| Thailand | Phutala | Phu-Ta-La | Aiyara | Ai-Ya-Ra | Saming | Sa-Ming | Kraison | Krai-Son |
| United Arab Emirates | Quffal | Quf-Faal | Daaman | Daa-Man | Deem | Deem | Gargoor | Gar-Goor |
| Yemen | Bakhur | Bakhoor | Ghwyzi | Ghwayzi | Hawf | Hawf | Balhaf | Balhaf |

(contd.)

| WMO/ ESCAP Panel Member countries | Column 9 | | Column 10 | | Column 11 | | Column 12 | | Column 13 | |
|-----------------------------------------------|------------|------------|-----------|------------|-----------|-----------|-----------|----------|-----------|-----------|
| | Name | Pron' | Name | Pron' | Name | Pron' | Name | Pron' | Name | Pron' |
| Bangladesh | Meghala | Meghla | Samiron | Somiron | Pratikul | Protikul | Sarobor | Sorobor | Mahanisha | Mohanisha |
| India | Prabhanjan | Prabhanjan | Ghurni | Ghurni | Ambud | Ambud | Jaladhi | Jaladhi | Vega | Vega |
| Iran | Arsham | Arsham | Hengame | Hengame | Savas | Savas | Tahamtan | Tahamtan | Toofan | Toofan |
| Maldives | Kurangi | Kurangi | Kuredhi | Kuredhi | Horangu | Horangu | Thundi | Thundi | Faana | Faana |
| Myanmar | Pinku | Pinnku | Yinkaung | Jin Gaun | Linyone | Lin Joun | Kyeekan | Kji Gan | Bautphat | Bau'hpa |
| Oman | Rukam | Roukaam | Wataad | Wa Tad | Al-jarz | Al-Jarouz | Rabab | Ra Bab | Raad | Raad |
| Pakistan | Sarsar | Sar-Sar | Badban | Baad-Baan | Sarrab | Sarrab | Gulnar | Gul-Nar | Waseq | Waa-Seq |
| Qatar | Anbar | Anbar | Oud | Oud | Bahar | Bahar | Seef | Seef | Fanar | Fanaar |
| Saudi Arabia | Nakheel | Nakheel | Haboob | Haboob | Bareq | Bariq | Alreem | Areem | Wabil | Wobil |
| Sri Lanka | Viduli | Viduli | Ogha | Ogha | Salitha | Salitha | Rivi | Rivi | Rudu | Rudu |
| Thailand | Matcha | Mat-Cha | Mahingsa | Ma-Hing-Sa | Phraewa | Phrae-Wa | Asuri | A-Su-Ri | Thara | Tha-Ra |
| United Arab Emirates | Khubb | Khubb | Degl | Degl | Athmad | Ath-Md | Boom | Boom | Saffar | Saf-Faar |
| Yemen | Brom | Brom | Shuqra | Shuqrah | Fartak | Fartak | Darsah | Darsah | Samhah | Samhah |

Note:

1. Panel Members name are listed alphabetically country wise
2. The names will be used sequentially column-wise
3. The first name will start from the first row of column one and continue sequentially to the last row in the column thirteen
4. Table will be used only once
5. The names already used from the list till December 2021 are shown in red colour.

Table.II-2: Table for naming tropical cyclones for the north Indian Ocean region (including Bay of Bengal and Arabian Sea) effective from September, 2004 (All names in this list have been used).

| Panel Member | Column one | | Column two | | Column three | | Column four | |
|--------------|------------|----------|------------|----------|--------------|--------|-------------|----------|
| | Names | Pron' | Names | Pron' | Names | Pron' | Names | Pron' |
| B'desh | 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' |
| B'desh | 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 |

2.4 Bulletins issued by RSMC, New Delhi

2.4.1 Extended range outlook:

IMD started issuing Extended Range Outlook (ERO) for cyclogenesis during next two weeks every Thursday from 22nd April, 2018. The impact expected over the area of cyclogenesis was introduced from 07th May, 2022. IMD also introduced guidance on expected formation of cyclonic circulation and low pressure area over the region from June, 2021. The ERO contains information about large scale features over the region, guidance on probable cyclogenesis from various global/regional models, probability of cyclogenesis as LOW (0-33%), MODERATE (34-67%) and HIGH (68-100%) alongwith verification of forecast issued during last two weeks. The product is available on RSMC website at <http://www.rsmcnewdelhi.imd.gov.in/images/bulletin/eroc.pdf>. The archive of all ERO bulletins since May 2018 is also available on RSMC website.

Example 1: Extended Range Outlook issued on 5th May 2022 is presented below [Fig. II (1)].

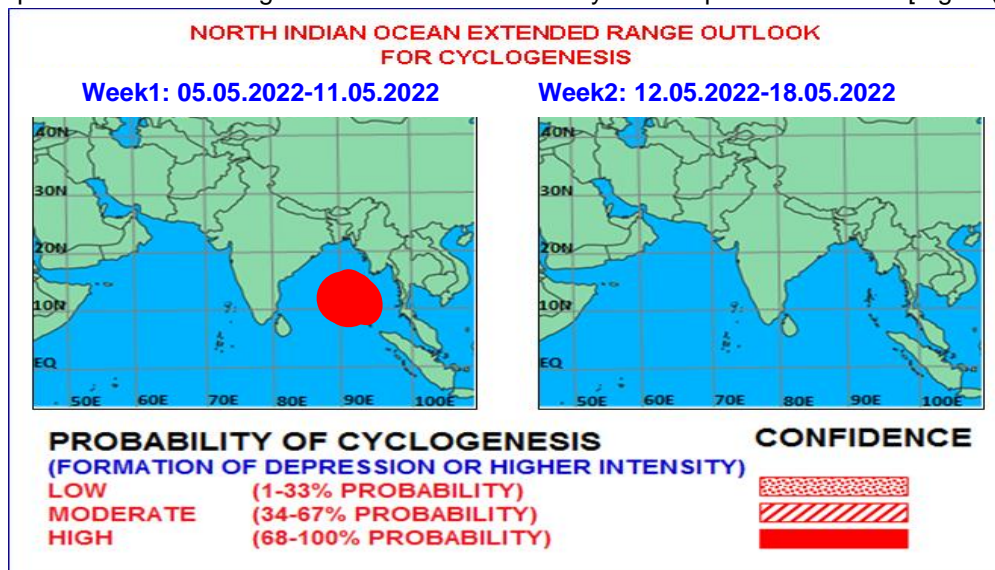


Fig. II-1: Extended Range Outlook graphics indicating probability of cyclogenesis issued on 5th May 2022 in association with SCS Asani

The Madden Julian Oscillation Index (MJO) currently lies in phase 1 with amplitude less than 1. It would move across phases 2, 3, 4 and 5 during next 5 days with gradually increasing amplitude. Hence, MJO will support enhancement of convective activity over the Bay of Bengal (BoB) during week 1.

Based on CFS forecast, during first half of week 1, MJO, Equatorial Rossby Waves (ERW), westerly winds (3-5 mps) over Equatorial Indian Ocean (EIO) & adjoining southeast Arabian Sea (AS) and south BoB and and stronger easterly winds (5-7 mps) likely to prevail over central BoB. During later part of week 2, weak easterly winds (1-3 mps) over central BoB and weak easterly winds (1-3 mps) over south BoB & south AS are likely to prevail. Thus, equatorial waves are likely to contribute towards enhancement of convective activity over EIO and adjoining southeast AS and south BoB & central BoB during first half of week1. During first half of week 2, weak easterly winds (1-3 mps) over north BoB, strong westerlies (3-5 mps) over south BoB alongwith ERW are likely to prevail. During later part of week 2, weak easterly winds (1-3 mps) over north BoB and westerly winds (3-5 mps) and ERW over EIO & adjoining southeast AS are likely to prevail. During week 2, equatorial waves may not support significantly towards enhancement of convective activity over the NIO region.

Considering the sea conditions, sea surface temperature (SST) is around 29-30°C over entire BoB and AS. The ocean heat content (OHC) is >100 KJ/cm² over entire Andaman Sea, central BoB, south BoB & adjoining EIO and 50-70 KJ/cm² over northwest BoB. Over the AS, OHC is >100 KJ/cm² over southeast and adjoining eastcentral AS.

Considering the model guidance, most of the deterministic models including IMD GFS, NCEP GFS, ECMWF, NCUM (R), NCUM (G), ECMWF, IMD WRF, IMD MME and probabilistic models including GEFS, NEPS, ECMWF ensemble are indicating likely cyclogenesis (formation of depression) over Andaman Sea

and adjoining southeast BoB during middle of week1 (around 8th May). The MME CFS (V2) is indicating >80% probability of cyclogenesis over Andaman Sea & adjoining southeast BoB. However, there is large variation among various models wrt intensification of the system. Most of the models are indicating the system to intensify upto a marginal cyclone. However, IMD GFS is indicating the system to intensity upto very severe category storm. Models are also unanimous about the northeastwards recurvature of the system.

Climatologically, during the period 1961-2020, there have been 69 cyclonic disturbances (CDs) (maximum sustained wind speed (MSW) ≥ 17 kt) over the NIO with 48 over the BoB and 21 over the AS (Fig.II-2a). Out of these, 50 intensified into cyclonic storm (MSW) ≥ 34 kt) with 35 over the BoB & 15 over the AS (Fig. II-2 b).

Hence, considering available guidance from various sources, it is concluded that a low pressure area is likely to form over south Andaman Sea and adjoining southeast Bay of Bengal areas on 6th May. There is high probability that the system would move northwestwards and intensify into a depression over southeast BoB and adjoining Andaman Sea during subsequent 48 hours.

Verification of forecast issued during last two weeks:

The forecast issued on 21st April for week 2 (29.04.2022-05.05.2022) indicated no probability of cyclogenesis over the region. The forecast issued on 28th April for week 1 (29.04.2022-05.05.2022) indicated likely formation of cyclonic circulation over south Andaman Sea during week1. Actually a cyclonic circulation developed over south Andaman Sea and neighbourhood on 4th May and persisted over the same region on 5th May. The realised rainfall during 14th to 20th April, 2022 from satellite-gauge merged data is presented in Fig. II-3.

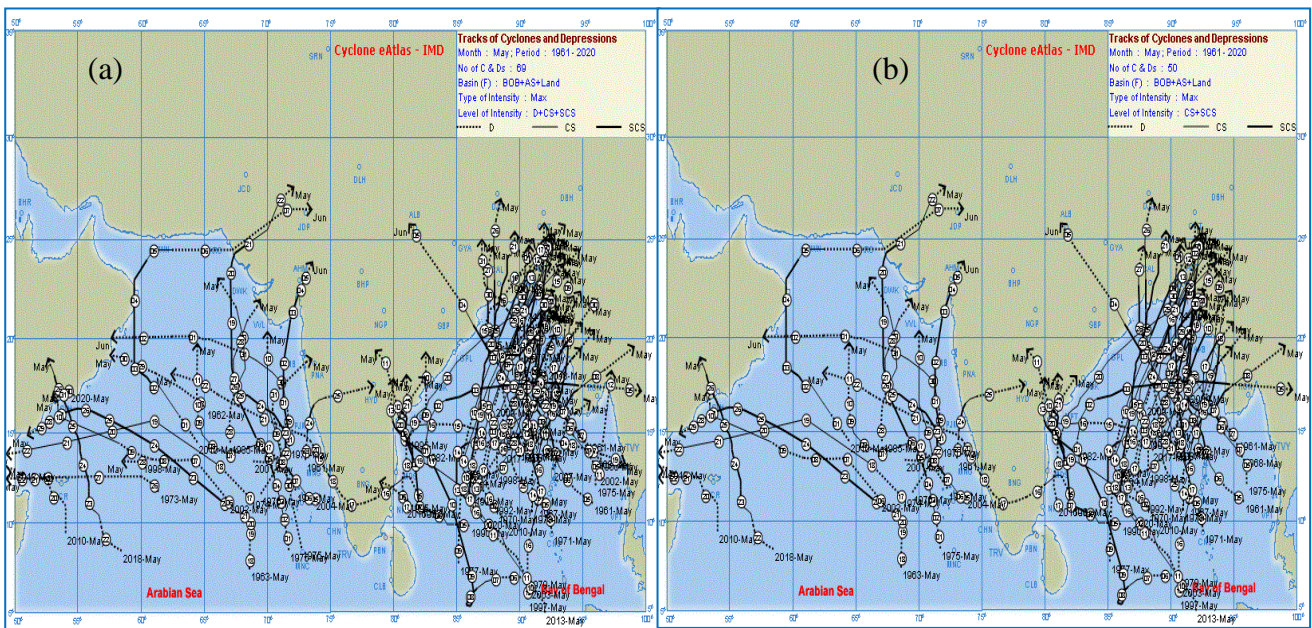


Fig. II-2: Tracks of (a)cyclonic disturbances (MSW) ≥ 17 kt and (b) cyclonic storms (MSW ≥ 34 kt) over the North Indian Ocean during the month of May based on period of 1961-2020

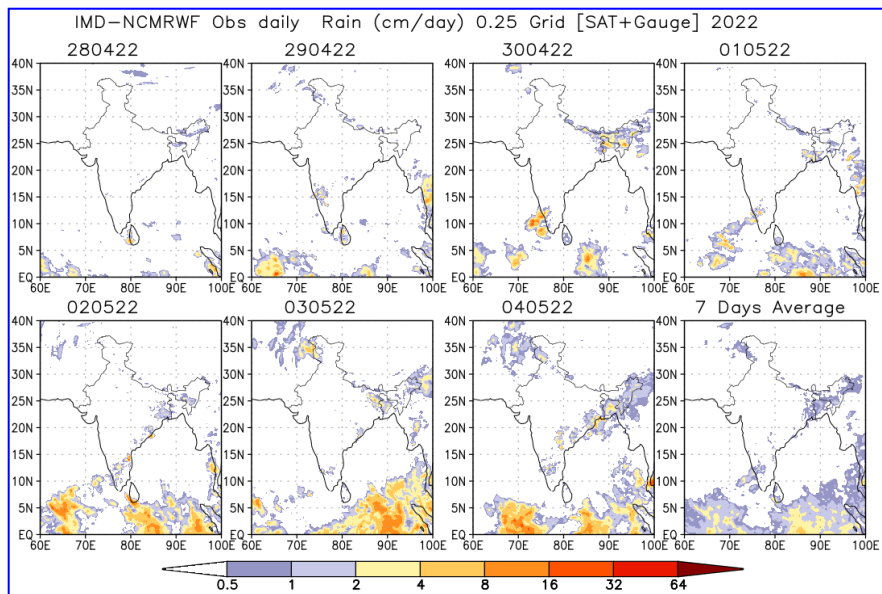


Fig. II-3: Rain gauge and satellite merged rainfall plots during 28th April to 4th May, 2022

2.4.2. Tropical Weather Outlook

The tropical weather outlook is prepared once daily by RSMC tropical cyclones, New Delhi throughout the year. It is transmitted through 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) has been extended from 3 to 5 days since April 2018 over the Bay of Bengal and Arabian Sea. 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 the region and the satellite imagery of the day with probability of cyclogenesis for next 24 hours in addition to above. Tropical Weather outlook will be replaced by Special Tropical Weather Outlook when a depression is located over the north Indian Ocean region based on 0000, 0300, 0600, 1200 and 1800 UTC observations or at any other synoptic hour depending upon the development of depression. The additional bulletins will be issued as and when felt necessary by RSMC, New Delhi.

Example of Tropical Weather Outlook under normal situation

DEMS-RSMC SPECIAL TROPICAL CYCLONES NEW DELHI DATED 04.05.2022

TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 120 HOURS ISSUED AT 0600 UTC OF 04.05.2022 BASED ON 0300 UTC OF 04.05.2022.

BAY OF BENGAL:

A CYCLONIC CIRCULATION FORMED OVER SOUTH ANDAMAN SEA & NEIGHBOURHOOD AT 0000 UTC AND LAY OVER THE SAME REGION AT 0300 UTC OF TODAY, THE 04TH MAY 2022. UNDER ITS INFLUENCE, A LOW PRESSURE AREA IS LIKELY TO FORM OVER THE SAME REGION AROUND 06TH MAY. IT IS VERY LIKELY TO MOVE NORTHWESTWARDS AND INTENSIFY GRADUALLY INTO A DEPRESSION DURING SUBSEQUENT 48 HOURS.

SCATTERED TO BROKEN LOW AND MEDIUM CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION LAY OVER EXTREME SOUTHWEST BOB, SOUTHEAST BOB AND ANDAMAN SEA. SCATTERED LOW AND MEDIUM CLOUDS WITH EMBEDDED MODERATE TO INTENSE CONVECTION LAY OVER CENTRAL PARTS OF NORTH BOB & EASTCENTRAL BOB.

PROBABILITY OF CYCLOGENESIS (FORMATION OF DEPRESSION) DURING NEXT 120 HRS:

| 24 HOURS | 24-48 HOURS | 48-72 HOURS | 72-96 HOURS | 96-120 HOURS |
|----------|-------------|-------------|-------------|--------------|
| NIL | NIL | LOW | MODERATE | HIGH |

ARABIAN SEA:

SCATTERED LOW AND MEDIUM CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION LAY OVER CENTRAL PARTS OF SOUTH ARABIAN SEA AND MODERATE TO INTENSE CONVECTION LAY OVER OVER EXTREME SOUTHEAST ARABIAN SEA. SCATTERED LOW AND MEDIUM CLOUDS WITH EMBEDDED WEAK TO MODERATE CONVECTION LAY OVER SOUTHEAST & ADJOINING EASTCENTRAL ARABIAN SEA OFF KARNATAKA - KERALA COAST.

PROBABILITY OF CYCLOGENESIS (FORMATION OF DEPRESSION) DURING NEXT 120 HRS:

| 24 HOURS | 24-48 HOURS | 48-72 HOURS | 72-96 HOURS | 96-120 HOURS |
|----------|-------------|-------------|-------------|--------------|
| NIL | NIL | NIL | NIL | NIL |

REMARKS: NIL

TYPICAL SATELLITE IMAGERY IS PRESENTED IN FIG. II-4

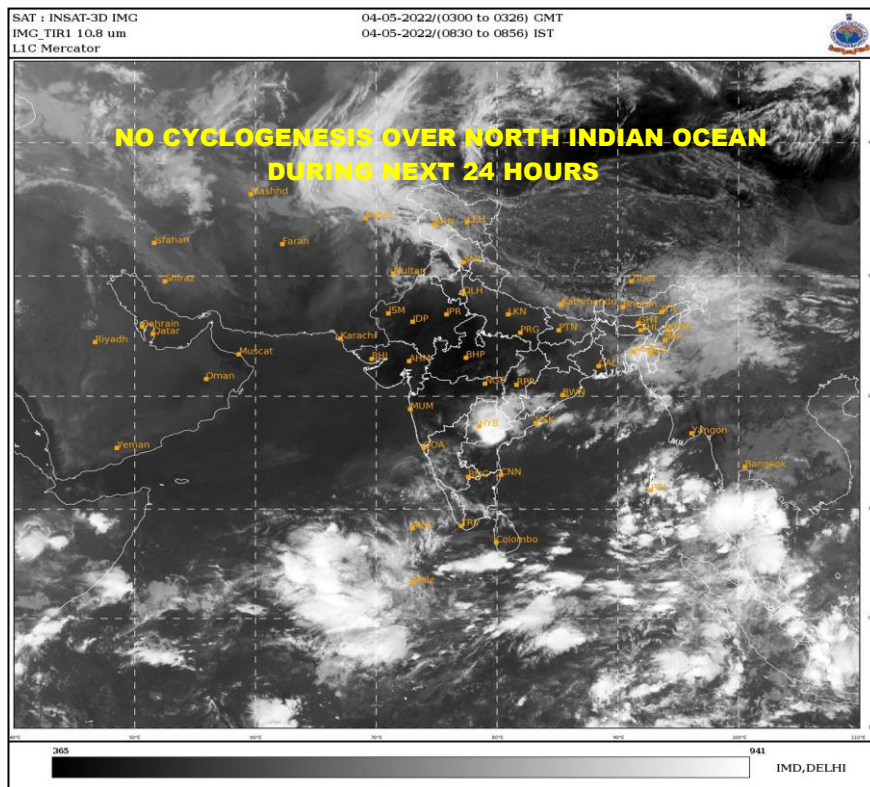


Fig. II-4: Typical satellite imagery based on 0300 UTC of 4th May, 2022

2.4.3 Pre-genesis track and intensity forecast

RSMC New Delhi introduced pre-genesis forecast of cyclogenesis, track & intensity from the stage of low pressure area from March, 2022 with forecast of track & intensity from depression stage upto next 72 hours, thus indicating probable date, time and location of expected cyclogenesis over the NIO. This bulletin is issued once daily based on 0300 UTC observations. A sample bulletin is presented in Example-4.

Example of Tropical Weather Outlook in association with low pressure area with pre-genesis forecast of track and intensity

TROPICAL WEATHER OUTLOOK

DEMS-RSMC SPECIAL TROPICAL CYCLONES NEW DELHI DATED 17.03.2022

TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 120 HOURS ISSUED AT 0600 UTC OF 17.03.2022 BASED ON 0300 UTC OF 17.03.2022.

BAY OF BENGAL:

THE LOW PRESSURE AREA OVER CENTRAL PARTS OF SOUTH BAY OF BENGAL MOVED EAST-NORTHEASTWARDS AND LAY CENTRED AT 0300 UTC OF TODAY THE 17TH MARCH OVER SOUTHEAST BAY OF BENGAL AND EAST EQUATORIAL INDIAN OCEAN. IT IS LIKELY CONTINUE TO MOVE EAST-NORTHEASTWARDS, BECOME A WELL MARKED LOW PRESSURE AREA AND LIE OVER SOUTHEAST BAY OF BENGAL AND ADJOINING SOUTH ANDAMAN SEA BY 0000 UTC OF 19TH MARCH. THEREAFTER, IT IS LIKELY TO MOVE NORTH-NORTHWESTWARDS ALONG & OFF ANDAMAN & NICOBAR ISLANDS, INTENSIFY INTO A DEPRESSION BY 0000 UTC OF 20TH MARCH AND INTO A CYCLONIC STORM BY 0000 UTC OF 21ST MARCH. THEREAFTER, IT IS LIKELY TO MOVE NEARLY NORTHWARDS AND REACH NEAR BANGLADESH-NORTH MYANMAR COASTS AROUND 0000 UTC OF 22ND MARCH, 2022.

SCATTERED TO BROKEN LOW AND MEDIUM CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION LAY OVER SOUTHEAST BAY OF BENGAL AND ADJOINING EQUATORIAL INDIAN OCEAN BETWEEN LATITUDE 2.0N & 8.0N AND LONGITUDE 86.0E & 93.0E IN ASSOCIATION WITH LOW PRESSURE AREA OVER THE REGION. MINIMUM CLOUD TOP TEMPERATURE IS - 93°C. THE SATELLITE IMAGERY AT 0300 UTC INDICATES INCREASE IN CONVECTION OVER THE REGION.

ESTIMATED MAXIMUM SUSTAINED WIND SPEED IS 10-20 KNOTS GUSTING TO 30 KNOTS AROUND THE SYSTEM CENTRE. THE ESTIMATED CENTRAL PRESSURE IS AROUND 1004 HPA. SEA CONDITION IS MODERATE TO ROUGH AND IS VERY LIKELY TO BECOME ROUGH TO VERY ROUGH FROM 18TH MARCH ONWARDS OVER SOUTHEAST BAY OF BENGAL & ADJOINING SOUTH ANDAMAN SEA AND EAST EQUATORIAL INDIAN OCEAN.

PROBABILITY OF CYCLOGENESIS (FORMATION OF DEPRESSION) DURING NEXT 120 HRS:

| 24 HOURS | 24-48 HOURS | 48-72 HOURS | 72-96 HOURS | 96-120 HOURS |
|----------|-------------|-------------|-------------|--------------|
| NIL | LOW | HIGH | HIGH | HIGH |

ARABIAN SEA:

SCATTERED LOW AND MEDIUM CLOUDS WITH EMBEDDED WEAK TO MODERATE CONVECTION OVER NORTH AND WESTCENTRAL ARABIAN SEA, SOUTHEAST ARABIAN SEA OFF KERALA COAST AND COMORIN AREA.

PROBABILITY OF CYCLOGENESIS (FORMATION OF DEPRESSION) DURING NEXT 120 HRS:

| 24 HOURS | 24-48 HOURS | 48-72 HOURS | 72-96 HOURS | 96-120 HOURS |
|----------|-------------|-------------|-------------|--------------|
| NIL | NIL | NIL | NIL | NIL |

REMARKS:

SEA SURFACE TEMPERATURE IS AROUND 29-30°C OVER ANDAMAN SEA, SOUTHEAST AND ADJOINING EASTCENTRAL BAY OF BENGAL (BOB). TROPICAL CYCLONE HEAT POTENTIAL IS AROUND 60-80 KJ/CM² OVER THE SAME REGION BECOMING LESS THAN 50 KJ/CM² OVER NORTH BOB. THE MADDEN JULIAN INDEX (MJO) CURRENTLY LIES IN PHASE 3 WITH AMPLITUDE MORE THAN 1. IT WILL CONTINUE IN SAME PHASE FOR NEXT 3 DAYS AND MOVE TO PHASE 4 WITH AMPLITUDE REMAINING MORE THAN 1. THE PHASE AND AMPLITUDE OF MJO IS CONDUCIVE FOR ENHANCED CONVECTION AND HENCE CYCLOGENESIS OVER THE BOB DURING NEXT 3 DAYS. STRONG WESTERLIES AND EQUATORIAL ROSSBY WAVES ARE LIKELY TO PREVAIL OVER THE REGION DURING NEXT 1 WEEK WHICH WOULD FAVOUR THE GENESIS.

LOW LEVEL VORTICITY HAS NOT CHANGED DURING PAST 24 HOURS AND IS ABOUT 50 X10⁻⁶ S⁻¹ AROUND SYSTEM CENTRE. VERTICALLY IT IS EXTENDING UPTO 500 HPA LEVEL. LOW LEVEL CONVERGENCE IS 20 X10⁻⁵ S⁻¹ TO THE SOUTHEAST OF SYSTEM CENTRE. UPPER LEVEL DIVERGENCE IS SAME AND IS AROUND 30 X10⁻⁵ S⁻¹ TO THE SOUTH OF SYSTEM CENTRE. WIND SHEAR IS MODERATE (20-25 KNOTS) AROUND THE SYSTEM CENTRE WITH DECREASING TREND (BECOMING 10-15 KNOTS) ALONG THE EXPECTED TRACK OF THE SYSTEM.

NUMERICAL MODELS INCLUDING IMD GFS, ECMWF AND ECMWF ENSEMBLE, NCUM (REGIONAL), NCUM (GLOBAL) AND IMD MULTIMODEL ENSEMBLE(MME) ARE INDICATING LIKELIHOOD OF FORMATION OF DEPRESSION OVER SOUTHEAST BOB & ADJOINING SOUTH ANDAMAN SEA ON 19TH MARCH WITH SUBSEQUENT INTENSIFICATION INTO A CYCLONIC STORM AROUND 21ST MARCH. HOWEVER, THERE IS VARIATION AMONG THESE MODELS W.R.T. PEAK INTENSITY WITH IMD GFS INDICATING HIGHER INTENSITY AND ECMWF & NCUM INDICATING INTENSIFICATION UPTO MARGINAL CYCLONIC STORM ONLY. THERE IS GOOD CONSENSUS AMONG THESE MODELS W.R.T. MOVEMENT OF SYSTEM TOWARDS THE BANGLADESH & NORTH MYANMAR COASTS.

IN VIEW OF ALL THE ABOVE, IT IS INFERRED THAT THE LOW PRESSURE AREA OVER SOUTHEAST BOB IS LIKELY TO MOVE EAST-NORTHEASTWARDS, BECOME A WELL MARKED LOW PRESSURE AREA AND LIE OVER SOUTHEAST BAY OF BENGAL AND ADJOINING SOUTH ANDAMAN SEA ON 19TH. THEREAFTER, IT IS LIKELY TO MOVE NORTH-NORTHWESTWARDS INITIALLY ALONG & OFF ANDAMAN & NICOBAR ISLANDS AND INTENSIFY INTO A DEPRESSION BY 0000 UTC OF 20TH & INTO ACYCLONIC STORM BY 21ST MARCH MORNING. IT WOULD THEN CONTINUE TO MOVE NEARLY NORTHWARDS AND REACH NEAR BANGLADESH AND ADJOINING NORTH MYANMAR COAST ON 22ND MARCH.

Typical graphical products including the satellite imagery, pre-genesis track & intensity forecast and fishermen warnings issued with the outlook are presented in Fig. II-5

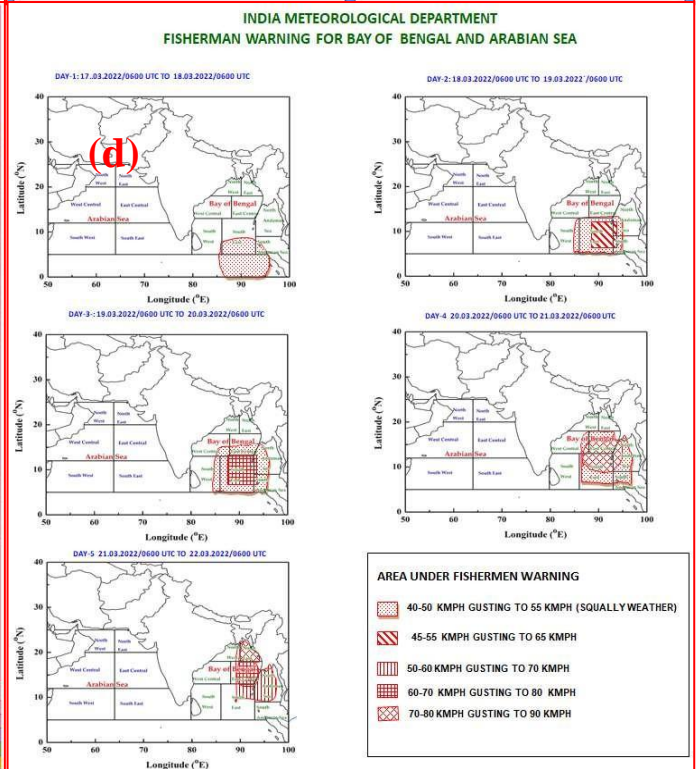
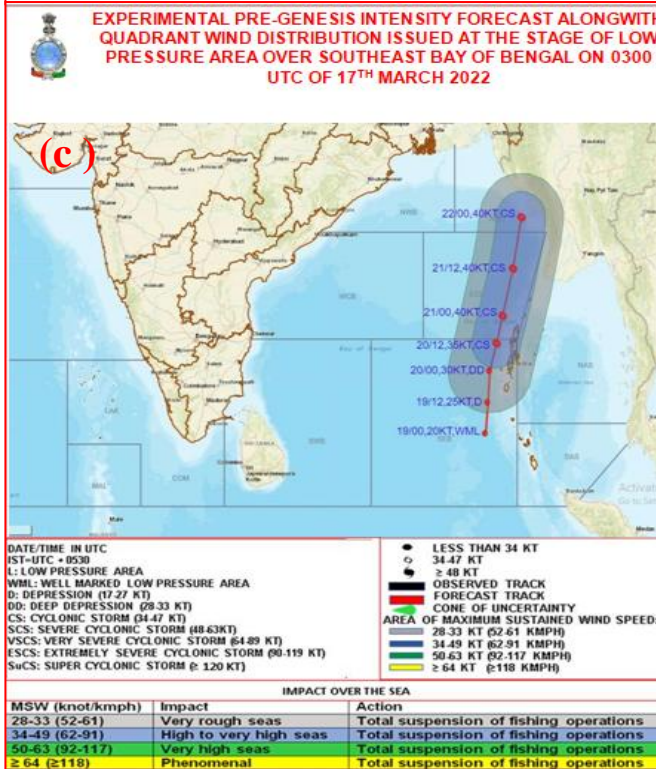
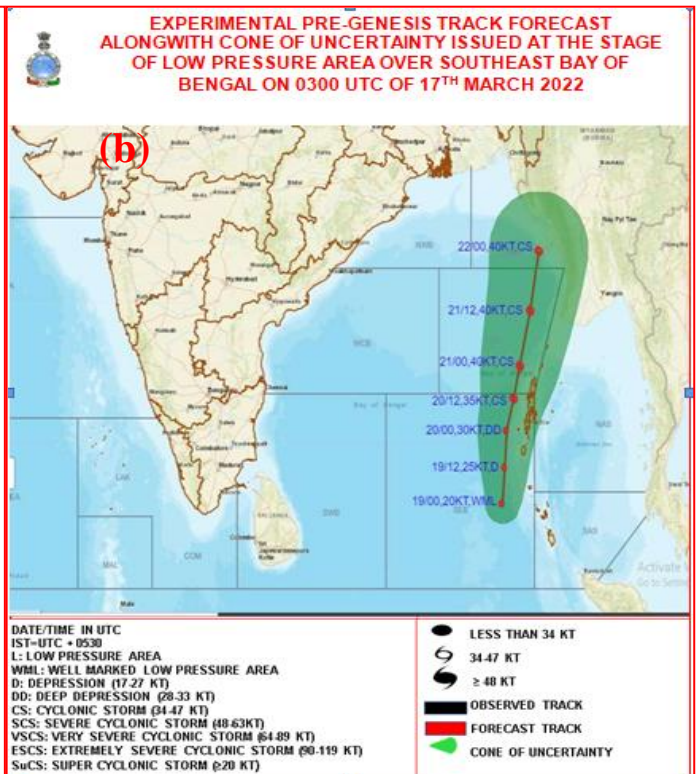
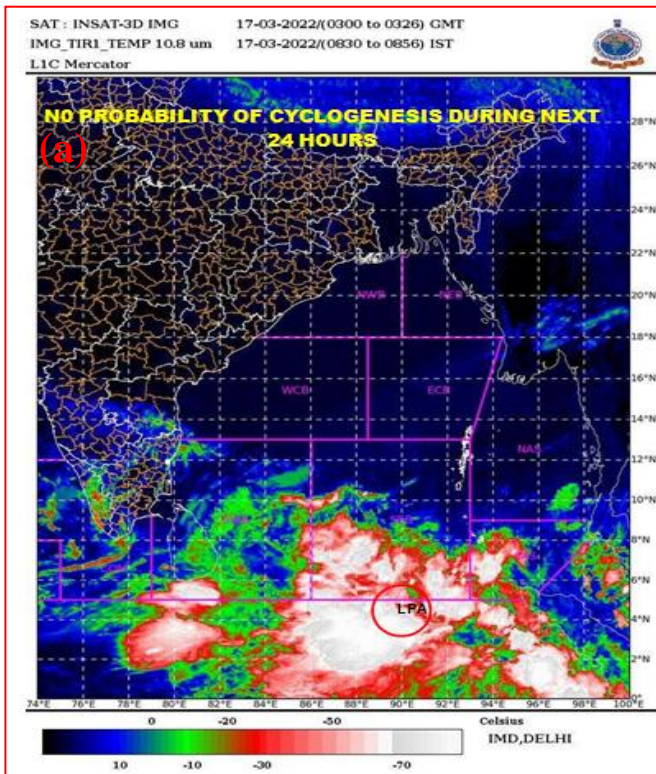


Fig. II-5: (a) Typical Satellite imagery (b) Observed and forecast track alongwith with cone of uncertainty (c) Observed and forecast track alongwith with Quadrant wind distribution. (d) Fisherman warning graphics based on based on 0600 UTC of 17th March at the stage of low pressure area

2.4.4. Special Tropical Weather Outlook

The special tropical weather outlook issued in association with the depression/deep 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 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. Since 2018, the above objective track and intensity forecast is also being issued from depression stage for next +12, +24, +36, +48, +60, +72 hrs, if the depression is expected to intensify into a cyclonic storm.

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

Example of Special Tropical Weather Outlook in association with a depression

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

DEMS-RSMC SPECIAL TROPICAL CYCLONES NEW DELHI DATED 20.03.2022

SPECIAL TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 120 HOURS ISSUED AT 0600 UTC OF 20.03.2022 BASED ON 0300 UTC OF 20.03.2022.

SUB: DEPRESSION OVER SOUTHEAST BAY OF BENGAL AND ADJOINING SOUTH ANDAMAN SEA

THE DEPRESSION OVER SOUTHEAST BAY OF BENGAL AND ADJOINING SOUTH ANDAMAN SEA, MOVED NEARLY NORTHWARDS AT A SPEED OF 12KMPH AND LAY CENTERED AT 0300 UTC OF TODAY, THE 20TH MARCH, OVER THE SAME REGION, NEAR LATITUDE 10.1°N AND LONGITUDE 92.6°E, ABOUT 110 KM NORTH-NORTHWEST OF CAR NICOBAR (43367)(NICOBAR ISLANDS), 170 KM SOUTH OF PORT BLAIR (43333) (ANDAMAN ISLANDS) AND 840 KM SOUTH-SOUTHWEST OF YANGON(48097) (MYANMAR). IT IS LIKELY TO MOVE NEARLY NORTHWARDS ALONG & OFF ANDAMAN & NICOBAR ISLANDS, INTENSIFY INTO A DEEP DEPRESSION BY 0000UTC OF 21ST AND INTO A CYCLONIC STORM BY 1200 UTC OF 21ST MARCH.

FORECAST TRACK AND INTENSITY ARE GIVEN IN THE FOLLOWING TABLE:

| Date/Time(UTC) | POSITION (LAT. °N/ LONG. °E) | MAXIMUM SUSTAINED SURFACE WIND SPEED (KMPH) | CATEGORY OF CYCLONIC DISTURBANCE |
|-----------------------|---------------------------------------------|------------------------------------------------------------|-------------------------------------------------|
| 20.03.22/0300 | 10.1/92.6 | 40-50 GUSTING TO 60 | DEPRESSION |
| 20.03.22/1200 | 11.1/93.1 | 45-55 GUSTING TO 65 | DEPRESSION |
| 21.03.22/0000 | 12.4/93.4 | 55-65 GUSTING TO 75 | DEEP DEPRESSION |
| 21.03.22/1200 | 13.8/93.5 | 65-75 GUSTING TO 85 | CYCLONIC STORM |
| 22.03.22/0000 | 15.4/93.6 | 60-70 GUSTING TO 80 | CYCLONIC STORM |
| 22.03.22/1200 | 17.0/93.8 | 55-65 GUSTING TO 75 | DEEP DEPRESSION |

SATELLITE SHOWS INTENSITY OF THE SYSTEM IS CHARACTERISED AS T 1.0. ASSOCIATED BROKEN LOW AND MEDIUM CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION LAY OVER SOUTHEAST BAY OF BENGAL AND ADJOINING SOUTH ANDAMAN SEA BETWEEN LATITUDE 6.0N & 13.0N AND LONGITUDE 90.0E & 97.0E. MINIMUM CTT MINUS 93 DEG C (.) VERY INTENSE CONVECTION LIES IN SOUTHEAST SECTOR OF THE SYSTEM CENTER.

THE ESTIMATED MAXIMUM SUSTAINED WIND SPEED IS 25 KNOTS GUSTING TO 35 KNOTS. THE SEA CONDITION IS ROUGH TO VERY ROUGH OVER ANDAMAN SEA AND ADJOINING SOUTHEAST BAY OF BENGAL. THE ESTIMATED CENTRAL PRESSURE IS 1002 HPA.

REMARKS:

SEA SURFACE TEMPERATURE IS AROUND 29-30°C OVER ANDAMAN SEA, SOUTHEAST AND ADJOINING EASTCENTRAL BAY OF BENGAL (BOB). TROPICAL CYCLONE HEAT POTENTIAL IS AROUND 60-80 KJ/CM² OVER THE SAME REGION BECOMING LESS THAN 50 KJ/CM² OVER NORTH BOB. THE MADDEN JULIAN OSCILLATION (MJO) INDEX CURRENTLY LIES IN PHASE 3 WITH AMPLITUDE MORE THAN 1. IT WILL CONTINUE IN SAME PHASE FOR NEXT 2 DAYS AND MOVE TO PHASE 4 WITH AMPLITUDE REMAINING MORE THAN 1. THE PHASE AND AMPLITUDE OF MJO IS CONDUCIVE FOR ENHANCED CONVECTION AND HENCE CYCLOGENESIS OVER THE BOB DURING NEXT 2 DAYS. STRONG WESTERLIES, KELVIN WAVES AND EQUATORIAL ROSSBY WAVES ARE LIKELY TO PREVAIL OVER THE REGION DURING NEXT 3 DAYS WHICH WOULD FAVOUR INTENSIFICATION.

LOW LEVEL VORTICITY IS ABOUT $75 \times 10^{-6} \text{ S}^{-1}$ AROUND THE SYSTEM CENTRE WITH VERTICAL EXTENSION UPTO 500 HPA LEVEL. LOW LEVEL CONVERGENCE IS $20 \times 10^{-5} \text{ S}^{-1}$ TO THE NORT OF SYSTEM CENTRE. UPPER LEVEL DIVERGENCE IS AROUND $20 \times 10^{-5} \text{ S}^{-1}$ AROUND THE SYSTEM CENTRE. VERTICAL WIND SHEAR IS MODERATE (15-20 KNOTS) AROUND THE SYSTEM CENTRE WITH DECREASING TREND (BECOMING 10-15 KNOTS) ALONG THE EXPECTED TRACK OF THE SYSTEM. CURRENT CONDITIONS INDICATE THAT THE SYSTEM IS LYING IN FAVOURABLE ENVIRONMENT.

NUMERICAL MODELS INCLUDING IMD GFS, ECMWF AND ECMWF ENSEMBLE, NCUM (REGIONAL), NCUM (GLOBAL) AND IMD MULTIMODEL ENSEMBLE (MME) ARE INDICATING SYSTEM TO BECOME A DEEP DEPRESSION ON 21ST MARCH AND INTO A MARGINAL CYCLONIC STORM AROUND 22ND MARCH. HOWEVER, THERE IS VARIATION AMONG THESE MODELS W.R.T. PEAK INTENSITY WITH IMD GFS INDICATING HIGHER INTENSITY AND ECMWF & NCUM INDICATING INTENSIFICATION UPTO DEEP DEPRESSION STAGE ONLY. HOWEVER, MOST OF THE MODELS ARE UNANIMOUS REGARDING MOVEMENT OF SYSTEM TOWARDS MYANMAR AND ADJOINING SOUTHEAST BANGLADESH COASTS.

IN VIEW OF ABOVE, THE SYSTEM IS LIKELY TO MOVE NEARLY NORTHWARDS ALONG & OFF ANDAMAN & NICOBAR ISLANDS, INTENSIFY INTO A DEEP DEPRESSION BY 0000UTC OF 21ST AND INTO A CYCLONIC STORM BY 1200 UTC OF 21ST MARCH

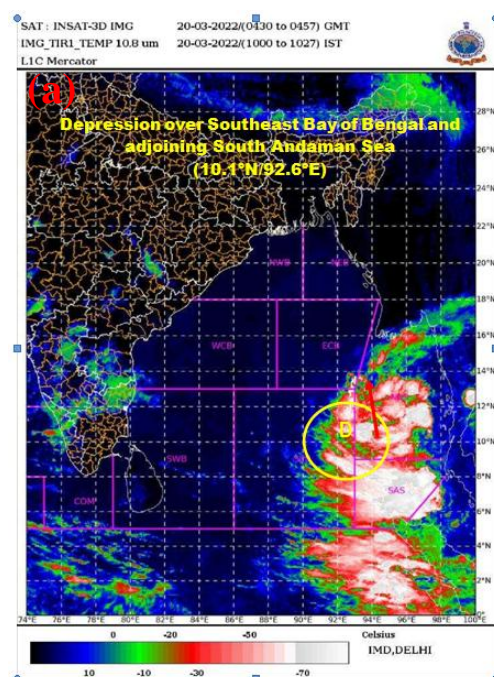


Fig. II-6:(a) Typical Satellite imagery based on 0300 UTC of 20th March

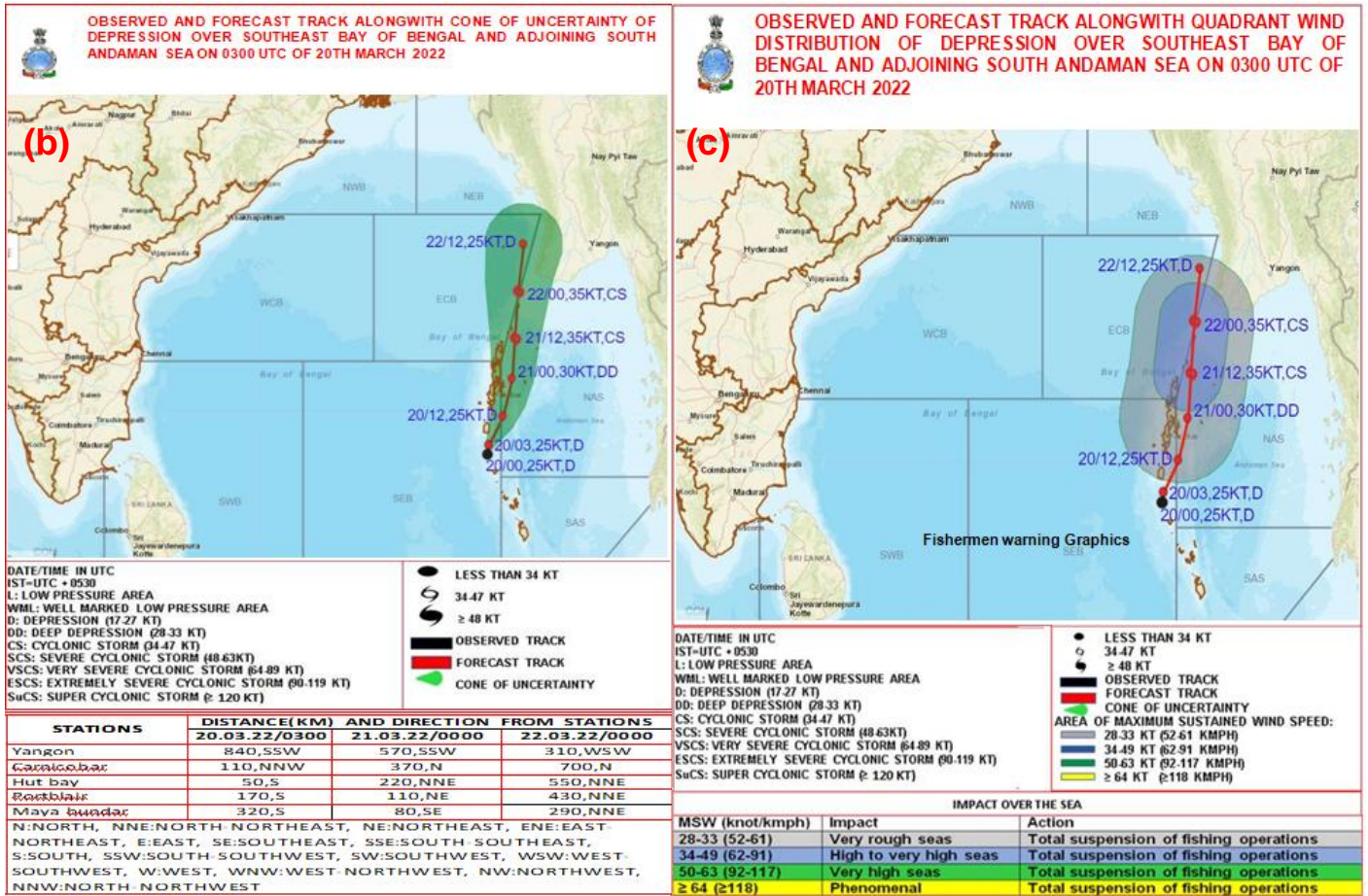


Fig. II-6 contd.: (b) Observed and forecast track alongwith with cone of uncertainty and (c) Observed and forecast track alongwith with Quadrant wind distribution based on 0300 UTC of 20th March

Example of Special Tropical Weather Outlook in association with a deep depression

DEMS-RSMC SPECIAL TROPICAL CYCLONES NEW DELHI DATED 21.03.2022

SPECIAL TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 120 HOURS ISSUED AT 0300 UTC OF 21.03.2022 BASED ON 0000 UTC OF 21.03.2022.

SUB: DEPRESSION OVER NORTH ANDAMAN SEA AND ADJOINING SOUTHEAST BAY OF BENGAL INTENSIFIED INTO A DEEP DEPRESSION OVER THE SAME REGION

THE DEPRESSION OVER NORTH ANDAMAN SEA AND ADJOINING SOUTHEAST BAY OF BENGAL, MOVED NORTH-NORTHEASTWARDS AT A SPEED OF 12 KMPH DURING LAST 06 HOURS, INTENSIFIED INTO A DEEP DEPRESSION AND LAY CENTERED AT 0000 UTC OF TODAY, 21ST MARCH, OVER THE SAME REGION, NEAR LATITUDE 11.9°N AND LONGITUDE 93.7°E, ABOUT 110 KM EAST-NORTHEAST OF PORT BLAIR(43333) (ANDAMAN ISLANDS), 320 KM NORTH-NORTHEAST OF CAR NICOBAR (43367) (NICOBAR ISLANDS) AND 610 KM SOUTH-SOUTHWEST OF YANGON (48097) (MYANMAR). IT IS LIKELY TO INTENSIFY FURTHER INTO A CYCLONIC STORM BY 1200UTC OF 21ST MARCH. IT IS LIKELY TO MOVE

NEARLY NORTHWARDS ALONG & OFF ANDAMAN ISLANDS TOWARDS MYANMAR COAST BY 0000UTC OF 23RD MARCH.

FORECAST TRACK AND INTENSITY ARE GIVEN IN THE FOLLOWING TABLE:

| DATE/TIME(UTC) | POSITION (LAT. °N/ LONG. °E) | AXIMUM SUSTAINED SURFAC WIND SPEED (KMPH) | CATEGORY OF CYCLONIC DISTURBANCE |
|----------------|------------------------------------|----------------------------------------------|----------------------------------------|
| 21.03.22/0000 | 11.9/93.7 | 50-60 GUSTING TO 70 | DEEP DEPRESSION |
| 21.03.22/1200 | 13.7/93.9 | 65-75 GUSTING TO 85 | CYCLONIC STORM |
| 22.03.22/0000 | 15.1/93.8 | 65-75 GUSTING TO 85 | CYCLONIC STORM |
| 22.03.22/1200 | 16.9/93.9 | 55-65 GUSTING TO 75 | DEEP DEPRESSION |
| 23.03.22/0000 | 18.4/94.1 | 45-55 GUSTING TO 65 | DEPRESSION |

AS PER INSAT 3D IMAGERY, INTENSITY OF THE SYSTEM IS CHARACTERISED AS T 2.0. ASSOCIATED BROKEN LOW AND MEDIUM CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION LAY OVER ANDAMAN SEA AND ADJOINING SOUTHEAST BAY OF BENGAL BETWEEN LATITUDE 10.0N & 15.0N AND LONGITUDE 91.0E & 97.0E AND ANDAMAN& NICOBAR ISLANDS. MINIMUM CLOUD TOP TEMPERATURE IS AROUND MINUS 93 DEG C. INTENSE CONVECTION LIES IN EAST SECTOR OF THE SYSTEM CENTRE.

THE ESTIMATED MAXIMUM SUSTAINED WIND SPEED IS 30 KNOTS GUSTING TO 40 KNOTS. THE SEA CONDITION IS ROUGH TO VERY ROUGH OVER ANDAMAN SEA AND ADJOINING SOUTHEAST BAY OF BENGAL. THE ESTIMATED CENTRAL PRESSURE IS 1002 HPA.

REMARKS:

SEA SURFACE TEMPERATURE IS AROUND 29-30°C OVER ANDAMAN SEA, SOUTHEAST AND ADJOINING EASTCENTRAL BAY OF BENGAL (BOB). TROPICAL CYCLONE HEAT POTENTIAL IS AROUND 60-80 KJ/CM² OVER THE SAME REGION BECOMING LESS THAN 50 KJ/CM² OVER NORTH BOB. THE MADDEN JULIAN OSCILLATION (MJO) INDEX CURRENTLY LIES IN PHASE 3 WITH AMPLITUDE MORE THAN 1. IT WILL CONTINUE IN SAME PHASE FOR NEXT 2 DAYS AND MOVE TO PHASE 4 WITH AMPLITUDE REMAINING MORE THAN 1. THE PHASE AND AMPLITUDE OF MJO IS CONDUCIVE FOR ENHANCED CONVECTION AND HENCE CYCLOGENESIS OVER THE BOB DURING NEXT 2 DAYS.

LOW LEVEL VORTICITY HAS INCREASED SIGNIFICANTLY FROM 50 X10⁻⁶ S⁻¹ TO 150 X10⁻⁶ S⁻¹ DURING LAST 6 HOURS AND LIES AROUND THE SYSTEM CENTRE WITH VERTICAL EXTENSION UPTO 500 HPA LEVEL. LOW LEVEL CONVERGENCE IS 20X10⁻⁵ S⁻¹ NORTHEAST OF THE SYSTEM CENTRE. UPPER LEVEL DIVERGENCE IS AROUND 20 X10⁻⁵ S⁻¹ ALSO AT NORTHEAST OF THE SYSTEM CENTRE. VERTICAL WIND SHEAR IS MODERATE (15-20 KNOTS) AROUND THE SYSTEM CENTRE WITH DECREASING TREND (BECOMING 10-15 KNOTS) ALONG THE EXPECTED TRACK OF THE SYSTEM. CURRENT CONDITIONS INDICATE THAT THE SYSTEM IS LYING IN FAVOURABLE ENVIRONMENT.

NUMERICAL MODELS INCLUDING IMD GFS, ECMWF AND ECMWF ENSEMBLE, NCM (REGIONAL), NCM (GLOBAL) AND IMD MULTIMODEL ENSEMBLE (MME) ARE INDICATING SYSTEM TO FURTHER INTENSIFY INTO A MARGINAL CYCLONIC STORM DURING NEXT 12 HOURS. HOWEVER, THERE IS VARIATION AMONG THESE MODELS W.R.T. PEAK INTENSITY WITH IMD GFS INDICATING HIGHER INTENSITY AND ECMWF & NCM INDICATING INTENSIFICATION UPTO DEEP DEPRESSION STAGE ONLY. HOWEVER, MOST OF THE MODELS ARE UNANIMOUS REGARDING MOVEMENT OF SYSTEM TOWARDS MYANMAR AND ADJOINING SOUTHEAST BANGLADESH COASTS.

IN VIEW OF ABOVE, THE SYSTEM IS LIKELY TO MOVE NEARLY NORTHWARDS ALONG & OFF ANDAMAN & NICOBAR ISLANDS AND INTENSIFY INTO A MARGINAL CYCLONIC STORM DURING SUBSEQUENT 12 HOURS.

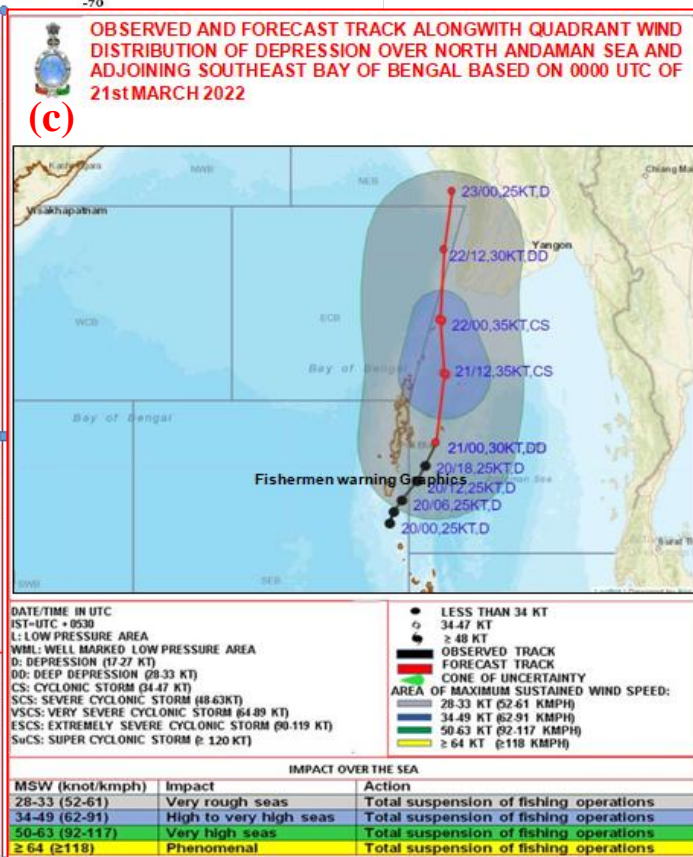
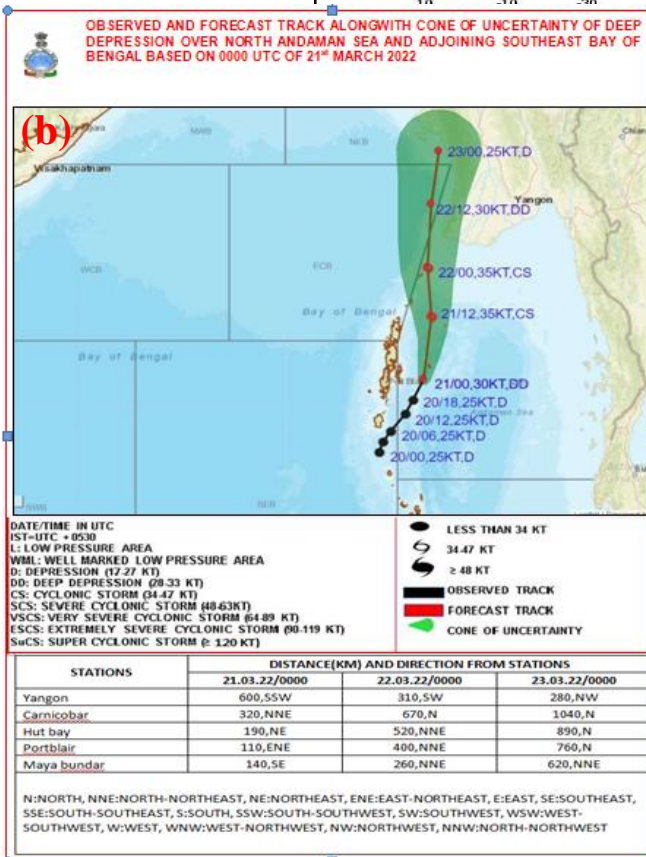
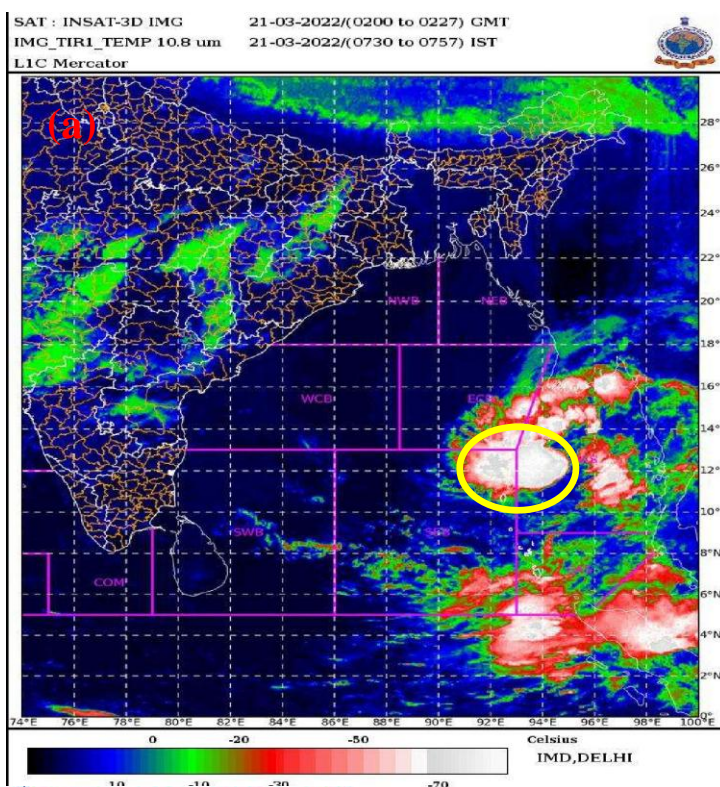


Fig. II-7: (a) Typical Satellite imagery, (b) Observed and forecast track alongwith cone of uncertainty, (c) Observed and forecast track alongwith with Quadrant wind distribution based on 0000 UTC of 21st March in association with Deep Depression over Andaman Sea

(d)

**INDIA METEOROLOGICAL DEPARTMENT
FISHERMAN WARNING FOR BAY OF BENGAL AND ARABIAN SEA**

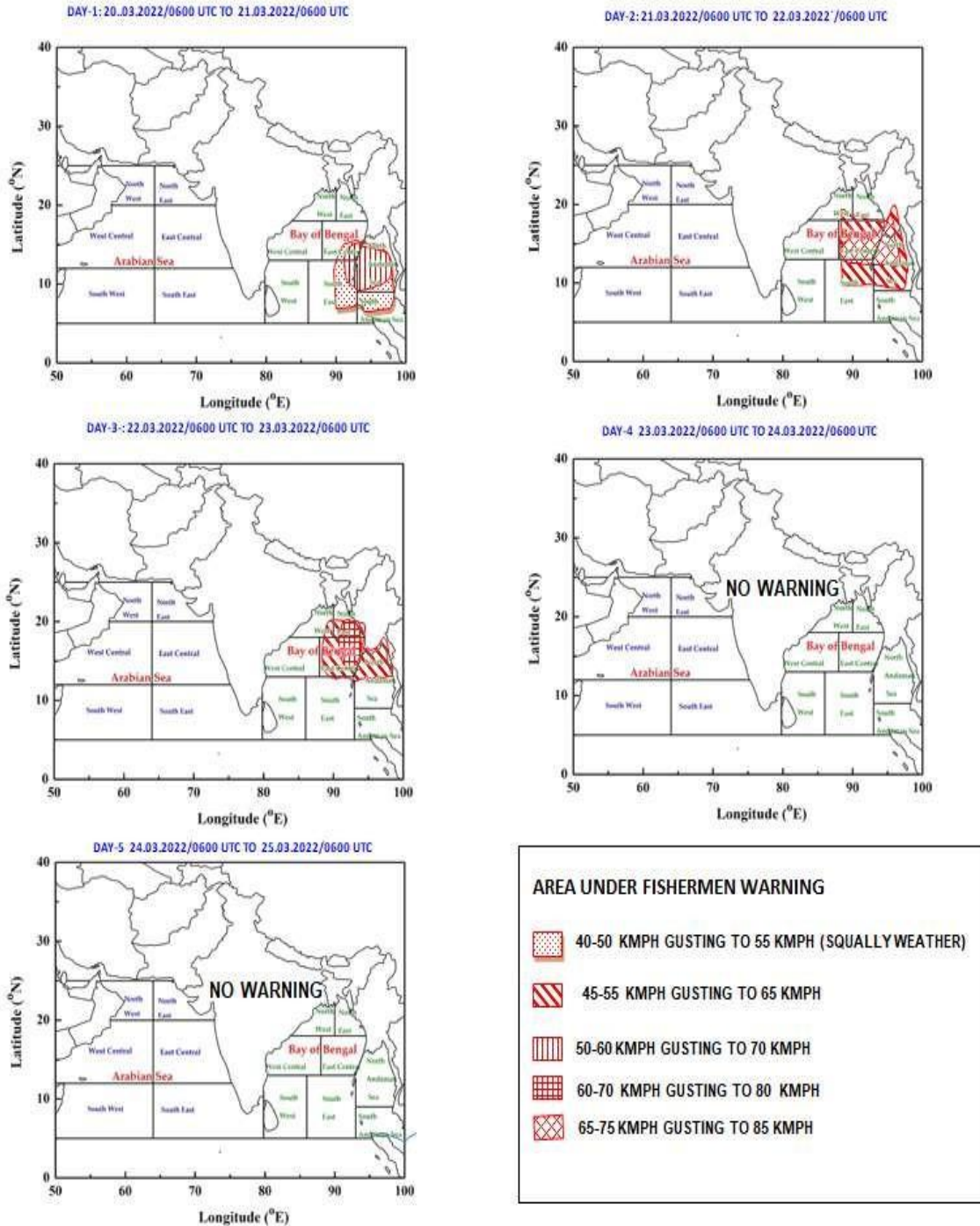


Fig. II-7: (d) Fishermen warning graphics for entire north Indian Ocean based on 0000 UTC of 21st March in association with Deep Depression over Andaman Sea

2.4.5 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 three hourly 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 has been extended between 40⁰E to 100⁰E from 2018 onwards from 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 are also be reported in the advisory bulletin. Advisories are exchanged under appropriate headings for regional distribution by RTH, New Delhi on the GTS.

**Example of Tropical cyclone advisory in association with severe cyclonic storm Asani
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 (THROUGH RTH JEDDAH)
NATIONAL CENTRE FOR METEOROLOGY, UAE (THROUGH RTH JEDDAH)
PRESIDENCY OF METEOROLOGY AND ENVIRONMENT, SAUDI ARABIA (THROUGH RTH JEDDAH)
IRAN METEOROLOGICAL ORGANISATION, (THROUGH RTH JEDDAH)
QATAR METEOROLOGICAL DEPARTMENT (THROUGH RTH JEDDAH)**

TROPICAL CYCLONE ADVISORY NO. 19 FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 120 HOURS ISSUED AT 1000 UTC OF 10.05.2022 BASED ON 0600 UTC OF 10.05.2022

SUB: SEVERE CYCLONIC STORM 'ASANI' OVER WESTCENTRAL BAY OF BENGAL

THE **SEVERE CYCLONIC STORM 'ASANI' (PRONOUNCED AS ASANI)** OVER WESTCENTRAL AND ADJOINING SOUTHWEST BAY OF BENGAL MOVED WEST-NORTHWESTWARDS WITH A SPEED OF 25 KMPH DURING PAST 06 HOURS AND LAY CENTERED AT 0600 HOURS UTC OF TODAY, THE 10TH MAY, OVER WESTCENTRAL BAY OF BENGAL NEAR LATITUDE 15.0°N AND LONGITUDE 82.5°E, 210 KM SOUTH-SOUTHEAST OF KAKINADA (43189), 310 KM SOUTH-SOUTHWEST OF VISAKHAPATNAM (43149), 530 KM SOUTHWEST OF GOPALPUR (43049) AND 630 KM SOUTHWEST OF PURI (43053).

IT IS VERY LIKELY TO MOVE NEARLY NORTHWESTWARDS AND REACH WESTCENTRAL BAY OF BENGAL CLOSE TO KAKINADA-VISAKHAPATNAM COASTS BY 11TH MAY MORNING. THEREAFTER, IT IS VERY LIKELY TO RECURVE SLOWLY NORTH-NORTHEASTWARDS AND MOVE ALONG ANDHRA PRADESH COAST BETWEEN KAKINADA AND VISAKHAPATNAM AND THEN EMERGE INTO NORTHWEST BAY OF BENGAL OFF NORTH

ANDHRA PRADESH AND ODISHA COASTS. IT IS LIKELY TO WEAKEN GRADUALLY INTO A CYCLONIC STORM BY 11TH MAY MORNING AND INTO A DEPRESSION BY 12TH MAY MORNING. THE CYCLONIC STORM IS UNDER THE CONTINUOUS SURVEILLANCE OF DOPPLER WEATHER RADAR (DWR) AT MACHILIPATNAM (ANDHRA PRADESH).

FORECAST TRACK AND INTENSITY ARE GIVEN IN THE FOLLOWING TABLE:

| DATE/TIME (UTC) | POSITION (LAT. °N/ LONG. °E) | MAXIMUM SUSTAINED SURFACE WIND SPEED (KMPH) | CATEGORY OF CYCLONIC DISTURBANCE |
|-----------------|------------------------------|---------------------------------------------|----------------------------------|
| 10.05.22/0600 | 15.0/82.5 | 100-110 GUSTING TO 120 | SEVERE CYCLONIC STORM |
| 10.05.22/1200 | 15.4/82.1 | 95-105 GUSTING TO 115 | SEVERE CYCLONIC STORM |
| 10.05.22/1800 | 15.8/81.9 | 85-95 GUSTING TO 105 | CYCLONIC STORM |
| 11.05.22/0000 | 16.2/81.9 | 80-90 GUSTING TO 100 | CYCLONIC STORM |
| 11.05.22/0600 | 16.7/82.3 | 75-85 GUSTING TO 95 | CYCLONIC STORM |
| 11.05.22/1800 | 17.3/82.9 | 65-75 GUSTING TO 85 | CYCLONIC STORM |
| 12.05.22/0600 | 17.6/83.6 | 55-65 GUSTING TO 75 | DEEP DEPRESSION |
| 12.05.22/1800 | 17.9/84.5 | 45-55 GUSTING TO 65 | DEPRESSION |

THE INTENSITY OF THE SYSTEM IS T3.5. INSAT-3D IMAGERY INDICATES BROKEN LOW AND MEDIUM CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION OVER AREA BETWEEN LATITUDE 11.0N & 15.5N AND LONGITUDE 80.0E & 84.5E. THE SATELLITE IMAGERY INDICATES INTENSE CONVECTION OVER SOUTH COASTAL ANDHRA PRADESH AND ADJOINING NORTHEAST TAMILNADU. MINIMUM CLOUD TOP TEMPERATURE IS MINUS 93 DEG C.

AT 0600 UTC, A BUOY(13⁰12'N/84⁰19'E) REPORTED MAXIMUM SUSTAINED WIND SPEED OF 220⁰/21.4KT AND MEAN SEA LEVEL PRESSURE 999.1 HPA.

THE ESTIMATED MAXIMUM SUSTAINED WIND SPEED IS 55 KNOTS GUSTING TO 65 KNOTS. THE SEA CONDITION IS VERY HIGH OVER WESTCENTRAL BAY OF BENGAL. THE ESTIMATED CENTRAL PRESSURE IS 989 HPA.

REMARKS:

THE MADDEN JULIAN OSCILLATION INDEX (MJO) CURRENTLY LIES IN PHASE 5 WITH AMPLITUDE LESS THAN 1. IT WOULD CONTINUE IN SAME PHASE 5 DURING NEXT 2 DAYS WITH AMPLITUDE BECOMING MORE THAN 1. HENCE, MJO WILL SUPPORT ENHANCEMENT OF CONVECTIVE ACTIVITY OVER THE BAY OF BENGAL (BOB) DURING NEXT 3-4 DAYS.

SEA SURFACE TEMPERATURE (SST) IS AROUND 30-31⁰C OVER ENTIRE BOB. IT DECREASES GRADUALLY TOWARDS THE ANDHRA PRADESH & ODISHA COASTS BECOMING 28⁰C. THE OCEAN HEAT CONTENT (OHC) IS >100 KJ/CM² OVER WESTCENTRAL & SOUTH BAY OF BENGAL (BOB) BECOMING 50-70 KJ/CM² OVER NORTHWEST BOB & ALONG & OFF ANDHRA PRADESH & ODISHA COASTS AND ADJOINING WESTCENTRAL BOB.

LOW LEVEL VORTICITY IS ABOUT 300 X10⁻⁶ S⁻¹ TO THE SOUTH OF SYSTEM CENTRE. VERTICALLY IT IS EXTENDING UPTO 200 HPA LEVEL. VORTICITY FIELD IS ORIENTED SOUTH-NORTH INDICATING NORTHWARDS VORTICITY ADVECTION. LOW LEVEL CONVERGENCE IS AROUND 20 X10⁻⁵ S⁻¹ TO THE WEST OF SYSTEM CENTRE. UPPER LEVEL DIVERGENCE IS AROUND 10 X10⁻⁵ S⁻¹ TO THE SOUTHWEST OF THE SYSTEM CENTRE. WIND SHEAR IS MODERATE (15-20 KNOTS) AROUND THE SYSTEM AREA. IT IS LIKELY TO BECOME LOW TO MODERATE (10-15 KNOTS) ALONG THE FORECAST TRACK OVER WESTCENTRAL & NORTHWEST BOB. THIS WILL HELP SYSTEM MAINTAIN IT'S INTENSITY FOR SOME TIME. AS THE SYSTEM MOVES FURTHER NORTHWARDS, IT WILL ENCOUNTER LOWER SST & OHC AND HENCE WILL SHOW GRADUAL WEAKENING. THERE WILL BE DRY AIR INCURSION REACHING INTO THE CORE AREA FROM INDIAN LANDMASS AS THE SYSTEM MOVES FURTHER NORTHWARDS. IT WILL HELP IN WEAKENING OF THE SYSTEM. IT IS LIKELY TO RECURVE NORTHEASTWARDS FROM 11TH MORNING WHILE MOVING ALONG THE PERIPHERY OF SUB-TROPICAL RIDGE ASSOCIATED WITH ANTICYCLONIC CIRCULATION OVER THE EASTCENTRAL BOB.

MOST OF THE NUMERICAL MODELS ARE IN GOOD AGREEMENT THAT IT IS VERY LIKELY TO RECURVE NORTH-NORTHEASTWARDS, MOVE TOWARDS NORTHWEST BAY OF BENGAL OFF NORTH ANDHRA PRADESH AND ODISHA COASTS. IT IS LIKELY TO WEAKEN GRADUALLY INTO A CYCLONIC STORM DURING NEXT 12 HOURS.

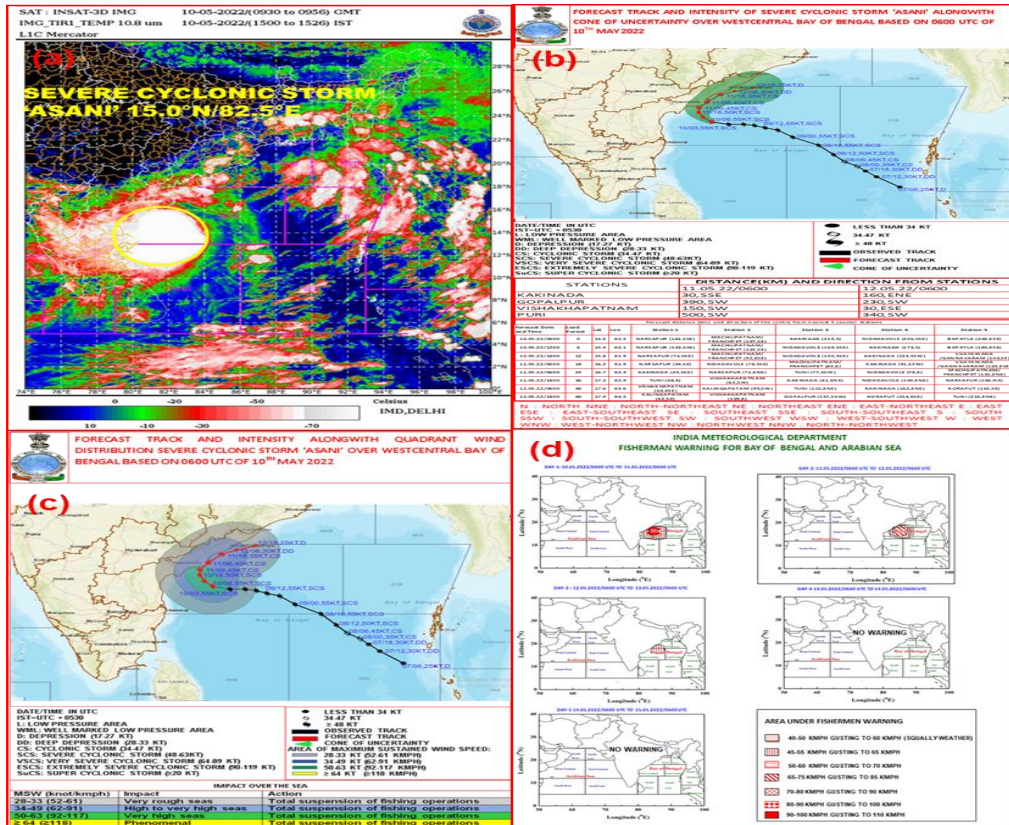


Fig. II-8: (a) Typical Satellite imagery based on 0600 UTC of 10th May in association with SCS ASANI over Bay of Bengal (b) Observed and forecast track alongwith with cone of uncertainty based on 0600 UTC of 10th May (c) Observed and forecast track alongwith with Quadrant wind distribution based on 0600 UTC of 10th May (d) Fisherman warning graphics based on 0600 UTC of 10th May

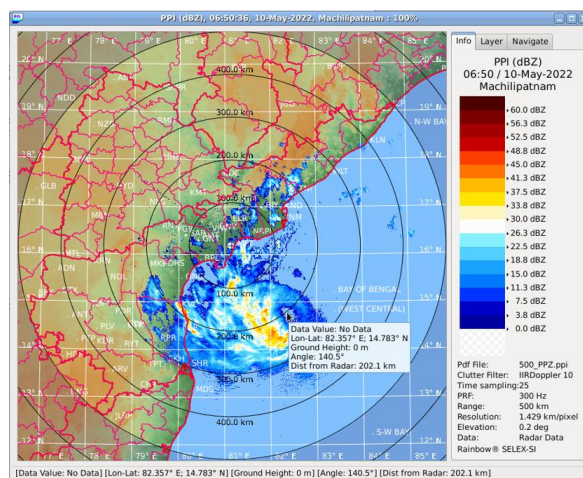


Fig. II-8 contd.: (e) Doppler Weather Radar imagery from Machilipatnam at 0600 Utc Of 10th May

2.4.6. Hourly update bulletin

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

BULLETIN NO. 04

DATE: 11-05-2022

TIME OF ISSUE: 1430 HRS IST

| DATE/TIME (IST) OF OBSERVATION | BASED ON 11-05-2022 (1330 HRS IST) |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| LOCATION LATITUDE/LONGITUDE | THE CYCLONIC STORM 'ASANI' (PRONOUNCED AS 'Asani') LAY CENTRED AT 1330 HRS IST OF THE 11 th MAY, 2022 OVER WESTCENTRAL BAY OF BENGAL NEAR LATITUDE 16.15°N AND LONGITUDE 81.6°E, ABOUT 50 KM EAST OF MACHILIPATNAM, 30 KM SOUTH-SOUTHWEST OF NARSAPUR. |
| CURRENT INTENSITY NEAR CENTRE | 70-80 KMPH GUSTING TO 90 KMPH |
| PAST MOVEMENT | MOVED NORTHEASTWARDS WITH A SPEED OF ABOUT 10 KMPH DURING PAST 03 HOURS. |
| FORECAST MOVEMENT | TO MOVE NORTH-NORTHEASTWARDS ALONG NARSAPUR, YANAM, KAKINADA, TUNI & VISAKHAPATNAM COASTS TILL EVENING OF TODAY AND EMERGE INTO WESTCENTRAL BAY OF BENGAL OFF NORTH ANDHRA PRADESH COAST BY TODAY NIGHT. |
| FORECAST INTENSITY | <ul style="list-style-type: none"> • CYCLONIC STORM ASANI LIKELY TO WEAKEN INTO A DEEP DEPRESSION BY NIGHT AND INTO A DEPRESSION BY 12TH MAY MORNING. • GALE WIND SPEED REACHING 70-80 KMPH GUSTING TO 90 KMPH IS PREVAILING AROUND THE SYSTEM CENTER OVER WESTCENTRAL BAY OF BENGAL. IT WOULD GRADUALLY DECREASE BECOMING 65-75 KMPH GUSTING TO 85 KMPH BY TODAY AFTERNOON OVER THE SAME REGION. FURTHER, IT WOULD DECREASE TO 45-55 KMPH GUSTING TO 65 KMPH OVER WESTCENTRAL BAY OF BENGAL ON 12TH MAY MORNING. |
| FORECAST WIND ALONG THE COAST | <ul style="list-style-type: none"> • GALE WIND SPEED REACHING 70-80 KMPH GUSTING TO 90 KMPH LIKELY TO PREVAIL ALONG & OFF KRISHNA, EAST & WEST GODAVARI, YANAM OF PUDUCHERRY UT AND VISAKHAPATNAM DISTRICTS AND 50-60 KMPH GUSTING TO 70 KMPH ALONG & OFF ADJOINING DISTRICTS OF COASTAL ANDHRA PRADESH DURING FORENOON TO AFTERNOON OF TODAY. IT WOULD THEN DECREASE GRADUALLY TO 45-55 KMPH GUSTING TO 65 KMPH OVER THE SAME REGION BY 12TH MAY MORNING. • SQUALLY WIND SPEED REACHING 40-50 KMPH GUSTING TO 60 KMPH IS LIKELY TO CONTINUE ALONG & OFF ODISHA AND WEST BENGAL COASTS ON 11TH TO 12TH MAY |
| FORECAST RAINFALL | <ul style="list-style-type: none"> • 11th MAY: LIGHT TO MODERATE RAINFALL AT MOST PLACES WITH HEAVY TO VERY HEAVY RAINFALL AT A FEW PLACES WITH ISOLATED EXTREMELY HEAVY FALLS IS LIKELY OVER COASTAL ANDHRA PRADESH AND HEAVY RAINFALL AT ISOLATED PLACES IS LIKELY OVER SOUTH COASTAL ODISHA. • 12th MAY: LIGHT TO MODERATE RAINFALL LIKELY AT MANY PLACES OVER COASTAL ANDHRA PRADESH, COASTAL AREAS OF ODISHA AND WEST BENGAL AND HEAVY RAINFALL AT ISOLATED PLACES OVER COASTAL ANDHRA PRADESH. |
| FORECAST STORM SURGE | STORM SURGE OF HEIGHT ABOUT 0.5 M ABOVE ASTRONOMICAL TIDE IS LIKELY TO INUNDATE LOW LYING AREAS OF KRISHNA, EAST & WEST GODAVARI DISTRICTS OF ANDHRA PRADESH AND YANAM OF UT OF PUDUCHERRY |

2.4.7 Tropical cyclone warnings for the high Seas (WWMIWS)

The IMO/WMO Worldwide Met-Ocean Information and Warning Service (WWMIWS) is the internationally coordinated service for the promulgation of meteorological warnings and forecasts.

The WWMIWS guidance and coordination for marine meteorological maritime safety information messages issued on EGC (SafetyNET), NAVTEX and HF NBDP communication systems covering the following areas:

- warnings and forecasts for the High Seas;
- warnings and forecasts for coastal, offshore and local waters (including ports, lakes,harbour areas).

Operational guidance for handling and formatting meteorological information is given in detail in the Annex IV of the WMO Technical Regulations (Manual on Marine Meteorological Services – WMO-No. 558). The provision of warnings for weather systems that produce average wind speeds of 34 knots and greater are a mandatory requirement of the WWMIWS.

In relation to international marine requirements, the WWMIWS coordinates the broadcast of forecasts and warnings to vessels at sea through the Global Maritime Distress and Safety System (GMDSS), which includes SafetyNET satellite communications.

As part of the WWMIWS coordination, there are the following types of Centres:

Issuing service means a National Meteorological Service which has accepted responsibility for ensuring that meteorological warnings and forecasts for shipping are disseminated through the Inmarsat SafetyNET service to the designated area (METAREA) for which the Service has accepted responsibility under the WWMIWS.

Preparation service means a National Meteorological Service which has accepted responsibility for the preparation of warnings and forecasts for parts of or an entire designated area (METAREA) in the WMO system for the dissemination of meteorological forecasts and warning to shipping under the WWMIWS and for their transfer to the relevant Issuing Service for broadcast.

The METAREA Coordinator is responsible for ensuring that TC warnings for the WWMIWS in their METAREA are issued onto the appropriate GMDSS communication system.

Areas of responsibility (METAREAs) of the WWMIWS for the purpose of disseminating tropical storm warnings to vessels are given in **Fig.II-9**.

The cyclone warning centres broadcasting forecasts and warnings on coastal radio stations for the benefit of the ships 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**.



Fig. II-9: AREAS OF RESPONSIBILITY AND DESIGNATED NATIONAL METEOROLOGICAL SERVICES FOR THE ISSUE OF WARNINGS AND WEATHER AND SEA BULLETINS FOR THE WWMIWS

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**.

TABLE II- 3: 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 Malacca | HSA | Gulf of Thailand, west of southern Thailand, Strait of and South China Sea. |
| Qatar | | Arabian Gulf North of 26.5°N - AAA=AGN Arabian Gulf South of 26.5°N including the Strait of Hormuz - AAA=AGS(in association with Pakistan Met Department) |

Format and content of warnings for the WMMIWS

The format and content of warnings issued for the WMMIWS, as outlined below, has been derived from guidance provided in the Manual on Marine Meteorological Services (WMO No.558).

TC warnings for the WMMIWS shall use the following wind warning category labels:

- Gale force wind warning (Beaufort force 8 or 9);
- Storm-force wind warning (Beaufort force 10 or 11);
- Hurricane-force wind warning (Beaufort force 12 or over).

Any TC-related wind warning issued for the WMMIWS should include the following content (excluding any relevant system metadata requirements):

Tropical cyclone warnings for the high Seas contain the following informations:

- (a) Header label for marine radio broadcast purposes (“SECURITE”)

Note: This label needs to be visible on any product provided to mariners with the potential to be read out on marine radio systems.

- (b) Type of warning (GALE, STORM-FORCE, HURRICANE-FORCE WIND WARNING)
 (c) Name of the issuing centre
 (d) Name of the system and name of the basin
 (e) Date and time of reference in UTC
 (f) Type of disturbance (Tropical cyclone);
 (g) Location of disturbance (latitude and longitude)
 (h) Central pressure (hPa)
 (i) Intensity (maximum 10-minute average winds in knots)
 (j) Direction and speed of movement of the disturbance
 (k) Extent of affected area in nautical miles
 (l) Wind speed (knots) and direction in the affected areas
 (m) Sea and swell condition in affected areas (in qualitative terms)
 (n) Expected location and intensity at 12 and 24 hours time periods.
 (o) Indication of when next warning will be issued.

Example of GMDSS Bulletin is presented below:

GLOBAL MARITIME 222300
 DATE 22-06-2022 GMDSS BULLETIN-II 221800
 FROM:-MARINE FORECAST DIVISION, DGM, NEW DELHI
 TO: DGM (ISSD), NEW DELHI

 GMDSS BULLETIN FOR MET. AREA VIII (N), NORTH OF EQUATOR
 VALID FOR 24/48 HOURS FROM 1800 UTC 22 JUNE 2022.
 PART-I STORM WARNING NIL (.)
 PART-II SEASONAL WEATHER (.)
 A1-FORECAST FOR 24 HOURS
 ARB A1 ARABIAN SEA: EQUATOR TO 10 DEG. N AND W OF 80 DEG.E (.)
 I)WINDSPEED AND DIRECTION: 1)N OF 5 DEG N: SW/W-LY 15/25 KTS BEC NW/W-LY 15/20 KTS
 TO THE E OF 65 DEG E (.)
 2)S OF 5 DEG N TO W OF 72 DEG N : SW-LY 10/20 KTS BEC ANTI-CYCLONIC 05/10 KTS
 TO THE E OF 65 DEG E (.)
 3)REST AREA: S/SW-LY 05/15 KTS (.)
 II)WEATHER: 1)E OF 60 DEG E: FAIRLY WIDESPREAD RA/TS (.)
 2)REST AREA: FAIR (.)
 III)VISIBILITY: 1)E OF 60 DEG E: 4-3 NM (.)
 2)REST AREA: FAIR (.)
 IV)WAVE HEIGHT: 1)W OF 70 DEG E TO N OF 4 DEG N: 2.5-4.5 MTR (.)
 2)REST AREA: 2.0-2.5 MTR (.)
 A1-FORECAST FOR 48 HOURS
 ARB A1 ARABIAN SEA: EQUATOR TO 10 DEG. N AND W OF 80 DEG.E (.)
 I)WINDSPEED AND DIRECTION: 1)N OF 5 DEG N: SW-LY 15/25 KTS BEC NW/W-LY 15/20 KTS
 TO THE E OF 66 DEG E (.)

2)S OF 5 DEG N TO W OF 72 DEG N : SW/S-LY 10/20 KTS BEC ANTI-CYCLONIC 05/10 KTS TO THE E OF 64 DEG E (.)
 3)REST AREA: SW-LY 10/15 KTS (.)
 II)WEATHER: 1)E OF 61 DEG E: WIDESPREAD RA/TS (.)
 2)REST AREA FAIR (.)
 III)VISIBILITY: 1)E OF 61 DEG E: 3-2 NM (.)
 2)REST AREA 10-8 NM (.)
 IV)WAVE HEIGHT: 1)W OF 70 DEG E TO N OF 5 DEG N: 2.0-4.0 MTR (.)
 2)REST AREA: 2.0-2.5 MTR (.)
 ARB A2-ARABIAN SEA:-23 DEG 45 MIN N 68 DEG E TO 12 DEG N 63 DEG E TO CAPE GARDAFUI TO N OF 10 DEG N (.)
 A2-FORECAST FOR 24 HOURS
 I)WINDSPEED AND DIRECTION: 1)W OF 64 DEG E: SW-LY 15/30 KTS BEC S/SE-LY 10/15 KTS TO THE N OF 23 DEG N (.)
 2)E OF 62 DEG E TO 70 DEG E: W/NW-LY 10/20 KTS (.)
 3)REST AREA: W/SW-LY 15/20 KTS BEC CYCLONIC 05/10 KTS TO THE N OF 15 DEG N (.)
 II)WEATHER: 1)E OF 62 DEG E TO S OF 21 DEG N: WIDESPREAD RA/TS (.)
 2)REST AREA: FAIR (.)
 III)VISIBILITY: 1)E OF 62 DEG E TO S OF 21 DEG N: 3-2 NM (.)
 2)REST AREA: 10-8 NM (.)
 IV)WAVE HEIGHT: 2.5-4.5 MTR (.)
 A2-FORCAST FOR 48 HOURS
 I)WINDSPEED AND DIRECTION: 1)W OF 70 DEG E: SW/W-LY 10/25 KTS BEC W/NW-LY 10/20 KTS TO THE E OF 65 DEG E (.)
 2)REST AREA: W/SW-LY 15/20 KTS BEC CYCLONIC 05/10 KTS TO THE N OF 14 DEG N (.)
 II)WEATHER: 1)E OF 61 DEG E TO S OF 21 DEG N: WIDESPREAD RA/TS (.)
 2)REST AREA: FAIR (.)
 III)VISIBILITY: 1)E OF 61 DEG E TO S OF 21 DEG N: 3-2 NM (.)
 2)REST AREA: 10-8 NM (.)
 IV)WAVE HEIGHT: 2.5-4.5 MTR (.)
 BOB A3-BAY OF BENGAL: EQUATOR TO 10 DEG N BETWEEN E OF 80 DEG E AND WEST OF 10 DEG N/98 DEG 30 MIN E TO 6 DEG N/95 DEG E AND THENCE S-WARDS TO EQUATOR (.)
 A3-FORECAST FOR 24 HOURS
 I)WINDSPEED AND DIRECTION: 1)W OF 90 DEG E: SW-LY 10/15 KTS (.)
 2)REST AREA: SW/W-LY 10/15 KTS BEC ANTI-CYCLONIC 05/10 KTS TO THE S OF 5 DEG N (.)
 II)WEATHER: FAIRLY WIDESPREAD RA/TS (.)
 III)VISIBILITY: 4-3 NM (.)
 IV)WAVE HEIGHT: 1.5-2.5 MTR (.)
 A3-FORECAST FOR 48 HOURS
 I)WINDSPEED AND DIRECTION: 1)W OF 80 DEG E: SW-LY 10/20 KTS (.)
 2)REST AREA: SW/W-LY 10/15 KTS BEC CYCLONIC 05/10 KTS TO THE S OF 5 DEG N (.)
 II)WEATHER: SCATTERED RA/TS (.)
 III)VISIBILITY: 6-4 NM (.)
 IV)WAVE HEIGHT: 1.5-2.5 MTR (.)
 BOB: A4: BAY OF BENGAL N OF 10 DEG N AND E OF 80 DEG E (.)
 A4-FORECAST FOR 24 HOURS
 I)WINDSPEED AND DIRECTION: SW-LY 10/20 KTS (.)
 II)WEATHER: WIDESPREAD RA/TS (.)
 III)VISIBILITY: 3-2 NM (.)
 IV)WAVE HEIGHT: 1.0-2.5 MTR (.)
 A4-FORECAST FOR 48 HOURS
 I)WINDSPEED AND DIRECTION: SW-LY 15/20 KTS BEC W/NW-LY 05/10 KTS TO THE E OF 94 DEG E (.)
 II)WEATHER: WIDESPREAD RA/TS (.)
 III)VISIBILITY: 3-2 NM (.)
 IV)WAVE HEIGHT: 1.0-2.5 MTR (.)

=====

TOO:-22/2300

2.4.8 **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 T1T2 = 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 OPMET 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 hourly 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
TCAC: NEW DELHI
DTG: 20220510/0600Z
TC: ASANI
NR: 12
PSN: N1500 E08230
MOV: NW06KT
INTST CHANGE: NC
C: 989HPA
MAX WIND: 55KT
FCST PSN+06HR: 10/1200Z N1524 E08206
FCST MAX WIND +06HRS: 55 KT
FCST PSN+12HR: 10/1800Z N1548 E08154
FCST MAX WIND +12HRS: 50 KT
FCST PSN+18HR: 11/0000Z N1612 E08154
FCST MAX WIND +18HRS: 45 KT
FCST PSN+24HR: 11/0600Z N1642 E08218
FCST MAX WIND +24HRS: 40 KT
RMK: NIL
NEXT MSG: 100522/1500Z
TOO: 101534HRS IST
```

(**)Change in intensity at the time of observation hours. Reported as "INTSF" (intensifying), "WKN" (weakening) and "NC" (no change). (his practice has been introduced in November, 2020)

(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-10.

TCAC GRAPHIC BULLETIN BASED ON 0600 UTC OF 10th MAY, 2022 IN ASSOCIATION WITH SEVERE CYCLONIC STORM 'ASANI' OVER WESTCENTRAL BAY OF BENGAL

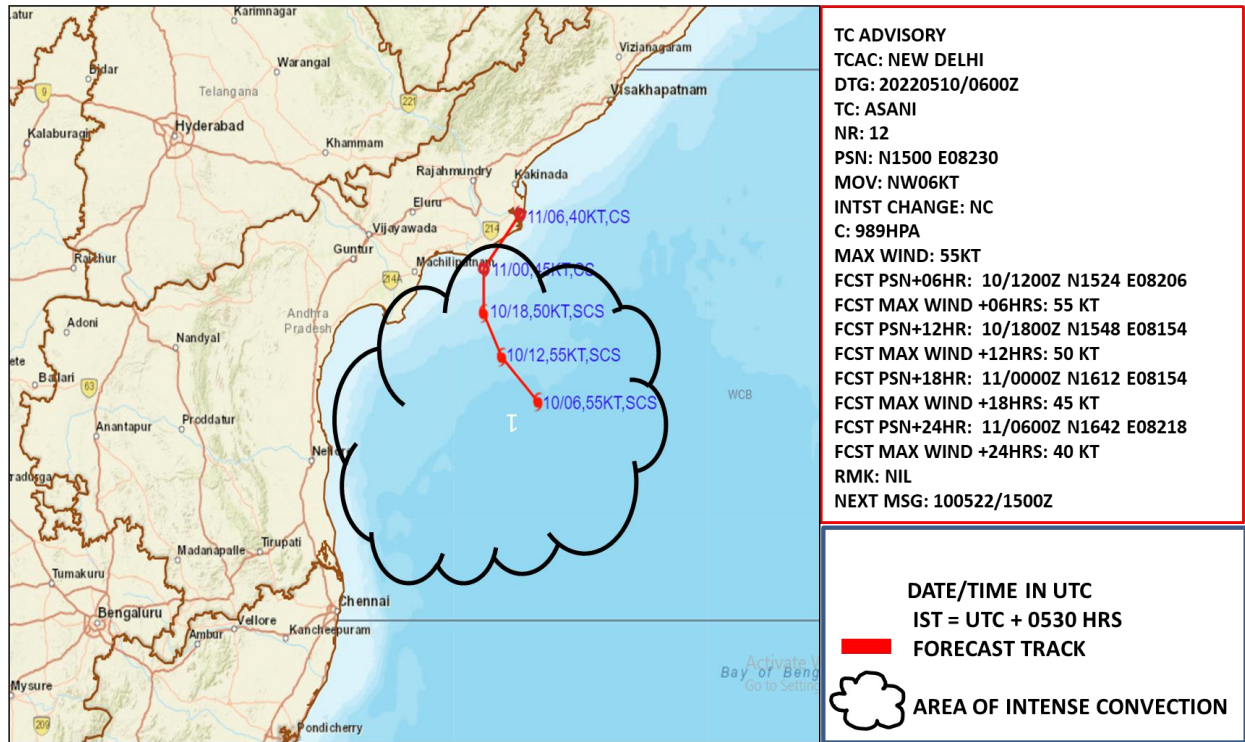


Fig II-9: Typical graphical TCAC bulletin during SCS ASANI

(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 coded format. Typical example is presented below:

Example:

```
0001
ASANI
202205070600 09.4 091.3 025 O
202205071200 10.3 090.2 030 O
202205071800 10.8 089.7 030 O
202205080000 11.2 089.3 035 O
202205080600 11.6 088.7 045 O
202205081200 12.2 088.2 050 O
202205081800 13.0 087.5 055 O
202205090000 13.7 086.3 055 O
202205090600 14.3 085.6 055 O
202205091200 14.5 085.0 055 O
202205091800 14.7 084.5 055 O
202205100000 14.8 084.0 055 O
202205100600 15.0 082.5 055 O
202205101200 15.4 082.1 055 F
202205101800 15.8 081.9 050 F
202205110000 16.2 081.9 045 F
202205110600 16.7 082.3 040 F
```

2.4.9 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.

2.4.10 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. The textual message is given in bulletin.

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 depression and based on 00, 06, 12 and 18 UTC. These are also sent by e-mail to the Panel member countries.

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 hours 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 00, 06, 12, 18, 24, 36, 48, 60, 72, 84, 96, 108, 120 hrs. Recently during 2019, it has been revised w.e.f. cyclone FANI based on the errors during 2014-18. There has been a reduction of 20-30% errors for various lead periods in 2019 as compared to the values during 2014 due to reduction in track forecast errors during 2014-18 as compared to that during 2009-13. Typical example of track with cone of uncertainty is presented Fig. II-11. 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.

| Lead time (hrs) | Standard error (nm) used for uncertainty forecast w.e.f. April, 2019 |
|-----------------|----------------------------------------------------------------------|
| 00 | 010 |
| 06 | 020 |
| 12 | 030 |
| 18 | 040 |
| 24 | 045 |
| 36 | 055 |
| 48 | 070 |
| 60 | 085 |
| 72 | 095 |
| 84 | 115 |
| 96 | 130 |
| 108 | 145 |
| 120 | 160 |

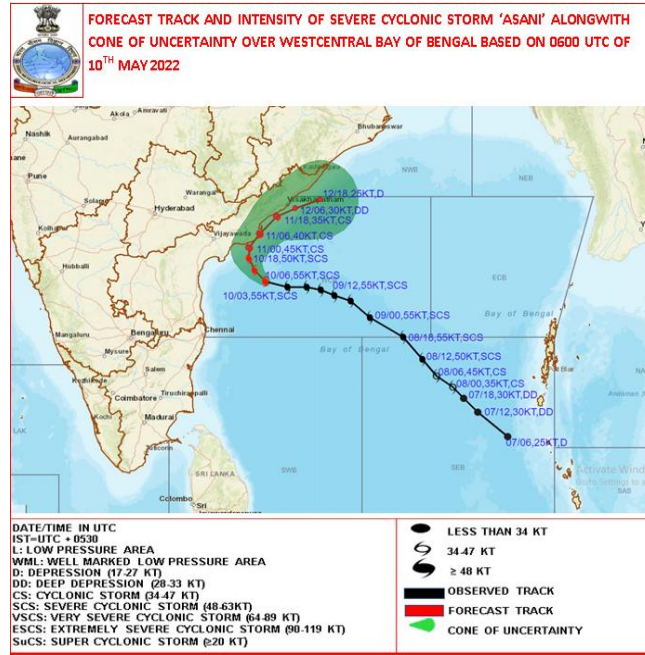


Fig.II-11 Observed and forecast track based on 0600 UTC of 10th in association with SCS ASANI

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 same interval of time. A typical graphical presentation of this forecast is shown in Fig.II-12. 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.

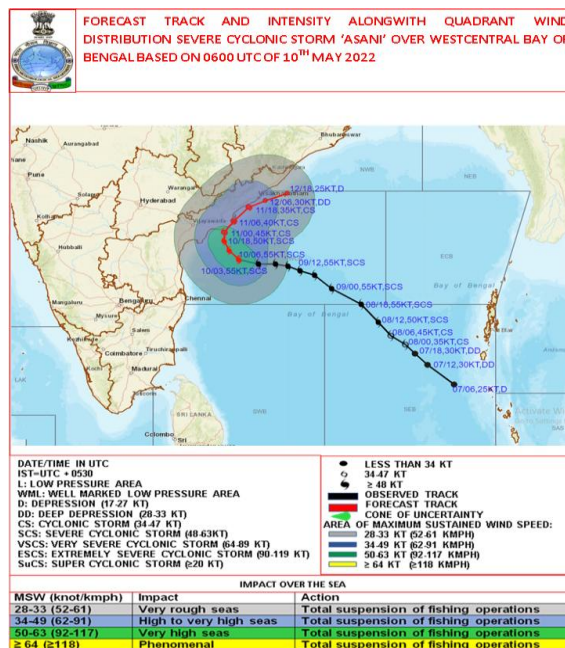


Fig.II-12: A typical example of observed track and forecast area of maximum sustained wind in association based on 0600 UTC of 10th in association with SCS ASANI

(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 vortex 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 ASANI OVER BAY OF BENGAL ON 0600 UTC OF 10-05-2022 FOR WHICH FORECAST IS PREPARED:

PRESENT DATE AND TIME: **100600**

PRESENT POSITION: **15°N/82.5°E**

POSITION ACCURATE TO 20 KM

PRESENT MOVEMENT (DDD/FF) PAST SIX HOURS: 278/15KT

PRESENT WIND DISTRIBUTION:

MAX SUSTAINED WINDS: 55 KT, GUSTS 65 KT

RADIUS OF MAXIMUM WIND **18 NM**

WINDS VARY IN EACH QUADRANT

RADII ARE LARGEST RADII EXPECTED ANYWHERE IN THE QUADRANT

WIND RADII VALID OVER OPEN WATER ONLY

RADIUS OF 027KT WINDS:

120 NM NORTHEAST QUADRANT

100 NM SOUTHEAST QUADRANT

120 NM SOUTHWEST QUADRANT

100 NM NORTHWEST QUADRANT

RADIUS OF 034KT WINDS:

70 NM NORTHEAST QUADRANT

70 NM SOUTHEAST QUADRANT

50 NM SOUTHWEST QUADRANT

50 NM NORTHWEST QUADRANT

RADIUS OF 050KT WINDS:

40 NM NORTHEAST QUADRANT

40 NM SOUTHEAST QUADRANT

30 NM SOUTHWEST QUADRANT

30 NM NORTHWEST QUADRANT

FORECASTS:

06 HRS, VALID AT:

101200Z 15.4°N/82.1°E

MAX SUSTAINED WINDS: 55 KT, GUSTS 65 KT

RADIUS OF 027KT WINDS:

120 NM NORTHEAST QUADRANT

100 NM SOUTHEAST QUADRANT

120 NM SOUTHWEST QUADRANT

100 NM NORTHWEST QUADRANT

RADIUS OF 034KT WINDS:

70 NM NORTHEAST QUADRANT

70 NM SOUTHEAST QUADRANT

50 NM SOUTHWEST QUADRANT

50 NM NORTHWEST QUADRANT

RADIUS OF 050KT WINDS:

40 NM NORTHEAST QUADRANT

40 NM SOUTHEAST QUADRANT

30 NM SOUTHWEST QUADRANT

30 NM NORTHWEST QUADRANT

12 HRS, VALID AT:

101800Z 15.8°N/81.9°E

MAX SUSTAINED WINDS: 50 KT, GUSTS 60 KT

RADIUS OF 027KT WINDS:

120 NM NORTHEAST QUADRANT
 100 NM SOUTHEAST QUADRANT
 120 NM SOUTHWEST QUADRANT
 100 NM NORTHWEST QUADRANT

RADIUS OF 034KT WINDS:

70 NM NORTHEAST QUADRANT
 70 NM SOUTHEAST QUADRANT
 50 NM SOUTHWEST QUADRANT
 50 NM NORTHWEST QUADRANT

RADIUS OF 050KT WINDS:

40 NM NORTHEAST QUADRANT
 40 NM SOUTHEAST QUADRANT
 30 NM SOUTHWEST QUADRANT
 30 NM NORTHWEST QUADRANT

18 HRS, VALID AT:

110000Z 16.2°N/81.9°E

MAX SUSTAINED WINDS: 45 KT, GUSTS 55 KT

RADIUS OF 027KT WINDS:

120 NM NORTHEAST QUADRANT
 100 NM SOUTHEAST QUADRANT
 120 NM SOUTHWEST QUADRANT
 100 NM NORTHWEST QUADRANT

RADIUS OF 034KT WINDS:

70 NM NORTHEAST QUADRANT
 70 NM SOUTHEAST QUADRANT
 50 NM SOUTHWEST QUADRANT
 50 NM NORTHWEST QUADRANT

24 HRS, VALID AT:

110600Z 16.7°N/82.3°E

MAX SUSTAINED WINDS: 40 KT, GUSTS 50 KT

RADIUS OF 027KT WINDS:

120 NM NORTHEAST QUADRANT
 100 NM SOUTHEAST QUADRANT
 120 NM SOUTHWEST QUADRANT
 100 NM NORTHWEST QUADRANT

RADIUS OF 034KT WINDS:

70 NM NORTHEAST QUADRANT
 70 NM SOUTHEAST QUADRANT
 50 NM SOUTHWEST QUADRANT
 50 NM NORTHWEST QUADRANT

36 HRS, VALID AT:

111800Z 17.3°N/82.9°E

MAX SUSTAINED WINDS: 35 KT, GUSTS 45 KT

RADIUS OF 027KT WINDS:

120 NM NORTHEAST QUADRANT
 100 NM SOUTHEAST QUADRANT
 120 NM SOUTHWEST QUADRANT
 100 NM NORTHWEST QUADRANT

RADIUS OF 034KT WINDS:

70 NM NORTHEAST QUADRANT
 70 NM SOUTHEAST QUADRANT
 50 NM SOUTHWEST QUADRANT
 50 NM NORTHWEST QUADRANT

48 HRS, VALID AT:

120600Z 17.6°N/83.6°E

MAX SUSTAINED WINDS: 30 KT, GUSTS 40 KT

RADIUS OF 027KT WINDS:

120 NM NORTHEAST QUADRANT
 100 NM SOUTHEAST QUADRANT
 120 NM SOUTHWEST QUADRANT
 100 NM NORTHWEST QUADRANT

60 HRS, VALID AT:

121800Z 17.9°N/84.5°E

MAX SUSTAINED WINDS: 25 KT, GUSTS 35 KT

2.5.3 TC Vital:

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

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) | 01B |
| character*9 tcv_storm_name | Storm name | ASANI |
| integer tcv_century | 2-digit century id (19 or 20) | 20 |
| integer tcv_yymmdd | Date of observation | 220510 |
| integer tcv_hhmm | Time of observation (UTC) | 0600 |
| integer tcv_lat | Storm Lat (X10), always >0 | 150 (for 15.0 ⁰ latitude) |
| character*1 tcv_latns | 'N' or 'S' | N |
| integer tcv_lon | Storm Lon (*10), always >0 | 0825 (for 82.5 ⁰ longitude) |
| character*1 tcv_lonew | 'E' or 'W' | E |
| integer tcv_stdirdir | Storm motion vector (in degree) | 278 (Past six hours) (westwards) |
| integer tcv_stspd | Speed of storm movement (m/sX10) | 042 (Past six hours Reported in 3 digits) (4.2 mps or 8 knots) |
| integer tcv_pcen | Min central pressure (mb) | 0989 (Reported in 4 digits) |
| integer tcv_penv | outermost closed isobar(mb) | 1006 (Reported in 4 digits) |
| integer tcv_penvrads | rad outermost closed isobar(km) | 0350 (Reported in 4 digits) (350 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) | 035 (Reported in 4 digits) (half of average of radius of MSW) |
| integer tcv_r15ne | NE rad of 34 knots winds (km) | 0130 (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) | 0093 (Reported in 4 digits) |
| integer | tcv_r15nw | NW rad of 34 knots winds (km) | 0093 (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 | D |

Example:

IMD 03B ASANI 20220510 0600 150N 0825E 278 042 0989 1006 0350 028 035 0130 0130
0093 0093 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 31km/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) |
| | Very Severe cyclonic storm | 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 |
| | Tropical cyclone : | |
| | Category 1 | 64-82 knots |
| | Category 2 | 83-95 knots |
| | Category 3 | 96- 112 knots |
| | Category 4 | 113-136 knots |
| | Category 5 | More than 136 knots |
| 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 |

| | | |
|--------------------------------------------------|------------------------------------|----------------------------------------|
| Qatar | Depression | less than 34 knots |
| | Tropical storm | 34-63 knots |
| | Tropical cyclone | 64 knots or more |
| | Tropical cyclone : | |
| | Category 1 | 64-82 knots |
| | Category 2 | 83-95 knots |
| | Category 3 | 96- 112 knots |
| Sri Lanka | Category 4 | 113-136 knots |
| | Category 5 | More than 136 knots |
| | Low pressure area | Less than 17 knots (31 km/h) |
| | Depression | 17- 27 knots (31 and 49 km/h) |
| | Deep Depression | 28- 33 knots (50 and 61 km/h) |
| | Cyclonic storm | 34 -47 knots (62 and 88 km/h) |
| | Severe cyclonic storm | 48- 63 knots (89 and 117 km/h) |
| Thailand | Very severe cyclonic storm | 64 -119 knots (118 and 166 km/h) |
| | Extremely severe cyclonic storm | 90 -119 knots (167 and 221 km/h) |
| | Super cyclonic storm | 120 knots and above (\geq 222 km/h) |
| | Tropical depression | 27 - 33 knots |
| | Tropical Cyclones | 34 knots and more |
| UAE | Tropical Depression | <63 kmph |
| | Tropical Storm | 63-118 kmph |
| | Tropical Cyclone CAT(1) | 119-153 kmph |
| | Tropical Cyclone CAT(2) | 154-177 kmph |
| | Tropical Cyclone CAT(3) | 178-208 kmph |
| | Tropical Cyclone CAT(4) | 209-251 kmph |
| | Tropical Cyclone CAT(5) | >251 kmph |
| 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 WMONo.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 | Wind speed uncertain |
| | Unknown intensity | |

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, E-24, 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 Disaster Management and Relief (MoDMR)
- (iv) All Ministries
- (v) The Sea Port Authorities at Chittagong, Mongla, Payra 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 Port Authorities
- (ix) Airport Authorities
- (x) Concerned Government Officials
- (xi) The general public (through Betar (Radio) Television, print and electronic media & 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 like cyclone, monsoon low, monsoon depression, synoptic forcing 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 Administrative Districts or sub-districts (Upazila) as far as possible.
- (viii) Approximate time of commencement of gale winds (speed more than 51 km/ h).
- (ix) Storm surge height in feet 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. India is an Issuing Service for METAREA VII(N) of the WWMIWS, and is responsible for broadcasting the products on SafetyNET to mariners at sea.

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 telephone, fax, e-mail & website. 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 or as frequent as require a day. "Warnings" are broadcast every hour and "Danger" and "Great Danger" messages are broadcast more frequently.

Dissemination of tropical cyclone warnings

- (i) Fax
- (ii) Telephones
- (iii) Automatic Message Switching System (AMSS)
- (iv) Bangladesh Betar (Radio)
- (v) Television
- (vi) Through print & electronic media
- (vii) Wireless Transmission (W/T)
- (viii) Internet, by keeping information on BMD website (<http://www.bmd.gov.bd>).
- (IX) Mobile App (BMD Weather App)
- (X) IVR (Interactive Voice Response)
- (XI) E-mail
- (XII) Social Media (Facebook)
- (XIII) SMS

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 four Cyclone Warning Centres at Bhubaneswar, Visakhapatnam, Ahmedabad and Thiruvananthapuram. The entire cyclone warning work is coordinated by the Cyclone Warning Division at Headquarter.

Tracking of tropical cyclones

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

- (i) 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 3DR) 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-C-2

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.- II-C-1).

India is an Issuing Service for METAREA VII (N) of the WWMIWS, and is responsible for broadcasting the products on SafetyNET to mariners at Sea. 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 are broadcast from Mumbai Radio. For the Bay of Bengal the bulletins are broadcast from Kolkata and Chennai Radio and issued by the Area Cyclone Warning Centre at Kolkata.

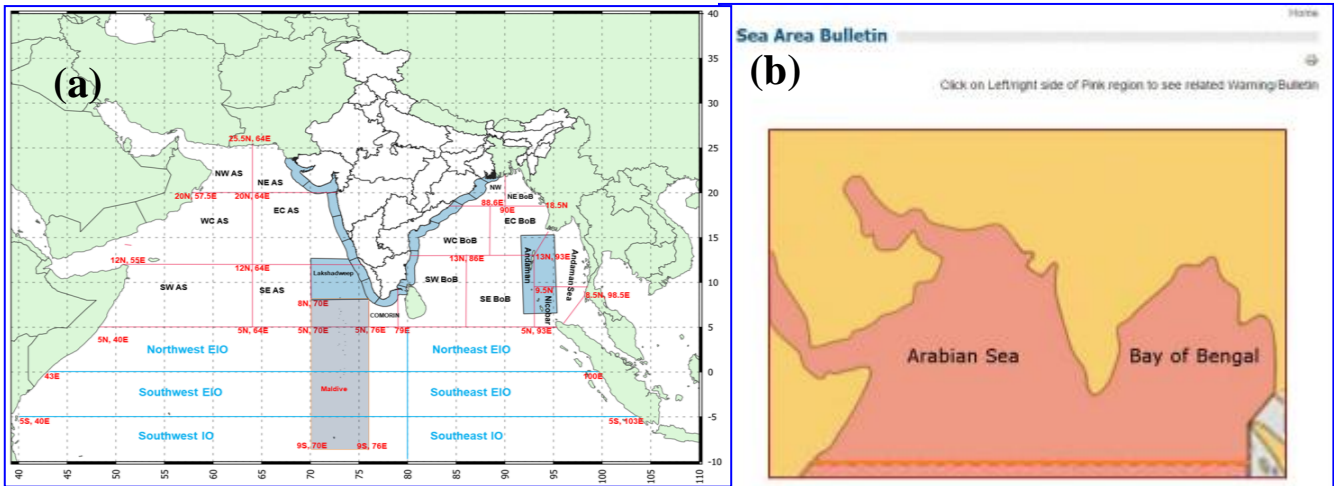



Fig II-C-1. (a): The exact area of responsibility of RSMC New Delhi and (b) areal coverage as indicated on RSMC website for sea area bulletin

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. Sample bulletin is presented in Fig. II-C-2.



प्रादेशिक मीसम केंद्र, कोलाबा, मुंबई
Regional Meteorological Centre, Mumbai
SEA AREA BULLETIN

AURORA OBSERVATIONS
Sea Area forecast valid for 12 hours starting from 0900 UTC of 10/05/2022

Part One:
TTT Warning: NIL

Part Two:
Synoptic Situation: Weather seasonal over Arabian Sea.

Part Three:
North East Arabian Sea :
Wind: SouthWesterly to Westerly 15 to 20 knots gusting to 25 knots .
Weather: Fair.
Visibility: Good.
Sea Condition: Moderate.

East Central Arabian Sea :
Wind: Westerly to Northwesterly 15 to 20 knots gusting to 25 knots .
Weather: Isolated rain or thundershowers.
Visibility: Good except in rain or thundershower.
Sea Condition: Moderate.

West Central Arabian Sea: North of lat 18 deg N
Wind: Southwesterly to Westerly 15 to 20 knots gusting to 25 knots .
Weather: Fair.
Visibility: Good.
Sea Condition: Slight to Moderate.

West Central Arabian Sea: South of lat 18 deg N
Wind: Mainly Westerly 10 to 15 knots gusting to 20 knots .
Weather: Fair.
Visibility: Good.
Sea Condition: Slight to Moderate.

South East Arabian Sea:
Wind: Mainly Northwesterly 15 to 20 knots Gusting to 25 knots.
Weather: Scattered rain or thundershowers.
Visibility: Good becoming poor in rain or thundershower.
Sea Condition: Moderate to Rough.

South West Arabian Sea :
Wind: Westerly to Northwesterly 10 to 15 knots gusting to 20 knots .
Weather: Scattered rain or thundershowers.
Visibility: Good becoming poor in rain or thundershower.
Sea Condition: Slight to Moderate.

GMDSS Area :

| | |
|---------------|----------------------------------------------------------------|
| Wind | Southwesterly to Westerly 10 to 15 knots gusting to 20 knots . |
| Weather | Isolated rain or thundershowers. |
| Visibility | Good except in rain or thundershower. |
| Sea Condition | Moderate. |

PART FOUR: Nil.

PART FIVE: Nil.

| | | | | | | |
|-----------------|-------|-------|-------|-------|-------|-------|
| PART SIX | 01003 | 99942 | 339 | 31995 | 02701 | 10326 |
| | 40037 | 539 | 32996 | 00000 | 1030 | 40039 |
| | 32996 | 02303 | 10290 | 40050 | 731 | 32596 |
| | 10292 | 40050 | 754 | 31596 | 43403 | 10328 |
| | 838 | 31596 | 23203 | 10330 | 40051 | 840 |
| | 31102 | 10320 | 40049 | 909 | 32596 | 42703 |
| | 40051 | 933 | 32996 | 00000 | 10360 | 40013 |
| | 99943 | 057 | 31595 | 72902 | 10302 | 40054 |
| | 32597 | 73608 | 10292 | 40074 | 110 | 32496 |
| | 10294 | 40063 | 117 | 32997 | 23602 | 10314 |
| | 192 | 31996 | 03204 | 10304 | 40055 | 226 |
| | 72703 | 10300 | 40020 | 284 | 22496 | 82908 |
| | 40058 | 311 | 32597 | 83210 | 10304 | 40066 |
| | 21496 | 80000 | 10252 | 40069 | 371 | 22496 |
| | 10268 | 40070 | | | | 83202 |
| PPAA | 60001 | 43285 | 44385 | 31517 | 33514 | 35510 |

Fig. II-C-2: Sample Sea Area bulletin for Arabian Sea at 0900UTC of 10th May 2022

RSMC New Delhi has commenced preparation of these bulletins in graphical format using QGIS tool and are also available over GIS platform since January, 2021 based on multi model ensemble guidance. Sample graphical products on QGIS are placed at Fig. II-C--3.

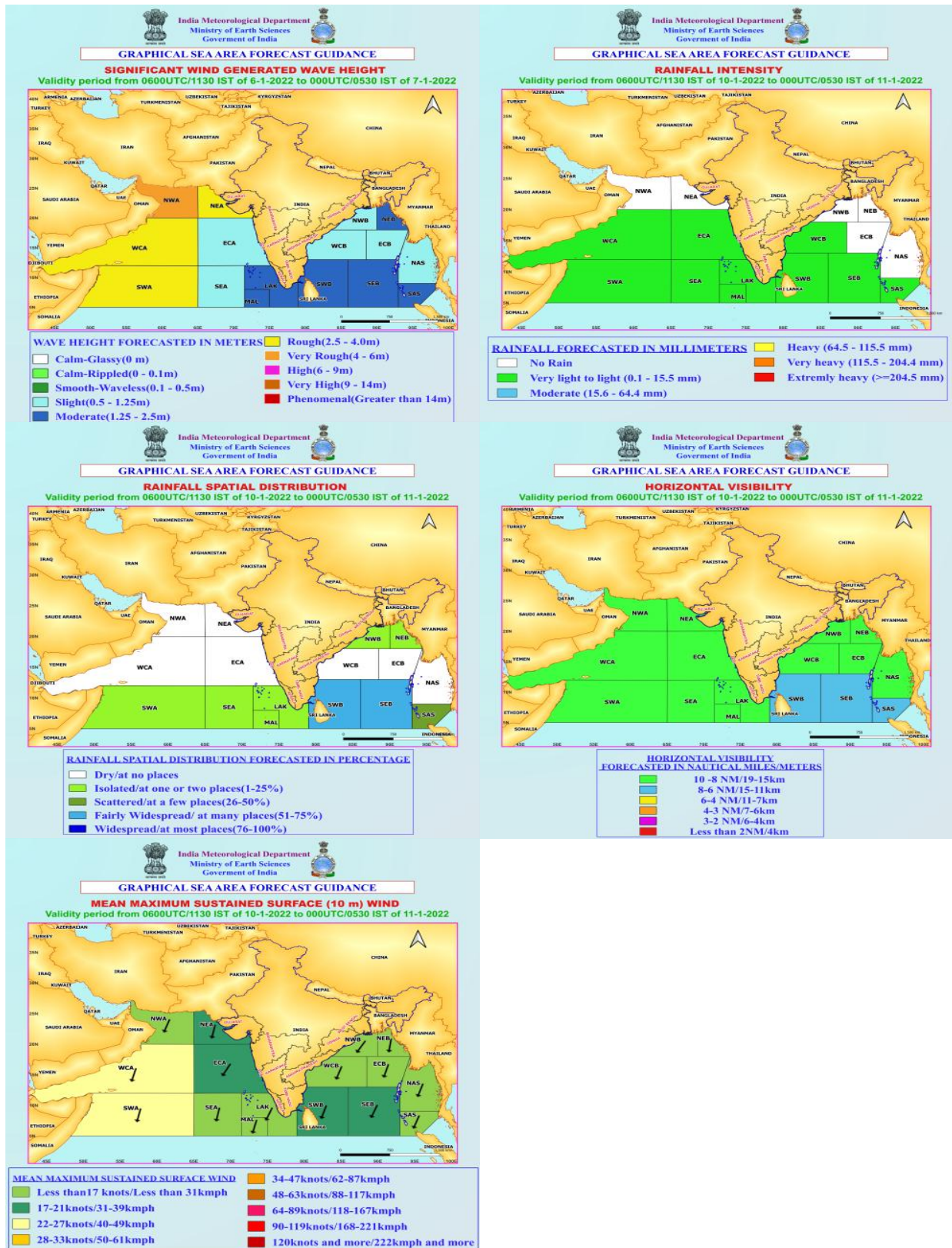


Fig. II-C-3: Sample Sea Area bulletin on QGIS based on multi model ensemble guidance

ANNEX II-C-2

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). Areal coverage for coastal weather bulletin is shown in Fig. II C-4. Sample bulletin is placed at Fig. II-C-5.

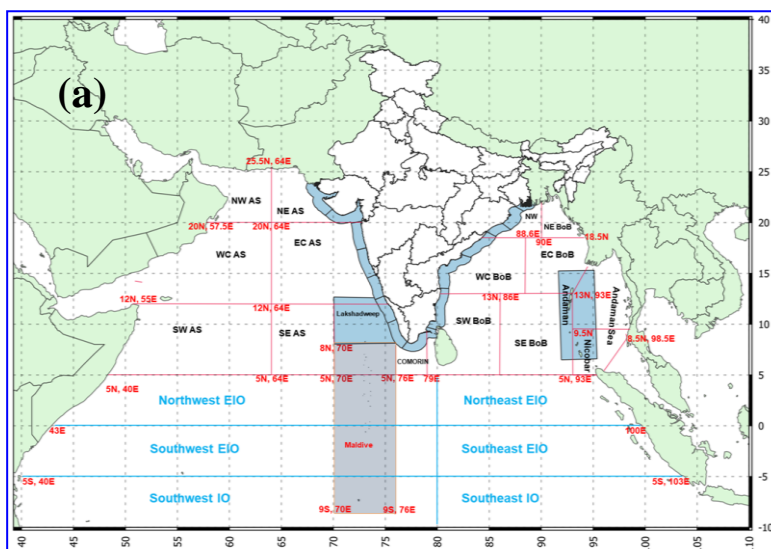


Fig. II-C-4: Sample areal coverage for coastal Weather bulletin along the coast of India



Print

India Meteorological Department/ भारत मौसम विज्ञान विभाग

CWC VISAKHAPATANAM PORT / सी .डबब्लू .सी विशाखापत्तनम पोर्ट

Coastal Weather Bulletin

Storm One Bulletin Valid for 12 hrs from 06 UTC of 2022-05-10 to 18 UTC of 2022-05-10

| | |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synoptic Situation | THE SEVERE CYCLONIC STORM 'ASANI' (PRONOUNCED AS ASANI) OVER WESTCENTRAL AND ADJOINING SOUTHWEST BAY OF BENGAL MOVED WEST NORTHWESTWARDS WITH A SPEED OF 05 KMPH DURING PAST 06 HOURS AND LAY CENTERED AT 0000 HOURS UTC OF TODAY, THE 10TH MAY, OVER WESTCENTRAL BAY OF BENGAL NEAR LATITUDE 14.8°N AND LONGITUDE 84.0°E, 300 KM SOUTHEAST OF KAKINADA (ANDHRA PRADESH), 330 SOUTH-SOUTHEAST OF VISAKHAPATNAM (ANDHRA PRADESH), 510 KM SOUTH-SOUTHWEST OF GOPALPUR (ODISHA) AND 590 KM SOUTH-SOUTHWEST OF PURI (ODISHA). IT IS VERY LIKELY TO MOVE NEARLY NORTHWESTWARDS TILL 10THMAY NIGHT AND REACH WESTCENTRAL BAY OF BENGAL OFF NORTH ANDHRA PRADESH COAST. THEREAFTER, IT IS VERY LIKELY TO RECURVE NORTHNORTHEASTWARDS AND MOVE TOWARDS NORTHWEST BAY OF BENGAL OFF NORTH ANDHRA PRADESH AND ODISHA COASTS. IT IS LIKELY TO WEAKEN GRADUALLY INTO A CYCLONIC STORM DURING NEXT 24HOURS. |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

North Andhra coast

| | |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wind | MAINLY NORTHEASTERLY 25 TO 30 KNOTS, IN THUNDERSHOWERS 35 KNOTS. |
| Weather | SCATTERED RAIN OR THUNDERSHOWERS. |
| Visibility | MODERATE BECOMING POOR IN RAIN, VERY POOR IN THUNDERSHOWERS. |
| Sea Condition | ROUGH TO VERY ROUGH. |
| Port Signal | DISTANT WARNING SIGNAL NUMBER TWO (DW-II) KEPT HOISTED AT VISAKHAPATNAM PORT. DISTANT WARNING SIGNAL NUMBER TWO (DW-II) WITH SECTION SIGNAL NUMBERS- II & IV KEPT HOISTED AT KAKINADA AND GANGAVARAM PORTS. |

South Andhra coast

| | |
|---------------|-------------------------------------------------------------------------------------------------------------|
| Wind | MAINLY NORTHEASTERLY 25 TO 30 KNOTS, IN THUNDERSHOWERS 35 KNOTS. |
| Weather | ISOLATED RAIN OR THUNDERSHOWERS. |
| Visibility | MODERATE BECOMING POOR IN RAIN, VERY POOR IN THUNDERSHOWERS. |
| Sea Condition | ROUGH TO VERY ROUGH. |
| Port Signal | DISTANT WARNING SIGNAL NUMBER TWO (DW-II) KEPT HOISTED AT MACHILIPATNAM, NIZAMPATNAM & KRISHNAPATNAM PORTS. |

| | |
|---------------|-------------------------|
| Time of Issue | 11:56 IST of 2022-05-10 |
|---------------|-------------------------|

Fig. II-C-5: Sample Coastal Weather bulletin issued by ACWC Mumbai at 0600 UTC of 10th May 2022

RSMC New Delhi has commenced preparation of these bulletins in graphical format using QGIS tool and are also available over GIS platform since January, 2021 based on multi model ensemble guidance. Sample graphical products on QGIS are placed at Fig. II-C--6.

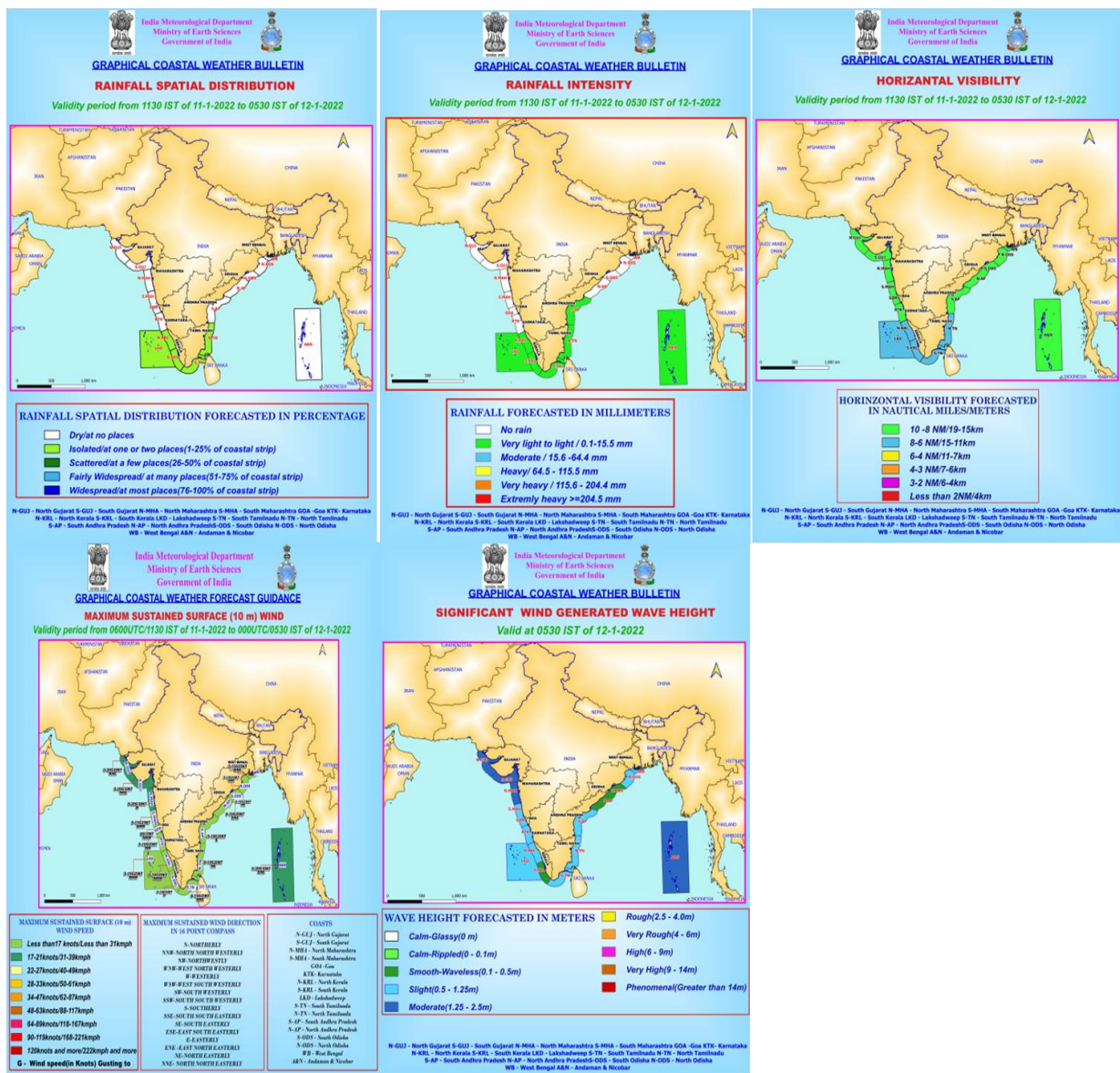


Fig. II-C-6: Sample Coastal area bulletin on QGIS based on multi model ensemble guidance

ANNEX II-C-3

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-7.

The meaning of the signals used in Indian ports is given in attachment to ANNEX II-C3

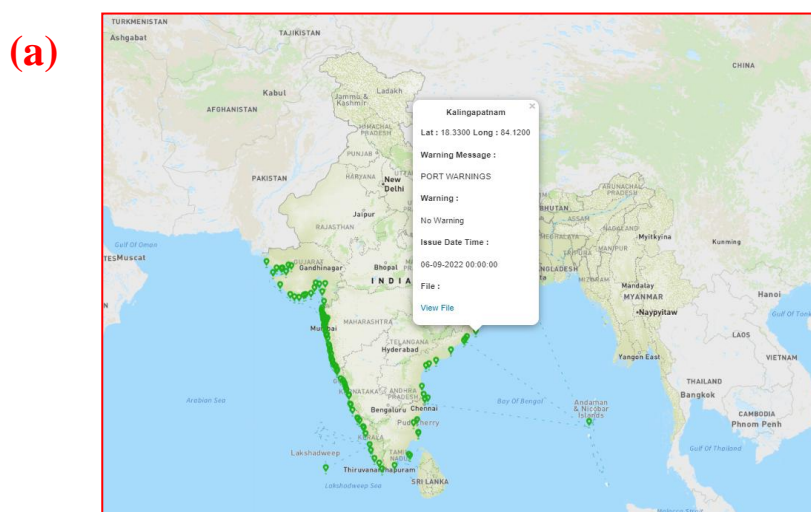


Fig. II-C-7(a): Sample Port Warning bulletin available at RSMC New Delhi website

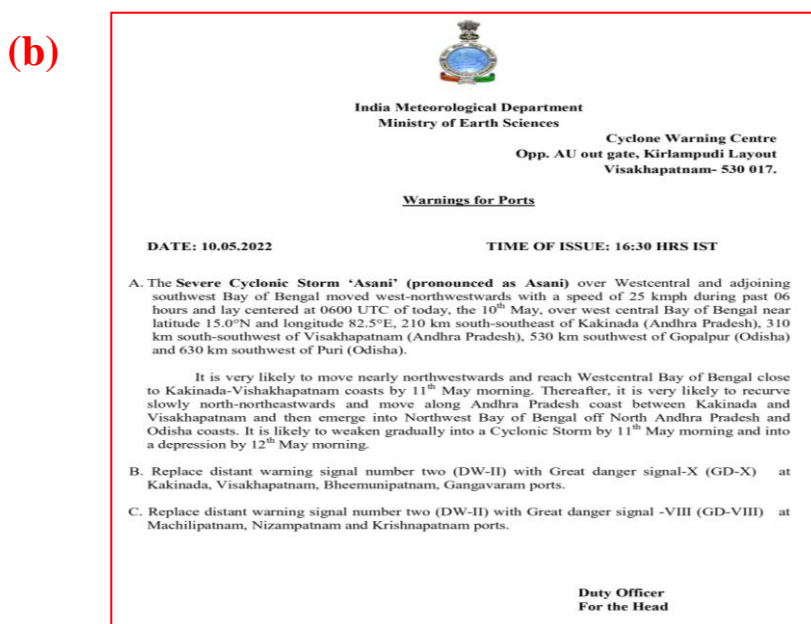


Fig. II-C-7(b): Sample Port Warning bulletin issued by CWC Visakhapatnam based on 0600 UTC of 10th May 2022 in association with SCS Asani

ANNEX II-C-4

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. Fishermen warnings in graphical form for next 5 days commenced w.e.f. April, 2018 and are available at RSMC website. RSMC New Delhi has commenced development of fishermen graphics on GIS platform based on multi model ensemble (MME) guidance alongwith probability of exceedance of maximum sustained winds speed (MSW) of 25 knots & more since 28th July, 2022. Sample areal coverage is presented in Fig. II-C-8. Fishermen warning graphics bulletin issued during cyclone Asani on 10th May is presented in Fig. II-C-9. Sample graphics showing fishermen warning area based on MME and graphics showing probability of exceedance of MSW \geq 25 knots is presented in Fig. II-C-10 and II-C-11.

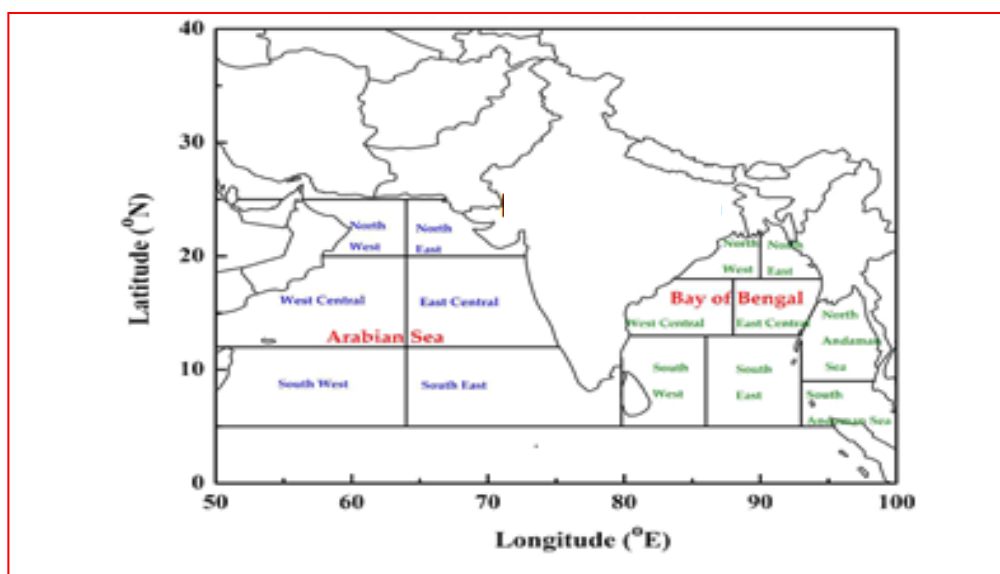


Fig.II-C-8: Areal coverage for fisherman warning

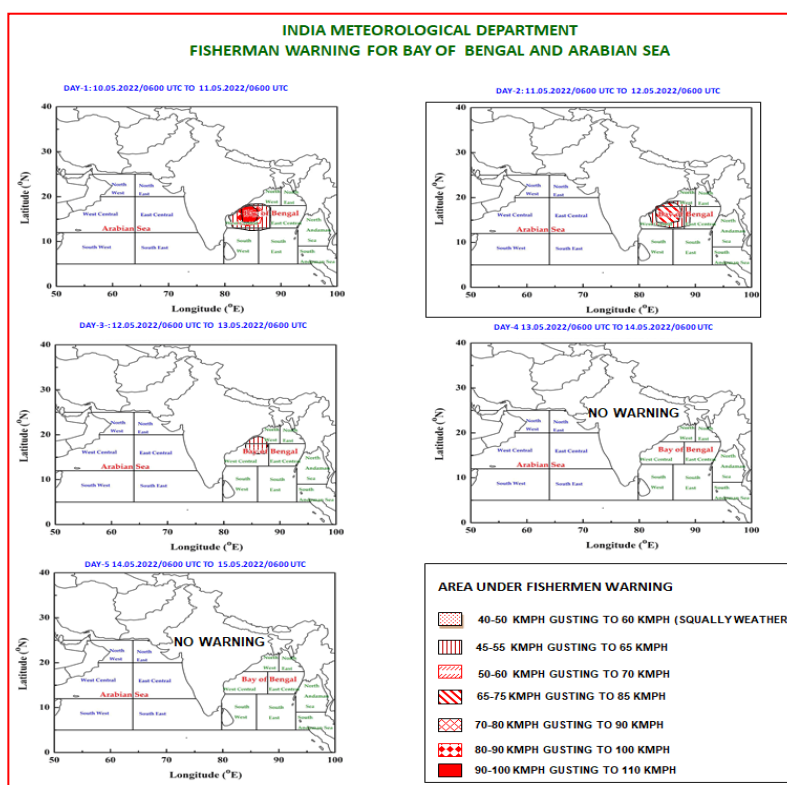


Fig.II-C-9: Fisherman Warning bulletin issued on 10th May in association with SCS Asani

Sample graphics showing fishermen warning area based on MME and graphics showing probability of exceedance of MSW \geq 25 knots is presented in Fig. II-C-10 and II-C-11.

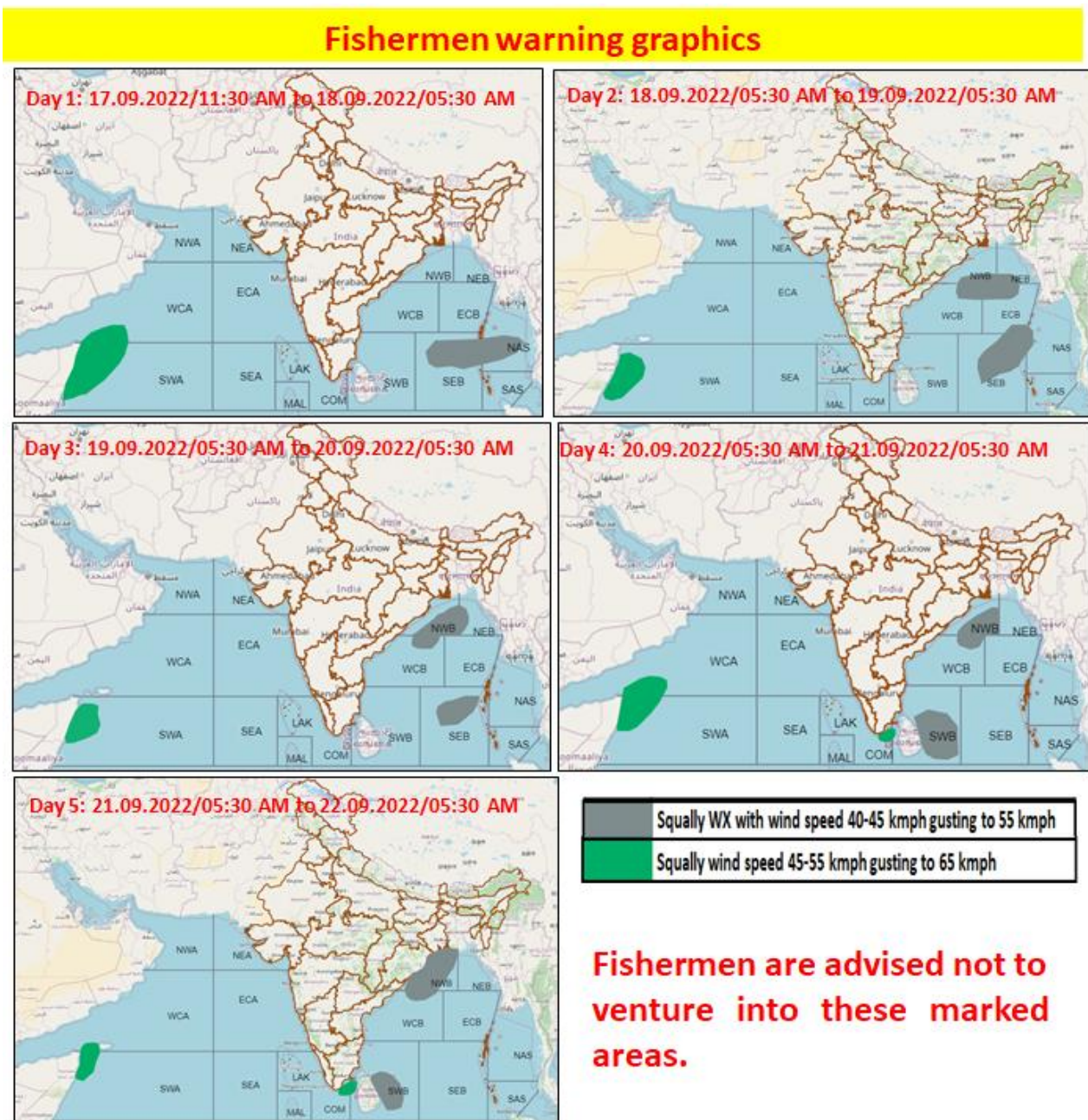


Fig.II-C-10:Sample graphics showing fishermen warning area based on MME

Probability of exceedance of maximum sustained winds ≥ 45 kmph

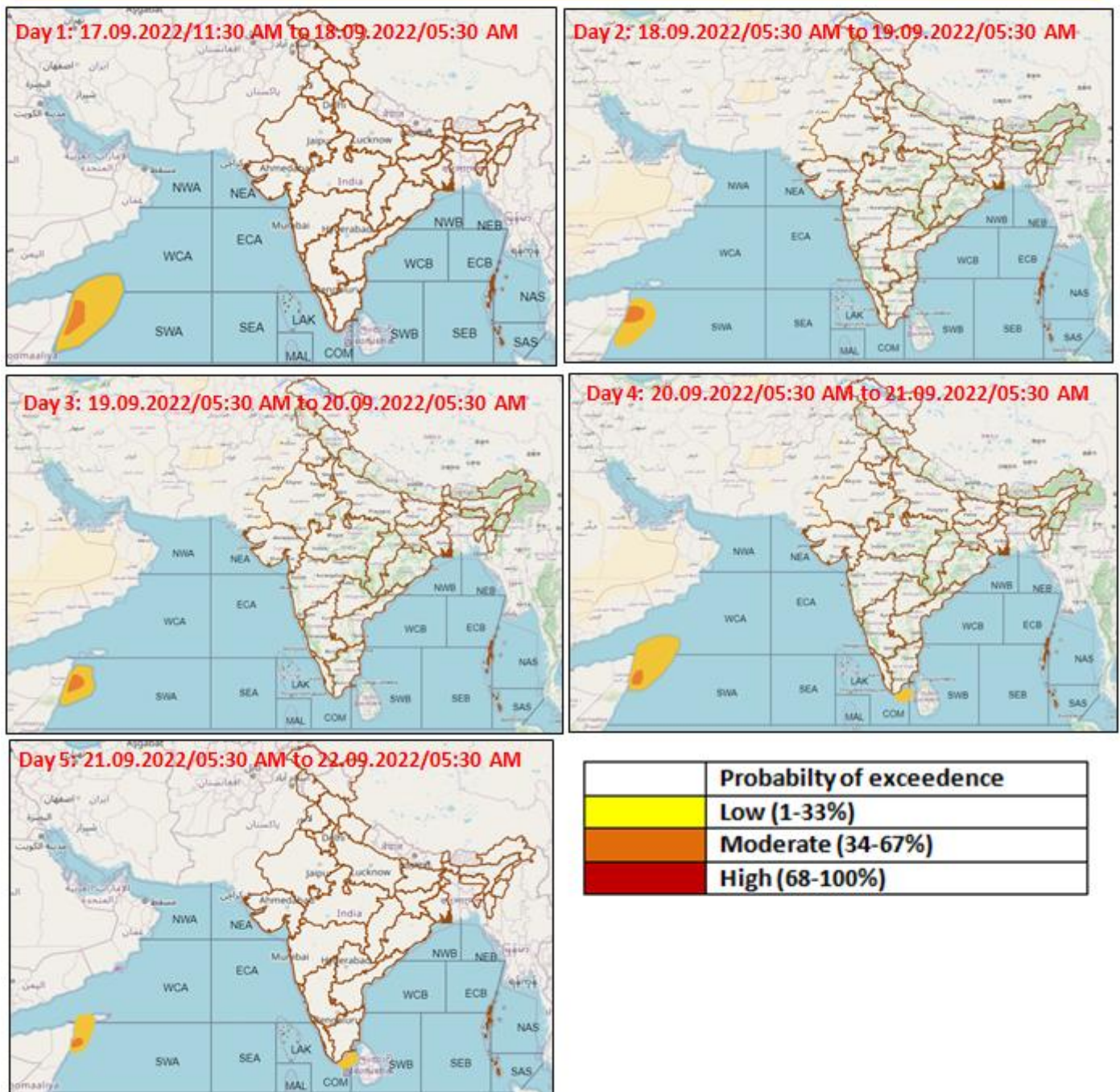


Fig.II-C-11:Sample graphics showing probability of exceedance of in areas having MSW \geq 25 knots

Tropical storm warnings to government officials (Four stage warnings)

At the initial stage a special “**Informatory Message**” is issued at low pressure area stage when it has the potential to intensify into a cyclonic storm at 0300 UTC or at any synoptic hour depending upon time of formation of low pressure system to all the disaster managers and press.

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.

However, this is not applicable in case of cyclonic disturbances developing near the coast and in case of rapidly intensifying systems. In such cases, the cyclone warning can be issued directly without issuing cyclone alert and watch bulletins and similarly cyclone watch can be issued directly without issuing pre-cyclone watch.

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.

ANNEX II-C-6

Table II-C.1: Damage Potential and Action Suggested

| Category/ T.No/ Wind Speed | Structur es | Commu nication & 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 / unsecur ed structur es | | Some breaches in Kutcha 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 Kutcha embankmen ts. | Minor | Fishermen advised not to venture into the open seas. |
| Cyclonic Storm T 2.5-T 3.0 62 – 87 kmph (34-47 knots) | Damag e to thatche d huts. | Minor damage to power and communica tion lines due to breaking of branches. | Major damage to Kutcha 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 inundation in low lying areas after erosion of Kutcha embankmen ts. | Minor to moderate. | Total suspension of fishing operations. |
| Severe Cyclonic Storm T 3.5 88-117 kmph (48-63 knots) | Major damage to thatche d houses/ huts. Roof tops may blow off. Unattac hed metal sheets may fly. | Minor damage to power and commu nication lines. | Major damage to Kutcha 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. | Phenomen al seas with wave height 9-14 m. Movement in motor boats unsafe. | Major damage to coastal crops. Storm surge upto 1.5 m (area specific) causing damage to embankmen ts/ salt pans. Inundation upto 5 km in specific areas. | Moderate | Total suspension of fishing operations. Coastal hutment dwellers to be moved to safer places. People in affected areas to remain indoors. |
| Very Severe Cyclonic Storm T 4.0- T 4.5 118-166 kmph (64-89 knots) | Total destruct ion of thatche d houses/ extensi ve damage to kutcha houses. Some damage to pucca houses. Potenti al threat from flying objects. | Bending/ uprooting of power and commu nication poles. | Major damage to Kutcha and Pucca roads. Flooding of escape routes. Minor disruption of railways, overhead powerline s and signalling systems. | Widespread damage to standing crops, plantations, orchards, falling of green coconuts and tearing of palm fronds. Blowing down of bushy trees like mango. | Phenomen al seas with wave height more than 14 m. Visibility severely affected. Movement in motor boats and small ships unsafe. | Storm surge upto 2 m. Inundation upto 10 km in specific areas. Small boats, country crafts may get detached from moorings. | Large | Total suspension of fishing operations. Mobilise evacuation from coastal areas. Judicious regulation of rail and road traffic. People in affected areas to remain indoors. |

| | | | | | | | | |
|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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 | Total suspension of fishing operations. Extensive evacuation from coastal areas. Diversion or suspension of rail and road traffic. People in affected areas to remain indoors. |
| 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 | Total suspension of fishing operations. Large-scale evacuation of coastal population. Total suspension of rail and road traffic in vulnerable areas. People in affected areas to remain indoors. |

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) W/T (especially police W/T)
- (x) Internet, by keeping information on IMD website (<http://www.mausam.gov.in>)/RSMC website(www.rsmcnewdelhi.imd.gov.in).
- (xi) Microwave link of the railways
- (xii) IVRS
- (xiii) e-mail
- (xiv) SMS and Mobile App.
- (xv) GMDSS
- (xvi) Warnings to fishermen in deep sea through through NavIC system*
- (xvii) NAVTEX for coastal weather bulletin
- (xviii) Social Media (Face Book, Whatsapp, Twitter, Instagram, Blog)
- (xix) Common Alert Protocol
- (xx) Application Programming Interface
- (xxi) Crowd sourcing (January, 2021)

CAP feeds are automatically aggregated to the WMO Alert Hub at <https://cap-sources.s3.amazonaws.com/in-imd-en/rss.xml>. These alerts are also disseminated to Google, AccuWeather, Global Multi-Hazard Alert System (GMAS) portal (<https://gmas.asia/>). IMD also participates as one of the alert generating agencies for the CAP alert projects of NDMA developed by CDOT.

* NavIC is the operational name of the Indian Regional Navigation Satellite System (IRNSS) developed by ISRO. Unlike GPS which is a Global tracking constellation, NavIC has been designed to focus especially on India and adjoining regions (1500 Kms around India) and is a very significant achievement for the country.

Application Programming Interface (API) has been developed for various products like heavy cyclones, rainfall, thunder storms, heat wave etc in 2021. It is used by various stake holders within the country and outside including Global Multi-hazard Alert System (GMAS) of WMO, Google, Apple etc. Stakeholders include Uttar Pradesh Government, Telangana Government, Kerala Government, Umang App, DD News, NDMA, Incredible India, KRC Network, NITI Aayog, Kerala State Disaster Management, Chandigarh Smart City Limited, Apple.com, Tomorrow.io, Uttarakhand Toursim, National Rice Research Institute Odisha, Madhya Pradesh Government, RMSI private limited, TV-9, CDAC etc.

India Meteorological Department launched its Crowd source web interface in January 2021 to allow users to make their own observations and share with service provider. This feature can be found in the "Public Observation" section of Mausam website of IMD (https://city.imd.gov.in/citywx/crowd/enter_th_datag.php). There is no need to register to send observations and the associated weather damages caused. User can report their observations (textual and .png format) along with their location and time of the events.

Rain, Thunder/lightning, Hailstorm, Duststorm, Fog, Snow, Gusty wind and the associated damage caused such as breaking of tree branches, uprooting of small/big trees, Telephone pole / Transmission tower damaged by bending, Telephone pole / Transmission tower uprooting, Damage to Kutcha structures (houses, cowsheds), Damage to Pukka structures (houses, shelters), Flooding of land, Damage/Death to livestock, Damage/Death to Humans, Damage to vegetation/crops. Member countries can also share observations in realtime through website for validation of forecast.

RSMC New Delhi commenced dissemination of warnings through whatsapp with member countries in March, 2022. Bulletins were shared with Department of Meteorology & Hydrology, Myanmar in march 2022.

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. Home page of RSMC website is presented in Fig. II-C-12

Fig.II-C-12: RSMC Website

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. These storm news and warnings include the 5 stage warnings viz. Yellow Stage, Orange Stage, Red Stage, Brown Stage and Green Stage during cyclone situations.

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 Phone, Single Side Band Transceiver (SSB), Email, Fax, SMS, GTS through RTHs and RSMC New Delhi. 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/www.dmh.gov.mm
7. Single Side Band Transceiver (SSB)
8. DMH Facebook

ANNEX II-E-2

***Tropical storm news and warnings for various sectors in Myanmar
(Five stage warnings)***

Yellow Color Stage

Yellow color means a storm is formed but it not moving towards Myanmar Coasts.

Orange color Emergency Stage

Orange color means storm is heading towards Myanmar Coasts.

Red color Emergency stage

Red color emergency stage mean the storm is heading towards Myanmar Coasts and cross within next (12) hours.

Brown color Emergency Stage

Brown color Emergency Stage means the storm is crossing Myanmar Coasts currently.

Green color Stage

Green color Stage means the storm abated and situation is clear by storm.

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 (DGMET) which falls under Public Authority for Civil Aviation in co-operation 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, upper air observations, weather radars, and satellite images from Eumetsat and NOAA. Images from Indian Satellites are being utilized via IMD website.

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 DGMET

Warning Procedures

Directorate General of Meteorology (DGMET) will issue tropical storm reports, advisories, warnings and amendments every 24 hours, 12 hours, 6 hours, or more frequently if required by changing conditions according to an internal SOP. 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 before 72 hours, a report will be issued and it will be renewed every other 48 hours.

Advisory

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

Alert

When it is expected that a depression, storm, severe storm or cyclone May approach Oman coast within 48 hours an alert will be issued and it will be renewed every other 12 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 6 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.

Pakistan is an Issuing Service for METAREA IX of the WWMIWS, and is responsible for broadcasting the products on SafetyNET to mariners at sea.

Warnings for Ports

Directorate General of Meteorology (DGMET) 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

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.

Pakistan is an Issuing Service for METAREA IX of the WWMIWS, and is responsible for broadcasting the products on SafetyNET to mariners at sea.

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.

When the cyclone is located in the Colombo Flight Information Region, SIGMET/AIRMERT provided by Aviation Meteorological Watch Office, Bandaranaike International Airport Katunayake.

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 less than 600 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 with validity period of 48 to 72 hours and wherever imperative.




(ii) When the cyclonic storm is less than 500 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 six (6) hours with validity period of 36 to 48 hours and wherever imperative.

(iii) When the cyclonic storm is less than 300 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, landfall time, storm surges and areas likely to be inundated with validity period of 18 hours.

Four colour code with flags are used for easy and quick understanding

| Signal No. | Colour | Description | Action required |
|------------|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | White  Information | Potential area of possibility to development of vortex /disturbance / Cyclone has formed | Information only, Vessels at sea to be vigilant and avoid the area, Listen to media |
| 2 | Amber  Alert | Cyclone has formed in the vicinity, Heavy rain and strong wind, rough sea (30-40kts, 50-80kmph) | Stay away from beach/sea, vessels in danger/be inside building |
| 3 | Amber  Alert | Cyclone has formed in the vicinity, very heavy rain with very strong winds, very rough seas (Winds > 40kts, 80kmph) | Be ready to leave buildings with weak structures (in relevant areas only) and low lying (flood prone) areas, secure your home/valuables. |
| 4 | Red | Heavy rain with very strong wind >40 kts, cyclone expected to cross land | Evacuate to pre-designated safe places |

| | | | |
|---|-----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|--|
| |  Warning | Cyclone is expected to cross land, Very heavy rain/very strong winds (v>50kts,100kmph) | |
| 5 | Green  Threat over | Cyclone warning cancellation/withdrawal bulletin | |

(b). Intensity Criterion (Signal levels)

(i) When the cyclonic storm is less than 300 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, landfall time, storm surges and areas likely to be inundated with validity period of 18 hours.

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, National Building Research organization, Minstry of Health, Highways etc.

Specific users

- Coastal fishing
- Shipping
- Port and Harbours
- 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

India is an Issuing Service for METAREA VII(N) of the WWMIWS, and is responsible for broadcasting the products on SafetyNET to mariners at Sea.

Dissemination of tropical cyclone warnings





The warnings/bulletins for the high seas are disseminated through Colombo (4PB). Other 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
- Social Media/Facebook/WhatsApp

Cyclone warning system in Qatar

There are no direct impacts of tropical cyclones on the country. However, Qatar Meteorology Department is responsible to provide marine weather related services to shipping and other coastal communities for the Arabian Gulf (sub area No 5) as part of METAREA IX in cooperation with Pakistan Met Department. Qatar Meteorology Department has a lot of tools and capabilities available to track tropical cyclones such as access of real time satellite and radar images, high resolution numerical weather prediction models as well as real time access to surface, upper air observations and ship reports.

Four colour code with flags are used for easy and quick understanding

| 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 10° N between 60° E and 95° E. The port warning signal used are given in Attachment to Annex II-H

India is an Issuing Service for METAREA VII(N) of the WWMIWS, and is responsible for broadcasting the products on SafetyNET to mariners at Sea.

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. | <p style="text-align: center;">To high seas</p> <p>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)</p> |
| | | <p style="text-align: center;">To coastal stations and ports</p> <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 6 hours)</p> |
| 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 | <p style="text-align: center;">To high seas</p> <p>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)</p> |
| | | <p style="text-align: center;">To coastal stations and ports</p> <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 6 hours)</p> <p>Port warning signals used in Thailand Ports are given in Attachment to Annex II-I.</p> |
| | | <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> <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 6 hours)</p> |

| | | |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tropical Cyclones (34 knots and more) | Comprehensive Warning/ Advisory will be issued every 3 hours containing : (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 | <p style="text-align: center;">To high seas</p> 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. <p style="text-align: center;">(every 3 hours)</p> |
| | | <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 <p style="text-align: center;">(every 3 hours)</p> 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 <p style="text-align: center;">(every 3 hours)</p> |

Tropical Cyclone Warning System in United Arab Emirates

Organization

Tropical cyclone warnings and advisories in United Arab Emirates are provided by the Meteorological Department, National Center of Meteorology (NCM) in cooperation with the National Emergency Crisis and Disasters Management Authority (NCEMA).

Tracking of tropical cyclones

The tropical cyclones tracking are done through satellite Imageries, conventional surface, ship and upper air observations, weather radar, regional Model outputs and RSMCs reports.

Tropical cyclone warning

Tropical cyclone warnings are provided for:

- (i) National Emergency Crisis and Disasters Management Authority (NCEMA).
- (ii) Ministry of Interior (MOI).
- (iii) Coast Guard.
- (iv) General public.
- (ii) Sea Ports.
- (iii) Gas, Oil and shipping Marine companies.
- (iv) Civilian and military aviation.
- (v) Governmental and non-Governmental entities.

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- Hot line landline and hot mobile-line connected with stakeholders.
- 2- Secured intranet connected with stakeholders.
- 3- Decoded fax-ware connected with stakeholders.
- 4- Internet (E-mail, website: ncm.ae & albahar.ncm.ae, mobile applications, social media).
- 5- SMStext messages.
- 6- Media (Local radio channels, local TV channels, local press).

| Day Signals* | Specifications | Night Signals* | Remarks |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------------------------------------------------------------------------|
| 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'westers) |) | 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 from a storm of light or moderate intensity (wind speed of 62-88 km/h (34-47 knots) That is expected to cross the coast to the South of Chattogram Port or Cox's Bazar Port and to the east of Mongla Port |) | 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 light or moderate intensity that is expected to cross the coast to the north of the port Chattogram (or Cox's Bazra and to the west of the port of Mongla) (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 light 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 (wind speed of 89 km/h or 48 knots or more) that is expected to cross the coast to the south of the port of Chattogram or Cox's Bazra and to the east of the port of Mongla. |) |) 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 of Chattogram or Cox's Bazar and to the west of the port Mangla) (wind speed same as in Signal No. VIII) |) |) |

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

Attachment to ANNEX II-B-3

| Day Signals* | Specifications | Night Signals* | Remarks |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Bangladesh</u> - 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 a devastating cyclone is following. | 7b) |)))) |
| <u>Signals Meant for River Ports</u> | | | |
| 24a | (I) <u>Cautionary Signal Number One</u> The area is threatened by squally winds of transient nature (Nor'wester squalls) of wind speed not exceeding 60 km/h (32 knots). A storm (wind speed of 61 km/h) or a nor'wester (wind speed 61 km/h or more) is likelt to strike the area (vessels of 65 feet and under in length are to seek shelter immediately) | 5b) |) these signals are used) for the river ports, river) and police stations in) Bangladesh) these signals are) used for the river) ports, river and) police stations in) Bangladesh |
| 2a | (III) <u>Danger Signal Number Three</u> A storm (wind speed of 62-88 km/h or more) is likely to strike the area soon (All vessel will seek shelter immediately). | 2b) |)) |

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

| Day Signals* | Specifications | Night Signals* | Remarks |
|--------------|----------------|----------------|---------|
|--------------|----------------|----------------|---------|

Bangladesh - continued

| | | | |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------------------|
| 10a | (IV) <u>Great Danger Signal Number Four</u> A violent storm (wind speed of 89 km/h or more) will strike the area soon (All vessels will take shelter immediately). | 31b |)))) |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------------------|

Attachment to Annex II-C1
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

Subject: Severe Cyclonic Storm 'ASANI' over Westcentral Bay of Bengal - CYCLONE WARNING for Andhra Pradesh coast (Red Message)

The **Severe Cyclonic Storm 'Asani' (pronounced as Asani)** over Westcentral and adjoining southwest Bay of Bengal moved west-northwestwards with a speed of 25 kmph during past 06 hours and lay centered at 1130 hours IST of today, the 10th May, over westcentral Bay of Bengal near latitude 15.0°N and longitude 82.5°E, 210 km south-southeast of Kakinada (Andhra Pradesh), 310 km south-southwest of Visakhapatnam (Andhra Pradesh), 530 km southwest of Gopalpur (Odisha) and 630 km southwest of Puri (Odisha).

It is very likely to move nearly northwestwards and reach Westcentral Bay of Bengal close to Kakinada-Vishakhapatnam coasts by 11th May morning. Thereafter, it is very likely to recurve slowly north-northeastwards and move along Andhra Pradesh coast between Kakinada and Visakhapatnam and then emerge into Northwest Bay of Bengal off North Andhra Pradesh and Odisha coasts. It is likely to weaken gradually into a Cyclonic Storm by 11th May morning and into a depression by 12th May morning.

The cyclonic storm is under the continuous surveillance of Doppler Weather Radar (DWR) at Machilipatnam (Andhra Pradesh).

Forecast track and intensity are given in the following table:

| Date/Time(IST) | Position (Lat. °N/ long. °E) | Maximum sustained surface wind speed (Kmph) | Category of cyclonic disturbance |
|----------------|---------------------------------|------------------------------------------------|-------------------------------------|
| 10.05.22/1130 | 15.0/82.5 | 100-110 gusting to 120 | Severe Cyclonic Storm |
| 10.05.22/1730 | 15.4/82.1 | 95-105 gusting to 115 | Severe Cyclonic Storm |
| 10.05.22/2330 | 15.8/81.9 | 85-95 gusting to 105 | Cyclonic Storm |
| 11.05.22/0530 | 16.2/81.9 | 80-90 gusting to 100 | Cyclonic Storm |
| 11.05.22/1130 | 16.7/82.3 | 75-85 gusting to 95 | Cyclonic Storm |
| 11.05.22/2330 | 17.3/82.9 | 65-75 gusting to 85 | Cyclonic Storm |
| 12.05.22/1130 | 17.6/83.6 | 55-65 gusting to 75 | Deep Depression |
| 12.05.22/2330 | 17.9/84.5 | 45-55 gusting to 65 | Depression |

Warnings:

(i) Rainfall (warning graphics enclosed)

10th May: Light to moderate rainfall at many places with **heavy to very heavy rainfall** at isolated places is likely over coastal Andhra Pradesh and rainfall at a few places with **heavy rainfall** at isolated places over coastal Odisha from 10th night.

11th May: Light to moderate rainfall at most places with **heavy to very heavy rainfall** at a few places with **isolated extremely heavy falls** is likely over coastal Andhra Pradesh and **heavy rainfall** at isolated places is likely over coastal Odisha & adjoining coastal West Bengal.

12th May: Light to moderate rainfall likely at a few places with **heavy rainfall** at isolated places is likely over coastal areas of Odisha and West Bengal.

(ii) Wind warning

- Gale wind speed reaching 100-110 kmph gusting to 120 kmph is prevailing around the system center over Westcentral Bay of Bengal. It would gradually decrease becoming 85-95 kmph gusting to 105 kmph over Westcentral and adjoining Northwest Bay of Bengal from midnight of 10th May and become 75-85 Kmph gusting to 95 Kmph from morning of 11th May over the same region. Further, it would decrease to 55- 65 Kmph gusting to 75 Kmph over northwest & adjoining Westcentral Bay of Bengal from morning of 12th May.

- Squally wind speed reaching 45-55 kmph gusting to 65 kmph is prevailing along and off Andhra Pradesh coast. It is likely to increase becoming 55-65 Kmph gusting to 75 Kmph from early hours of 11th May and gale wind speed reaching 75-85 kmph gusting to 95 kmph during morning to noon of 11th May along & off Andhra Pradesh coast (Krishna, East & West Godavari and Visakhapatnam districts).
- Squally wind speed reaching 45-55 kmph gusting to 65 kmph is likely to continue along & off Odisha coast during 10th to 12th May and along & off West Bengal coast during 11th to 12th May evening.

(iii) Sea condition

Sea condition is likely to be Very High over Westcentral Bay of Bengal till midnight of today, the 10th May. It would become high over westcentral & adjoining northwest Bay of Bengal on 11th May and very rough to rough over the same region on 12th May.

(iv) Storm Surge warning:

Storm surge of height about 0.5 m above astronomical tide is likely to inundate low lying areas of Krishna, East & West Godavari and Vishakhapatnam districts of Andhra Pradesh.

(iv) Fishermen Warning (Graphics enclosed)

- Total suspension of fishing operations over westcentral Bay of Bengal during 10th to 11th and over northwest Bay of Bengal 10 to 12th May.
- Fishermen are advised not to venture into westcentral Bay of Bengal during 10th to 11th May and into Northwest Bay of Bengal during 10th to 12th May.
- Fishermen out at sea are advised to return to coast.

(v) Advisory for offshore activities:

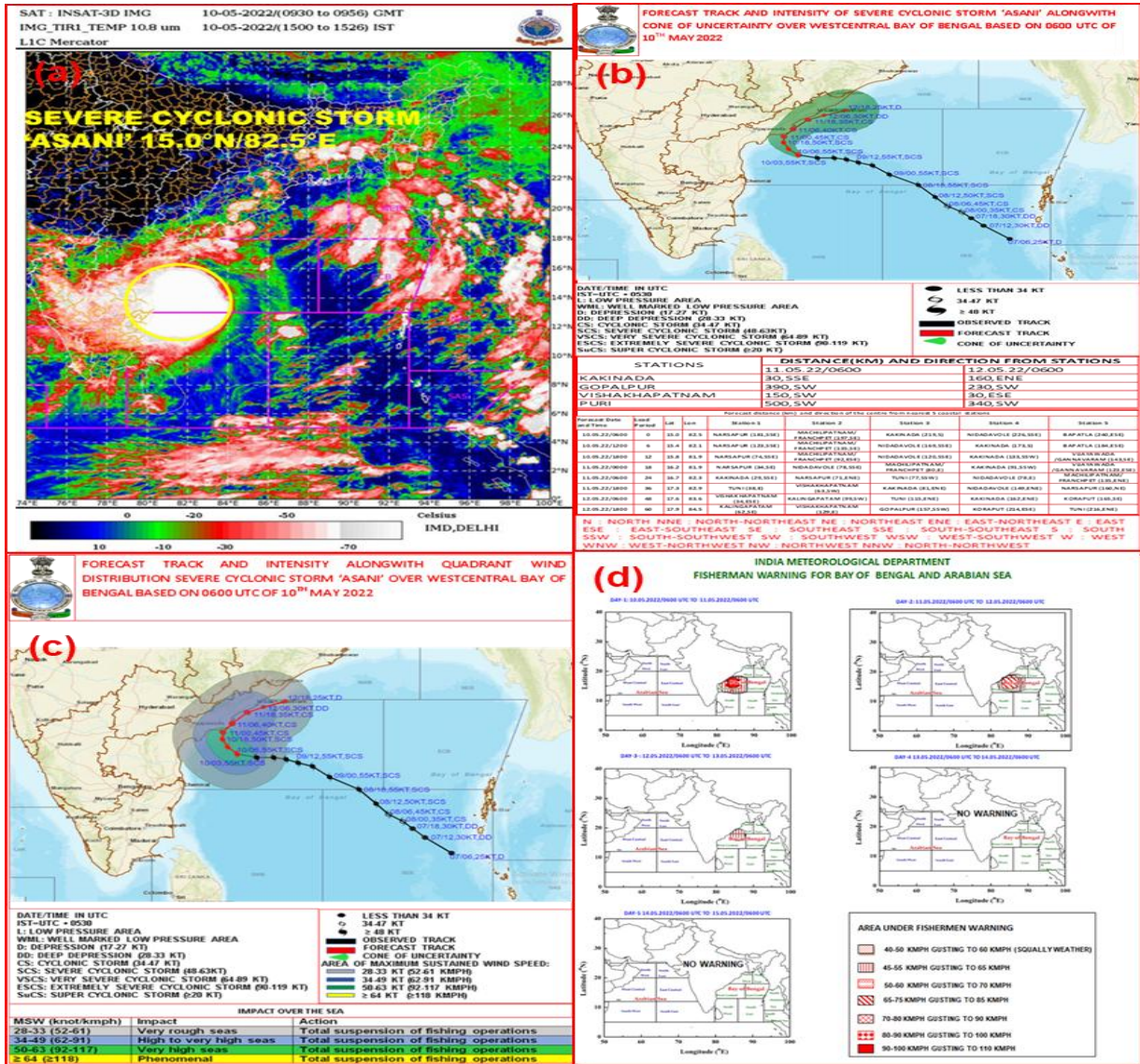
- Regulate offshore operations till 12th May.

(vi) Damage expected: (for Krishna, East & West Godavari and Vishakhapatnam districts of Andhra Pradesh)

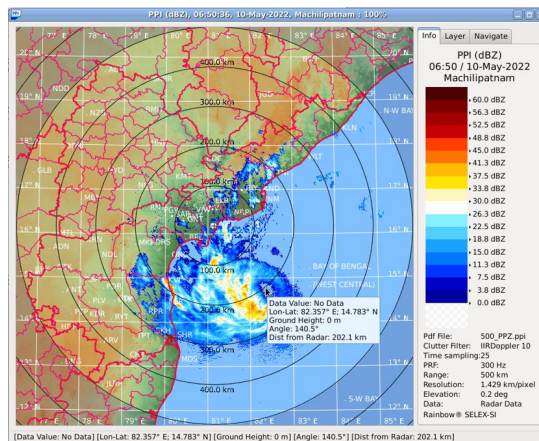
- Damage to thatched huts.
- Minor damage to power and communication lines due to breaking of branches.
- Major damage to Kutcha and minor damage to Pucca roads.
- Some damage to paddy crops, banana, papaya trees and orchards.

(vii) Action Suggested: (for Krishna, East & West Godavari and Vishakhapatnam districts of Andhra Pradesh)

- Check for traffic congestion on your route due to heavy rain before leaving for your destination.
- Follow any traffic advisories that are issued in this regard.
- Avoid going to areas that face the water logging problems often.
- Stay in safe places.



Typical Satellite imagery based on 0600 UTC of 10th May in association with SCS ASANI over Bay of Bengal (b) Observed and forecast track alongwith with cone of uncertainty based on 0600 UTC of 10th May (c) Observed and forecast track alongwith with Quadrant wind distribution based on 0600 UTC of 10th May (d) Fisherman warning graphics based on 0600 UTC of 10th May



Doppler Weather Radar imagery from Machilipatnam at 0600 UtC Of 10th May

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 ^w 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 |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------------------------|
| 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

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-2

| Day Signals* | Specifications | Night Signals* | Remarks |
|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------|
| <u>Pakistan</u> - 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 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 Pachjamit 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 |

| Day Signals* | Specifications | Night Signals* | Remarks |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|----------------|---------|
| 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 Pachjamit 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**.

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 | | | | | | |
| 253 | RUSTAQ | X | X | X | X | X | X | X | X | | | | | | |
| 254 | SAIQ | | X | X | X | X | | | | | | | | | |
| 255 | NIZWA* | | | X | X | X | | | | | | | | | |
| 256 | MUSCAT INT. AIRPORT | 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 | | | | | | |
| 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 | 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 | X | X | | X |
| 598 | JHELUM | X | 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 | X | X | | |
| 641 | LAHORE CITY | | X | X | X | 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 | X | X | | X |
| 685 | BAR KHAN | X | 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 | X | X | | |
| 715 | JACOBABAD | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 718 | KHANPUR | X | X | X | X | X | X | X | X | X | | | | | |
| 739 | PANJGUR | X | 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 | | | | | | |
| 759 | PASNI | X | X | X | X | X | X | X | X | X | X | X | X | X | (Pilot winds) |
| 764 | HYDERABAD | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 768 | CHHOR | | X | X | X | X | X | X | X | X | X | X | X | X | |
| 780 | KARACHI AIRPORT | X | X | X | X | X | X | X | X | X | X | X | X | | X |

TABLE III-1: LIST OF IMPLEMENTED REGIONAL BASIC SYNOPTIC NETWORK STATIONS

| | Name of station | Surface | | | | | | | | Radiowind | | | | Radiosonde | |
|-------|---------------------|---------|----|----|----|----|----|----|----|-----------|----|----|----|------------|----|
| | | 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 | | |
| 41883 | BOGRA | x | 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 | x | x | . |
| 41907 | ISHURDI | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41923 | DHAKA | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| 41936 | JESSORE | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41943 | FENI | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41950 | BARISHAL | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41953 | MAJDI COURT | x | x | x | x | x | x | x | x | | | | | | |
| 41963 | HATIYA | x | x | x | x | x | x | x | x | | | | | | |
| 41964 | SANDWIP | x | 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 | x | | | | | | |
| 41984 | KHEPUPARA | x | x | x | x | x | x | x | x | | | | | | |
| 41989 | KUTUBDIA | x | x | x | x | x | x | x | x | | | | | | |
| 41992 | COX'S BAZAR | x | x | x | x | x | x | x | x | x | x | x | x | | |

III-4

| Name of station | Surface | | | | | | | | Radiowind | | | | Radiosonde | |
|-----------------|----------------------|----|----|----|----|----|----|----|-----------|----|----|----|------------|----|
| | 1 | | 2 | | | | | | 3 | | | | 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 | X | X | X |
| 42101 | PATIALA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42111 | DEHRADUN | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42131 | HISSAR | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42165 | BIKANER | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42182 | NEW DELHI | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42189 | BAREILLY | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42260 | AGRA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42309 | NORTH LAKHIMPUR | | X | X | X | X | X | X | | | | | | |
| 42314 | DIBRUGARH/MOHANBARI | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42328 | JAISALMER | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42339 | JODHPUR | 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 | X | X | X |
| 42361 | GWALIOR | 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 |
| 42379 | GORAKHPUR | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42397 | SILIGURI | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42410 | GUWAHATI | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42415 | TEZPUR | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42452 | KOTA AERODROME | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42475 | ALLAHABAD/ BAMHRAULI | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42492 | PATNA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42559 | GUNA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42571 | SATNA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42587 | DALTONGANJ | | X | X | X | X | X | X | | | | | | |
| 42591 | GAYA | X | X | 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 | X |
| 42634 | BHUJ-RUDRAMATA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42779 | PENDRA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42798 | JAMSHEDPUR | X | X | X | 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 |
| 42840 | SURAT | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42867 | NAGPUR /SONEGAON | 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 |
| 42886 | JHARSUGUDA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42895 | BALASORE | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42909 | VERAVAL | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42921 | NASIK CITY | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42933 | AKOLA | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 42971 | BHUBANESWAR | 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 |
| 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

| 4 | Name of Station 1 | Surface 2 | | | | | | | | Radiowind 3 | | | | Radiosonde | |
|-------|----------------------|--------------|----|----|----|----|----|----|----|----------------|----|----|----|------------|----|
| | | | | | | | | | | | | | | | |
| | | 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 | X |
| 43314 | KOZHIKODE | X | 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 | X |
| 43329 | CUDDALORE | X | 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 | X |
| 43344 | TIRUCHIRAPALLI | X | 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 | X |
| 43353 | KOCHI WILLINGTON | X | 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 | X |
| 43371 | THIRUVANANTHAPURAM | X | 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 | X |
| 43421 | ANURADHAPURA | X | 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 | X |
| 43436 | BATTICALOA | X | 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 | X |
| 43466 | COLOMBO | X | 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 | X |
| 43486 | RATNAPURA | X | 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 | X |
| 43497 | HAMBANTOTA | X | 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 | X |
| 43555 | MALE | X | 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 | X |
| 43588 | KADEHDHOO | X | 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 | X |
| 48001 | PUTAO | X | 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 | X |
| 48008 | MYITKYINA | X | 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 | X |
| 48017 | PINLEBU | X | 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 | X |
| 48019 | BHAMO | X | 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 | X |
| 48024 | KALEMYO | X | 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 | X |
| 48030 | HAKHA | X | 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 | X |
| 48033 | SHWEBO | X | 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 | X |
| 48035 | LASHIO | X | 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 | X |
| 48037 | MONYWA | X | 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 | X |
| 48040 | HSIPAW | X | 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 | X |
| 48043 | PYINOOOLWIN | X | 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 | X |
| 48047 | MYINGYAN | X | 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 | X |
| 48051 | KYAUKTAW | X | 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 | X |
| 48053 | MEIKTILA | X | 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 | X |

III-7

| 4 | Name of Station 1 | Surface 2 | | | | | | | | Radiowind 3 | | | | Radiosonde | |
|-------|----------------------|--------------|----|----|----|----|----|----|----|----------------|----|----|----|------------|----|
| | | 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 | | | | | | |

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 | |
|-------|---------------------|---------|----|----|----|----|----|----|----|-----------|----|----|----|------------|----|
| | | 00 | 03 | 06 | 09 | 12 | 15 | 18 | 21 | 00 | 06 | 12 | 18 | 00 | 12 |
| 41850 | TETULIA | x | x | x | x | x | x | x | x | | | | | | |
| 41851 | DIMLA | x | x | x | x | x | x | x | x | | | | | | |
| 41856 | RAJARHAT | x | x | x | x | x | x | x | x | | | | | | |
| 41858 | SAYEDPUR | x | x | x | x | x | x | x | x | | | | | | |
| 41859 | RANGPUR | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41863 | DINAJPUR | x | x | x | x | x | x | x | x | | | | | | |
| 41881 | BADALGACHI | x | x | x | x | x | x | x | x | | | | | | |
| 41883 | BOGRA | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| 41886 | MYMENSINGH | x | x | x | x | x | x | x | x | | | | | | |
| 41888 | NETROKONA | x | x | x | x | x | x | x | x | | | | | | |
| 41891 | SYLHET | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| 41895 | RAJSHAHI | x | x | x | x | x | x | x | x | | | | | | |
| 41897 | TARASH | x | x | x | x | x | x | x | x | | | | | | |
| 41902 | NIKLI | x | x | x | x | x | . | . | . | | | | | | |
| 41906 | BAGHABARI | . | . | . | . | . | . | . | . | | | | | | |
| 41907 | ISHURDI | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41915 | SRIMONGAL | x | x | x | x | x | x | x | x | | | | | | |
| 41916 | ASHUGANJ | . | . | . | . | . | . | . | . | | | | | | |
| 41923 | DHAKA | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| 41924 | NARSINGDI | . | . | . | . | . | . | . | . | | | | | | |
| 41926 | CHUADANGA | x | x | x | x | x | x | x | x | | | | | | |
| 41927 | KUMARKHALI | x | x | x | x | x | x | x | x | | | | | | |
| 41929 | FARIDPUR | x | x | x | x | x | x | x | x | | | | | | |
| 41930 | ARICHA | . | . | . | . | . | . | . | . | | | | | | |
| 41933 | COMILLA | x | x | x | x | x | x | x | x | | | | | | |
| 41936 | JESSORE | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41938 | GOPALGANJ | x | x | x | x | x | x | x | x | | | | | | |
| 41939 | MADARIPUR | x | x | x | x | x | x | x | x | | | | | | |
| 41940 | MAWA | . | . | . | . | . | . | . | . | | | | | | |
| 41941 | CHANDPUR | x | x | x | x | x | x | x | x | | | | | | |
| 41943 | FENI | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41944 | DIGHINALA | . | . | . | . | . | . | . | . | | | | | | |
| 41946 | SATKHIRA | x | x | x | x | x | x | x | x | | | | | | |
| 41947 | KHULNA | x | x | x | x | x | x | x | x | | | | | | |
| 41948 | KOYRA | x | . | . | . | x | . | . | . | | | | | | |
| 41950 | BARISHAL | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41951 | BHOLA | x | x | x | x | x | x | x | x | | | | | | |
| 41953 | MAJDI COURT | x | x | x | x | x | x | x | x | | | | | | |
| 41955 | SAINT MARTIN | . | . | . | . | . | . | . | . | | | | | | |
| 41958 | MONGLA | x | x | x | x | x | x | x | x | | | | | | |
| 41960 | PATUAKHALI | x | x | x | x | x | x | x | x | | | | | | |
| 41961 | RAMGATI | x | . | . | . | x | . | . | . | | | | | | |
| 41962 | HIZLA | . | . | . | . | . | . | . | . | | | | | | |
| 41963 | HATIYA | x | x | x | x | x | x | x | x | | | | | | |
| 41964 | SANDWIP | x | x | x | x | x | x | x | x | | | | | | |
| 41965 | SITAKUNDA | x | x | x | x | x | x | x | x | | | | | | |
| 41966 | RANGAMATI | x | 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 | x | . | . | . | . | . | |
| 41979 | KAWKHALI | . | . | . | . | . | . | . | . | | | | | | |
| 41980 | BANDARBAN | . | . | . | . | . | . | . | . | | | | | | |
| 41981 | MONPURA | . | . | . | . | . | . | . | . | | | | | | |
| 41984 | KHEPUPARA | x | x | x | x | x | x | x | x | . | . | . | . | . | |
| 41989 | KUTUBDIA | x | x | x | x | x | x | x | x | . | . | . | . | . | |
| 41992 | COX'S BAZAR | x | x | x | x | x | x | x | x | x | x | x | x | | |
| 41998 | TEKNAF | x | x | x | x | x | x | x | x | | | | | | |

TABLE III-3
Buoys over north India Ocean

| Buoy's ID | Surface | | | | Radiowind | | | | Radiosonde | | | | | |
|---------------------|---------|----|----|----|-----------|----|----|----|------------|----|----|----|----|----|
| | 1 | | 2 | | 3 | | 3 | | 3 | | 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 | | | | | |
| BD13 (BOB) | X | X | | X | X | | | X | X | | | | | |
| CB01 (BOB) | X | X | | X | X | | | X | X | | | | | |

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**.

DWR TABLE III-4
WEATHER RADAR STATIONS KEEPING WATCH
OVER THE ARABIAN SEA AND THE BAY OF BENGAL
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 | |
| | Moulvibazar | 24°29'8" | 91°46'30" | Doppler | 2009 | |
| India | 42807 Kolkata | 22°33' | 88°20' | 10 cm DWR | 1973 2002 | |
| | 42976 Paradip | 20°15' | 86°39' | 10 cm DWR | 1973 | |
| | 43049 Gopalpur | 19°15' | 84°53' | 10 cm DWR | 2017 | |
| | 43149 Visakhapatnam | 17°44' | 83°20' | 10 cm DWR | 1970 2006 | |
| | 43185 Machilipatnam | 16°10' | 81°08' | 10 cm DWR | 1981 2004 | |
| | ---- Sriharikota | 13°39' | 80°13' | 10 cm DWR | 2004 | |
| | 43278 Chennai | 13°04' | 80°16' | 10 cm DWR | 1973 2002 | |
| | 43346 Karaikal | 10°54' | 79°50' | 10 cm DWR | 1989 2016 | |
| | 43353 Kochi | 09°55' | 76°15' | 10 cm DWR | 1987 2016 | |
| | 43371 Thiruvananthapuram | 08°31' | 76°51' | 05 cm DWR | 2017 | |
| | 43192 Goa | 15°29' | 73°49' | 10 cm DWR | 2002 2016 | |
| | 43057 Mumbai | 18°54' | 72°48' | 10 cm DWR | 1989 2016 | |
| | 42634 Bhuj | 23°14' | 69°38' | 10 cm DWR | 1987 2016 | |
| | Maldives | 43555 Male | 04°09' | 73°11' | 10 cm(DWR) | 2008 |
| | Myanmar | 48071 Kyaukpyu | 19°17' | 93°31' | Doppler | 2015 |
| 48097 Yangon | | 16°52' | 96°09' | Doppler | 2016 | |
| 48042 Mandalay | | 21°47' | 96°02' | Doppler | 2018 | |
| 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) | 2014 (Dual.Pol.) | | |

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 Pdsdsfsfs

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 pdsdsfsfs 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.

ANNEX III-A-2

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

- 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.

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. The products available from DWR of IMD which are available in IMD website include MAX(Z) Product (MAX_Z), Plan Position Indicator (PPI_Z), Volume Velocity processing (VVP_2), Plan Position Indicator (PPI_V), Surface Rainfall Intensity (SRI_150), Precipitation Accumulation (PAC) 24 hrs at 0300 UTC (HOURS_24)

Typical example of the Hourly radar bulletin issued by DWR stations at Gopalpur in association with CS GULAB, 2021 in India during the cyclone period is given below:

ANNEX III-A-6

CYCLONE BULLETIN NO: 19 CYCLONE: GULAB TIME: 26-09-2021 09:00 UTC

| | | |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| 1. | Name of the station | DWR VSK |
| 2. | Date and Time of Observation (UTC) | 0900 UTC |
| 3. | Name of the Cyclone | GULAB |
| 4. | Information about the eye of the Cyclone | |
| | a. Is the Eye Visible | YES |
| | b. Shape of the Eye | NOT WELL DEFINED |
| | c. Diameter of the Eye(km) | - |
| | d. Estimation of centre of the cyclone based on Eye/spiral band observation | 18.4° N / 85.1° E Az Ang 64.7° Distance from DWR: 186 kms |
| | e. Echo top height of rain bearing clouds around the cyclone within 100 Km radius (km) | 16 kms |
| | f. Maximum radar reflectivity (dBZ) & rainfall rate (mm/h) in the eye wall/spiral band region, its height (km) and position (azimuth and distance from the radar) | 47 dBZ Height: 16 kms Distance: 180 kms |
| | g. Maximum reflectivity at any other area (spiral/ streamers etc) | 47 dBZ |
| | h. Maximum radial velocity in eye wall/spiral band region (mps), its height (km) and its position (azimuth and distance from the Radar) | - |
| | i. Maximum velocity in any other area (spiral / streamers / rain shields etc) | 27 m/s (Radial) |
| 5. | Tendency of the Cyclone | |
| | a. Intensity(Increasing/Decreasing) | - |
| | b. Duration for which the information on movement pertains to | 1 hour |
| | c. Direction of Movement | W |
| | d. Estimated speed of Movement | 23.24 kmph |
| 6. | Any other Significant Feature | |
| 7. | Confidence | Good |

Satellite cloud imagery monitoring facilities in the Panel countries

Bangladesh

Bangladesh Meteorological Department (BMD) has the facilities of Himawari Satellite Receiving System of Japan. The satellite imageries of all of the available channels are updated on BMD website (<http://www.bmd.gov.bd>) regularly. With this system BMD is receiving images of Himawari 9. Satellite Images from 14 different channels have been received with 10 minutes intervals which is disseminated from Japanese communication satellite JC-SAT 2B. To analyze these satellite images SATAID data processing tool is used. BMD also has CMACast reception system. From this system BMD is receiving satellite images from Satellite FY-2D, FY-2E and FY-2F satellites. To analyze the images MICAPS data processing tool is used. Both of these reception systems are being used in operational weather forecasting.

Installation of the Receiving System of GK-2A (Korean Satellite) at BMD is under process and the available data will be utilized in operational forecasting.

India

At present IMD is receiving and processing meteorological data from two Indian geostationary Meteorological satellites namely INSAT-3D & INSAT-3DR. INSAT-3D launched on 26 July 2013 is positioned at 82°E and INSAT 3DR launched on 28th Aug 2016 is located at 74°E. 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. Imager payload provides 1 km. resolution imagery in visible & SWR band, 4 km resolution in IR band and 8 km in WV band.

At Present about 48 nos. of satellite cloud images are taken daily from each of INSAT-3D and INSAT-3DR in a staggered mode so that effectively, after every fifteen minutes a new set of satellite cloud Images from imager become available to the forecasters and atmospheric profile of temperature and humidity from Sounder payload are obtained on hourly basis of Indian land region and one and half hourly basis of Indian ocean region from INSAT-3D and INSAT-3DR satellites. INSAT-3D Meteorological Data Processing System (IMDPS) is processing meteorological data from INSAT-3D and INSAT3-DR that supports all operational activities of the Satellite Meteorology Division on round the clock basis and all the processed data is archived. All the Cloud Imageries and derived products Data are transmitted to forecasting offices of the IMD through dedicated website as well as to the other users in India and foreign countries through FTP/GTS.

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. Outgoing Long wave Radiation (OLR) at pixel resolution
4. Rainfall Estimates
 - a. Hydro-Estimator (HE) at pixel resolution
 - b. INSAT Multispectral Rainfall Algorithm (IMSRA) at 0.1X0.1degree resolution
 - c. Three Hourly accumulated Quantitative Precipitation Estimation (QPE) at 1X1degree resolution
5. Sea Surface Temperature (SST) at pixel resolution
6. Upper Tropospheric Humidity (UTH)
7. Cloud Motion Vector (CMV)
8. Water Vapour Wind (WVW)
9. Visible/ Midinfrared wind
10. Wind derived products
 - a. Lower level Vorticity
 - b. Upper level Divergence.
 - c. Lower level convergence.

- d. Vertical wind shear.
 - e. Wind shear tendency
11. Value added parameters from sounder products
- a. Layer Precipitable Water
 - b. Total Precipitable Water
 - c. Lifted Index
 - d. Dry Microburst Index
 - e. Maximum Vertical Theta-E Differential
 - f. 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.

Real-time Analysis of Product and Information Dissemination (RAPID) is a web-based visualization and analysis tool developed jointly by IMD & ISRO for monitoring and analysis of satellite data of INSAT 3D and INSAT 3DR. A satellite based nowcast tool to predict IR1 BT is also available in RAPID. As RAPID is a geo-reference platform, it provides real time information on genesis, growth and decay along with its location and other geo-physical parameters to help forecasters to provide more objective nowcast. This tool can be accessed through IMD website at the link: <http://www.rapid.imd.gov.in/>

The online Web Archival System is developed at IMD for archiving the INSAT-3D and INSAT 3DR products & imageries. It is updated on real-time basis and at any instance of time last six-month imageries and products remain available. These are available to registered users through ftp.

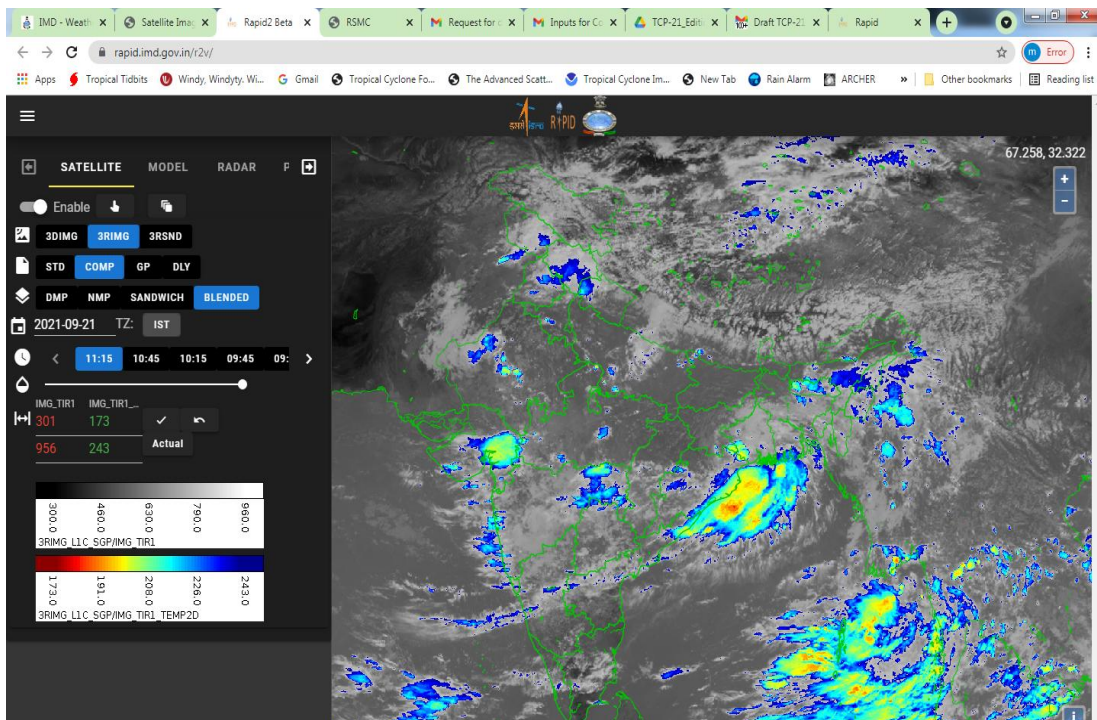


Fig.III-B-1: Image showing features available on RAPID Tool

1.1.4.1 Lightning monitoring:

The occurrence of lightning in India is being monitored with the help of lightning detectors established by Ministry of Earth Sciences and Indian Air Force. Currently, there are 237 No. of lightning detectors in the country (80 by Indian Institute of Tropical Meteorology and 157 by Indian Air Force). The area of lightning during preceding 10 min., 20 min. and 30 min. are superimposed with satellite and radar imageries. It

helps in proper monitoring of thunderstorm and lightning activities and nowcasting of such events. Typical lightning guidance is presented in Fig.III-B-2 below.

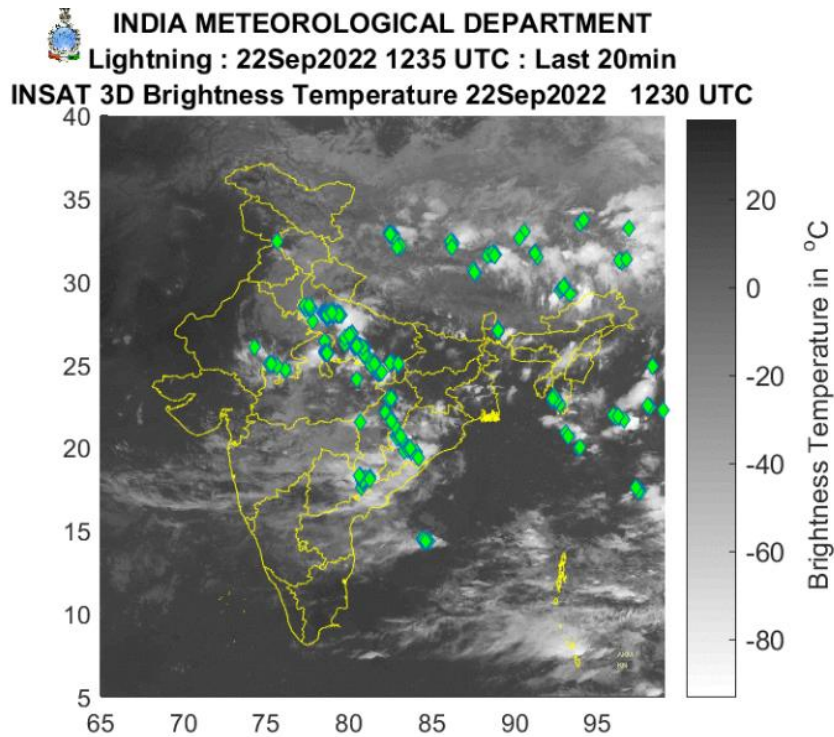


Fig.III-B-2 : Lightning guidance at 1235 UTC of 22 September, 2022

1.1.4.2. Meteosat-9: Products from MeteoSat 9 are also available IMD website at the link: <http://foreignsat.imd.gov.in/>

| INDIA METEOROLOGICAL DEPARTMENT Ministry of Earth Sciences EUMETCAST Images and Products | | MSG-IODC Channel Imagery | | Lightning Products | |
|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------------|--|
| | MSG-IODC Channel Imagery VIS-0.6 [†] VIS-0.8 [†] IR-1.6 [†] IR-3.9 IR-8.7 IR-9.7 IR-10.8 IR-12.0 IR-13.4 IR-10.8 (3D-View) IR-10.8 (Troll) WV-6.2 WV-7.3 Full Disk (Troll) | | Lightning Products Lightning Animation KML RealTime RealTime-15mins RealTime-30mins Previous Day | | |
| | Himawari Channel Imagery IR-BoB-region | | Real Time Amplitude Total C-C C-G | | |
| | MSG-IODC RGB Products Air Mass Convection [†] Day-Microphysics [†] Night Fog Dust True Colour [†] | | Real Time Count Total C-C C-G | | |
| | MSG IODC Nowcasting Products RDT CT ASII CRR CI-30 CI-60 CI-90 | | Last 3-hours Amplitude Total C-C C-G | | |
| | MSG IODC Winds Products HRW-ALL HRW-Top HRW-Mid HRW-Low | | Last 3-hours Count Total C-C C-G | | |
| | | | LMI Based Lightning Real Time Count Last 3-hours Count | | |
| | | | ARCHIVE User Guide | | |
| | | | IMD GFS | | |

Fig.III-B-3 : Meteo Sat-9 products

Maldives

Digital Meteorological Data Dissemination (DMDD) system donated by India Meteorological Department (IMD) receives WMO coded GTS data, half hourly cloud imagery from Satellite 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 Himawari Cast, CMA Cast ground reception system and also from US polar-orbiting satellites (NOAA series of the USA) by using internet.

An integrated satellite receiving system of Himawari Cast donated by Japan Meteorological Agency was upgraded on November 2015. This Himawari Cast system receives 14 channels and Himawari-8-9, NWP (JMA-GSM), Observation (SYNOP, TEMP, SHIP), Ocean Surface wind and MANAM.

An integrated satellite receiving system generously donated by China Meteorological Agency was installed on March 2012. This CMA Cast 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) METOSAT KU band at Muscat Airport and C band at Muscat Airport and Salalah Airport .
- (ii) HRPT system at Muscat International Airport And Salalah 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]
- (iv) 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.

Qatar

Qatar Meteorology Department receives Meteosat second generation satellite images on operational basis every 15 minutes which include visible, infrared, water vapor channels as well as HRV and various RGB satellite images.

Sri Lanka

Satellite imageries and products are received from HimawariCAST and CMACAST through the real time receiving systems .

METEOSAT-2SG/ INSAT imageries are accessed through Internet regularly

Thailand

The Meteorological Department in Thailand is receiving satellite imageries and products from Himawari 8, through HimawariCast receiving system, and FY-2 via internet.

UAE**Satellite cloud imagery monitoring facilities in NCM**

| Satellite | Position (Longitude) | Orbit | channels | period |
|--------------------|----------------------|---------------|----------|------------|
| Eumetsat Met-11 | 0° | Geostationary | 12 | 15 minutes |
| Eumetsat Met-8 | 41.5° E | Geostationary | 12 | 3 hours |
| Himawari-8 (Japan) | 140.7° East | Geostationary | 1 | 10 minutes |
| GOES-15 USA west | 135° W | Geostationary | 1 | 3 hours |
| GOES-16 USA east | 075° W | Geostationary | 1 | 15 minutes |
| FY2E (China) | 86.5° E | Geostationary | 5 | 1 hour |
| FY2G (China) | 105° E | Geostationary | 5 | 1 hour |

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 IV1. 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.
- (iii) 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 2021

4.2.1 Global Forecast System

The Global Forecast System (GFS), adopted from National Centre for Environmental Prediction (NCEP) is operationally run at India Meteorological Department (IMD), New Delhi on Cray XC40 based High Power Computing Systems (HPCS). The IMD-GFS (T1534/L64) global model is run with ~12 km horizontal resolution and 64 hybrid sigma-pressure layers with ENKF based Grid Point Statistical Interpolation (GSI) scheme as the global data assimilation to generate 10 days forecast. The model is run four times in a day (00, 06, 12 and 18 UTC). The real-time outputs are made available to the national web site of IMD (<https://mausam.imd.gov.in/> under Short to Medium Range Model Guidance).

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 (v3.9.1), 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 3.9.1) 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 3 km and 45 Eta levels in the vertical 4 times a day at 06 hourly interval..

The model domain covers the area between lat. 5°S to 40°N long 50°E to 102°E covering India and neighbouring south Asian countries. The model runs with its own regional data assimilation (Com GSI V3.7_EnKF1.3). The performance of the model is found to be reasonably skilful for cyclone genesis and track prediction.

4.2.2.2 Hurricane WRF Model (HWRF)

Since 2011, time to time the HWRF modelling system is developed and customized atmospheric and ocean models with other associated pre-processing and post-processing components are implemented in IMD under the framework of MoU between MoES and NOAA. The HWRF version H217 has been ported on the MHIR HPCS with horizontal resolution of 18 km for parent domain and 6km & 2 km for intermediate and innermost nested domains following the center of cyclonic storm. The model is running with 61 vertical levels with parent domain, intermediate and innermost domain covering area of 80°x80°, 24°x24° and 7°x7° respectively. The special feature modified for tropical cyclone forecasting includes vortex initialization and correction, GSI based regional data assimilation, coupler for two-way coupling between atmosphere and ocean components and fine-tuned physical parameterization schemes. This model is customized specifically to forecast the track, intensity and structure of tropical cyclones. The HWRF modelling system uses the dynamics and infrastructure from the NMM WRF modelling system. It uses physics that are proven to be better for the tropics. Also, at this time, it is an Ocean coupled model system with a Moving two-way interactive nest, and advanced data assimilation. IMD is operationally running ocean coupled HWRF models during Tropical Cyclone events with two ocean models viz. POM-TC and HYCOM. HYCOM initial conditions are provided through INCOIS whereas POM-TC is initialized based on climatology.

It is run 4 times a day in cyclic mode with GSI based (hybrid-EnVar) assimilation (80 members) with 6 hourly cycles in cycling mode with full physics configuration. The model is also configured with 2 different Ocean models i.e. Princeton Ocean Model (POM) and hybrid co-ordinate ocean model (HYCOM). The Unified Post-Processor (UPP) converts raw model outputs from all three domains into standard GRIB1/2 format. Moreover, GFDL tracker generates track and intensity information in a standard ATCF (Automated Tropical Cyclone Forecasting System) format processing all GRIB files with a specified time interval (3 or 6 hours) as per requirement.

The modeling system was fully operational and predicted all cyclones during the year 2021. Whenever any low-pressure system intensified and became depression over both sub-basins of North Indian Ocean, the cyclic run of the modelling system had been initiated. The model utilized ocean initial state from the ITOPSI (INCOIS Tendral Ocean Prediction System – Indian Ocean Model) during each cycle to initialize the HYCOM ocean component. All available observed data including conventional and satellite observations were assimilated into the regional GSI system to improve further the initial condition after the vortex initialization of the atmospheric first guess state of the model forecast from previous cycle (except first cycle).

The HWRF version H217 which was operational at EMC, NCEP USA has been ported on the MHIR HPCS with horizontal resolution of 18 km for parent domain and 6km & 2 km for intermediate and innermost nested domains following the center of cyclonic storm. The model is running with 61 vertical levels with parent domain, intermediate and innermost domain covering area of 80°x80°, 24°x24° and 7°x7° respectively. The model also has state of the art features specially modified for tropical cyclone forecasting. The special feature includes vortex initialization and correction, GSI based regional data assimilation, coupler for two way coupling between atmosphere and ocean

components of coupled HWRF model and physics options fine-tuned for tropical cyclone prediction. The ocean model provides the SST field to the atmospheric component through coupler during the model integration to update the effect of mixing, cooling as well as advection effect on SST field, whereas the atmospheric component provides the heat fluxes, wind stress, precipitation and surface pressure fields to the ocean model through coupler. The coupled HWRF model uses GFDL vortex tracker and diagnostic software to provide the graphic and text information on track, intensity as well as structure of tropical cyclones for real time operational requirements. The HWRF physics scheme upgrades include updated Scale-Aware Simplified Arakawa-Schubert (SASAS) scheme, Ferrier-Aligo microphysics, GFS Hybrid-EDMF PBL, partial cloudiness for RRTMG scheme, and surface-exchange coefficients in the surface layer.

Within coupled framework of HWRF modeling system, the POM is initialized based on the climatological data whereas the HYCOM is initialized based on the ocean fields from RTOFS (Real-Time Ocean Forecast System) of INCOIS, Hyderabad. The atmospheric component of HWRF is initialized based on the analysis and forecast from IMD-GFS (T1534L64) and associated GDAS analysis. The HWRF model uses 3D-EnVAR-GSI as its data assimilation component. The coupled HWRF model is run every 6 hours on real time basis in cyclic mode based on 00, 06, 12, 18 UTC initial conditions to provide track and intensity forecast along with surface wind, rain swaths and other diagnostic products for up to 126 hours.

The coupled HWRF system with both ocean models viz, POM-TC and HYCOM was operational simultaneously and model guidance products were provided from both the configurations.

4.2.2.3. High Resolution Rapid Refresh Modeling System (HRRR)

The High Resolution Rapid Refresh system based on Weather Research and Forecast (WRF-ARW) model with WRFDA (3DVAR-FGAT) data assimilation is experimentally operationalized in India Meteorological Department in collaboration with Space Application Center (ISRO) from beginning of 2021. The HRRR is hourly updated atmospheric model with horizontal resolution of 2km. The model uses forecast of IMD-GFS (T1534L64) model as first guess and forecast as boundary during cold start and is then cycled providing hourly updates based on Radar Data. Using analysis and updated boundary conditions from the WRFDA, the HRRR is run to produce forecasts up to 12 hours and forecasts are made available after every two hours on NWP website.

The model is run in three different domains covering Indian mainland. The three domains are North-West domain, East & North-East domain and South-Peninsular domain. HRRR with hourly updates provide frequent and updated precipitation and reflectivity forecasts with respect to the tropical cyclones which could be very useful in planning effective and immediate disaster mitigation strategies.

4.2.3. NWP based Objective Cyclone Prediction System (CPS)

The method comprises of five forecast components, namely (a) Cyclone Genesis Potential Parameter (GPP), (b) Multi-Model Ensemble (MME) technique for cyclone track prediction, (c) Cyclone intensity prediction, (d) Rapid intensification and (e) Predicting decaying intensity after the landfall.

4.2.4. 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.

4.2.5. Multi-model ensemble (MME) technique

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 (LATf) and longitude (LONf) 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(IND), 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.rsmcnwdelhi.imd.gov.in.

4.2.6. 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.

4.2.7. 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 increase from 0% to 100% when the total number of indices satisfied increases from zero to eight. The forecasts are made available in real time since 2013.

4.2.8. Decay of Intensity after the landfall

Tropical cyclones (TCs) are well known for their destructive potential and impact on human activities. The Super cyclone Orissa (1999) illustrated the need for the accurate prediction of inland effects of tropical cyclones. The super cyclone of Orissa maintained the intensity of cyclonic storm for about 30 hours after landfall. Because a dense population resides at or near the Indian coasts, the decay forecast has direct relevance to daily activities over a coastal zone (such as transportation, tourism, fishing, etc.) apart from disaster management. In view of this, the decay model (Roy Bhowmik et al. 2005) has been used for real time forecasting of decaying intensity (after landfall) of TCs.

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

The THORPEX Interactive Grand Global Ensemble (TIGGE, Philippe Bougeault et al. 2010) is an implementation of ensemble forecasting for global weather forecasting and is part of THORPEX, an international research programme established in 2003 by the World Meteorological Organization (WMO) to accelerate improvements in the utility and accuracy of weather forecasts up to two weeks ahead. As part of WMO Program to provide a guidance of tropical cyclone (TC) forecasts in near real-time for the ESCAP/WMO 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) in 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 ESCAP/WMO committee Members. The forecast products are made available in real time.

Since 2021, IMD has also implemented IFS TC Tracker (available from ECMWF) for all available TIGGE models (9 in numbers). These 9 models are from Bureau of Meteorology, Australia (BoM), Environment and Climate Change Canada (ECCC), European Centre for Medium-Range Weather Forecasts (ECMWF), India Meteorological Department (IMD), Japan Meteorological Agency (JMA), Korea Meteorological Administration (KMA), Met Office - UK (UKMO), and National Centers for Environmental Prediction, USA (NCEP), and National Centre for Medium Range Weather Forecasting (NCEP) are nine International Institutes model outputs (contributing to the TIGGE) are chosen based on availability at the ECMWF-TIGGE web data portal <https://apps.ecmwf.int/datasets/data/tigge/levtype=sfc/type=cf/> as on December 2021.

4.2.10. Global Ensemble Forecast System

The Ministry of Earth Sciences (MoES) has commissioned two very high resolution (12 km grid scale) state-of-the-art global Ensemble Prediction Systems (EPS) for generating operational 10-days probabilistic forecasts of weather with 21 members. The EPS involves the generation of multiple forecasts using slightly varying initial conditions. The forecast products from these two prediction systems are available in IMD-NWP website. The frameworks of the new EPSs are among the best weather prediction systems in the world at present. Very few forecasting centres in the world use this high resolution for short-medium range probabilistic weather forecasts. GEFS model is run twice a day based on 00 & 12 UTC initial conditions.

4.2.10.1. 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.

4.2.10.2. Models run at NCMRWF

Two global models are also run at NCMRWF, NGFS adapted from NCEP GFS and NCUM unified model adapted from UK Met Office. The observations assimilated at NCMRWF include various in-situ and remote sensing observations. In-situ observations includes measurements come from land weather stations, aircraft, radiosondes, ships and buoys. Satellite observation includes Infrared and microwave radiance measurements from Low Earth Orbiting (LEO) and Geostationary (GEO) satellites, Atmospheric Motion Vectors from LEO and GEO, ocean surface winds from scatterometers, GPS Radio Occultation measurements etc.

Indian Doppler Weather Radar (DWR) observation are also assimilated in the NCMRWF NWP systems. NCUM-G (N1024/L70) model features a horizontal resolution of 12km and 70 vertical levels reaching upto an altitude of 80 km. It uses “ENDGame” dynamical core, which provides improved accuracy of the solution of primitive model equations and reduced damping. This was upgraded in June 2018 from the earlier model with a horizontal resolution of 17km. 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. The new version of the NCUM has the model physics configuration of GA6.0 (Global Atmosphere version 6.0) and a land surface model configuration of GL 6.0 which is based on JULES land surface scheme (Walters et al., 2017). This helps in producing finer details in the simulations of synoptic scale systems such as cyclones, fronts, troughs and jet stream winds. ENDGame also increases variability in the tropics, which leads to an improved representation of tropical cyclones and other tropical phenomena (Walters et al., 2017). Hybrid 4D-Var data assimilation system prepares initial condition for NCUM. The advantage of the Hybrid 4D-Var is that it uses a blended background error, blend of “climatological” r and day-to-day varying flow dependent background error derived from the 22-member ensemble forecasts at NCMRWF. The hybrid approach is scientifically attractive because it elegantly combines the benefits of ensemble data assimilation with the known benefits of 4D-Var within a single data assimilation system.

NCUM-R is a regional model having a horizontal grid resolution of ~4km with 80 vertical levels reaching up to 38.5 km height. NCUM-R uses the high-resolution analysis prepared by regional 4D-Var system. In addition to most of the in-situ and satellite observation types used in the global NCUM, Indian DWR observations of radial wind and rainfall intensity estimates are also used in the regional NCUM DA system. The model domain of NCUM-R spans entire south Asia covering Bay of Bengal and part of Arabian Sea (5 N-40 N, 65-100 E).

NCMRWF Ensemble Prediction System (NEPS-G) 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 operational NCMRWF Ensemble Prediction System (NEPS) has 22 ensemble members. The horizontal resolution of NEPS is ~12km. The NCUM model analysis is used as the initial condition for the control model forecast. The perturbations are generated by Ensemble Transform Kalman Filter (ETKF) method which are added to the global deterministic analysis to create 22 perturbed initial conditions. These are used for generating ensemble member forecasts. One control and 11 perturbed ensemble members run from initial condition of 00UTC of current day and 11 more perturbed members run from 12 UTC of previous day to give 23 members (11 + 11 + 1 control) ensemble forecasts up to 10 days lead time. More details about NEPS-G are available in Mangain et al. (2018). The new 12-km NEPS-G is the highest resolution for Ensemble forecasting.

4.2.10.3. Models run at IITM Pune

Global Ensemble Forecast System (GEFS) was upgraded from ~27 km (T574 with GEFS v11.3) to ~12 km (T1534) resolution in year 2018. It is based on Global Forecast System (GFS v14.1) which is a part of the “Operational Model” developed at NCEP, USA in 2018. Table 1.0 gives the difference in the versions of the model which was newly implemented. The dynamics, horizontal resolution, representation of physics processes and the Near surface SST (NSST) are among the few to be mentioned which has significant changes in the new version. Apart from the more number of observations, surface perturbations (NSST) are also included in the Initial Conditions (ICs). The total number of 21 Ensembles (20 perturbed forecasts + 1 control forecast) constitutes the ensemble system. These 20 ensembles analysis are generated by Ensemble Kalman Filter (EnKF) method from the forecast perturbation of the previous cycles four times a day (00, 06, 12 and 18 UTC) at all 64 model vertical levels. These analysis perturbations are added to the reconfigured analysis obtained from the hybrid four-dimensional Ensemble variational data assimilation system (GDAS-Hybrid4DEnsVar) as part of the suite. The 243 hour forecast of GEFS is routinely generated based on 00UTC and 12UTC initial conditions which include a control forecast starting from GDAS assimilation and 20 (20 perturbations) ensemble members with each perturbed initial conditions.

4.2.10.4. 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 and INCOIS Advanced Circulation model (AdCirc)..

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 is ADCIRC model is adapted from USA.

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. However, it has not been operationalised considering the large inter-annual & intra-seasonal variability and less number of cases over north Indian Ocean region.

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

(A) WEATHER CHARTS

| Model | Products |
|-----------------------------|---------------------------------------------------------------------|
| GFS (T1534) | Analysis and forecast up to 240 hrs |
| WRF-VAR (ARW) Analysis 9 km | Analysis and forecast up to 72 hrs |
| WRF-VAR (ARW) Analysis 3 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 |
| HWRF | Analyses and forecasts upto five days |
| EPS | Forecast Track and strike probability upto five days |
| GEFS (T1534) | Analysis and forecast up to 192 hrs |
| NCMRWF : GEFS | EPS products, forecast track and strike probability upto five days. |
| NCUM | Analysis and forecast up to 240 hrs. |
| NCUM-EPS | Analysis and forecast up to 240 hrs. |

(B) DOPPLER RADAR PRODUCTS

- MAX(Z) Product (MAX_Z)
- Plan Position Indicator (PPI_Z)
- Volume Velocity processing (VVP_2)
- Plan Position Indicator (PPI_V)
- Surface Rainfall Intensity (SRI_150)
- Precipitation Accumulation (PAC) 24 hrs at 0300 UTC (HOURS_24)

(C) INSAT IMAGES & INSAT PRODUCTS**❖ 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 WVBT image from INSAT-3D
- Daily Average IR1BT image from INSAT-3D
- Cloud Motion Vectors (CMV)
- Water Vapour Winds (WVW)
- Visible/Mid-Infrared Winds (VISW/ MIRW)
- Cloud Top Temperature Image
- Cloud Top Temperature Image (Below -40°C)
- G.P.S. Precipitable Water Data
- 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)
- Map of Daily Mean OLR
- Map of Weekly Mean OLR
- Map of Monthly Mean OLR
- Quantitative Precipitation Estimate (QPE), HE & IMSRA
- Map of Daily QPE, HE & IMSRA
- Map of Weekly QPE, HE & IMSRA
- Map of Monthly QPE, HE & IMSRA

❖ SCATSAT-1 Imageries and Products**NOAA METOP IMAGES (Microwave channel)
SCAT SAT IMAGES**

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.

Tropical cyclone warnings for shipping (WWMIWS) shall be transmitted by agreed means of the GMDSS, according to the provision of the Manual on Marine Meteorological Services (WMO No. 558). The METAREA Coordinator is responsible for ensuring warnings are disseminated on the appropriate GMDSS communication channel. The list of METAREA Coordinators is available from WMO No.9, Volume D, Information for Shipping.

http://www.wmo.int/pages/prog/www/ois/Operational_Information/VolumeD/GMDSS/Focal_Points/GMDSS/fp.pdf

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 | 64 Kbps leased line TCP/IP WMO FTP and 150 Mbps IPVPN TCP/IP WMO Socket circuit over internet. |
| 2 New Delhi- Colombo (Sri Lanka) | 2 Mbps TCP/IP WMO Socket circuit over internet. |
| 3. New Delhi- Dhaka (Bangladesh) | 200 Mbps IPVPN TCP/IP WMO Socket circuit over Internet. |
| 4. New Delhi- Karachi (Pakistan) | 64 kbps leased line TCP/IP Socket circuit and 150 Mbps IPVPN TCP/IP WMO FTP circuit over internet. |
| 5. New Delhi –Malé (Maldives) | 150 Mbps TCP/IP WMO Socket circuit over internet |
| 6. New Delhi -Myanmar | 150 Mbps IPVPN TCP/IP WMO Socket circuit over internet. |
| 7. New Delhi -Muscat | 150 Mbps TCP/IP WMO Socket circuit over internet. |
| 8. New Delhi.-Jeddah | 150 Mbps TCP/IP WMO FTP circuit over internet. |
| 9. New Delhi – Yemen | No direct connectivity. |
| 10. Bangkok – NayPyiTaw (Myanmar) | 20 Mbps IPVPN TCP/IP WMO FTP circuit over Internet |
| 11. Bangkok - Jeddah | 1 Mbps MPLS TCP/IP WMO FTP Circuit and 20 Mbps TCP/IP WMO FTP circuit over internet. |

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 India Meteorological Department is hosting its own website www.internal.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.

5.6 Regional Meteorological Centres located at Delhi, Chennai, Nagpur, Kolkata, Guwahati 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. | Iran | | |
| 4. | Maldives | WTMV20 VRMM | Highest |
| 5. | Myanmar | WTBM20 and WOBM20 VBRR | Highest |
| 6. | Oman (Sultanate of Oman) | WTOM20 and WSOM20 OOMS | Highest |
| 7. | Pakistan | WWPK20 OPKC | Highest |
| 8. | Qatar | FQQT20(with Pakistan Met Service) | Highest |
| 9. | Saudi Arabia | | |
| 10. | Sri Lanka | WTSB40 VCCC | Highest |
| 11. | Thailand | WTTH20 VTBB | Highest |
| 12. | United Arab Emirates | | |
| 13. | 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 | Since conventional radar has been replaced by DWR, there is no message communication on GTS. |
| 3. | Iran | . |
| 4. | Maldives | SDMV20 VRMM |
| 5. | Myanmar | SDBM20 VBRR |
| 6. | Oman | |
| 7. | Pakistan | SDPK20 OPKC SDPK40 OPKC |
| 8. | Qatar | |
| 9. | Saudi Arabia | |
| 10. | Sri Lanka | SDSB20 VCCC |
| 11. | Thailand | SDTH20 VTBB |
| 12. | United Arab Emirates | |
| 13. | Yemen | |

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> | |
|----------------|---------------------------------|--------------------------------|
| | <u>Tropical weather outlook</u> | <u>Tropical storm advisory</u> |
| Bangladesh | WWBW20 VGDC, | BMAA01 VGDC |
| India | WTIN20 DEMS | BMAA01 VBRR |
| Pakistan | WWPK20 OPKC | BMAA01 OPKC |
| | | BMAA01 VCCC |
| | | BMAA01 VTBB |
| | | BMAA01 VRMM |
| | | BMAA01 OOMS |
| | | BMAA01 OYSN |
| | | BMAA01 OIII |
| | | BMAA01 OTBD |
| | | BMAA01 OEJD |
| | | BMAA01 OMAA |

Satellite bulletins generated by RTH, New Delhi

| | |
|--------------------------------------------------------|-------------------------------------|
| TCIN20 DEMS (Sat bulletins based on INSAT pictures) | - For International For National |
| TCIN50 DEMS (Sat bulletins based on INSAT pictures) | |
| 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>Originating center</u> |
|----|--------------------------|-------------------------------------------|------------------------------|
| 1. | Bangladesh | WCBWxx VGHS | 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 | WCYE31OYSN | SANAA |

Notes: Yemen

1. TCAC New Delhi shall send the TC advisories to the MWOs through AFTN. In addition to the MWOs listed above, the advisories 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 send the TC advisories to Singapore OPMET Data Bank – AFTN address WSSSYMYX.
3. The MWOs listed above sends 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

Bangladesh

Md. Azizur Rahman
 Director, BMD
 Bangladesh Meteorological Department
 Meteorological Complex, E-24
 Agargaon, Dhaka-1207
 Dhaka-1207

Phone: Off: (880) 2-9135742,
 (880) 2-9123838
 Cell:
 Res: (880) 2-9827598
 (880) 2-58152019
 E-mail: info@bmd.gov.bd,
 sifatar@yahoo.com
 FAX: 88 02 8152019, 48113333
 Home page: <http://www.bmd.gov.bd>

Kawsar Parvin
 Deputy Director
 Storm Warning Centre
 Dhaka

Phone: Off: (880) 2-9114388
 Res: (880) 2-9126806
 Cell: 01743783969
 Fax: (880) 2-58152019
swc@bmd.gov.bd

Duty Forecasting Officer
 Storm Warning Centre
 Dhaka

Phone: (880) 2-9141437
 (880) 2-9135742
 (880) 2-9111015
 (880) 2-9112439
 Fax: (880) 2-58152019
swc@bmd.gov.bd

India

Dr. Mrutyunjay Mohapatra
 Director General of Meteorology
 India Meteorological Department (IMD)
 Regional Telecommunication Hub
 Mausam Bhavan, Lodi Road

Phone: Off: (91) 11-24611842
 Res: (91) 11-24122236
 Fax (91) 11-24611792
 E-mail: mohapatrainmd@gmail.com
 Home page: <http://www.imd.gov.in>

Iran

Dr. Sahar Tajbakhsh Mosalman
 Deputy Minister of Roads and Urban Development
 President of the I.R. of Iran Meteorological
 Organisation and PR of Islamic Republic
 of Iran with WMO

Tel: +9821 660 700 38
 email: affairs.int@gmail.com
 FAX: +9821 660 700005

Maldives

Mr. Ali Sareef
 Deputy Director General,
 Maldives Meteorological Service,
 Hulhule' 22000,
 Maldives.

Phone: Off: (960) 332 3084
 332 3302
 Mobile: (960) 7771828
 Email: shareef@meteorology.gov.mv

Duty Forecaster,
 National Meteorological Centre

Phone: Off: (960) 332 3084
 Mobile: (960) 796 7171
 Email: metmdv@gmail.com

Myanmar

Dr. Kyaw Moe Oo
 Director-General
 Department of Meteorology
 and Hydrology
 Building No. 5

Phone: Off: (95) 67 3411031
 (95) 67 3411525
 (95) 67 3411422
 (95) 67 3411446

V-8
ANNEX V-A-2

Nay Pyi Taw (95) 67 3411527
(95) 67 3411527
Res: (95) 67 3403404
Fax: (95) 67 3411449
(95) 67 3411254
(95) 67 3411250
(95) 67 3411526
Mobile: (95) 9 250954638
Email: dg.dmh1@gmail.com
dg.dmh@mptmail.net.mm
Web page: www.moezala.gov.mm
www.dmh.gov.mm

Oman

Dr. Juma Said Al-Maskari
Director General of Meteorology
Public Authority for Civil Aviation
P.O. Box 1, P.C. 111
Muscat
Phone : 00968 24354555
Cell : 00968 99262656
Fax : 00968 24354504
Email : j.almaskari@met.gov.om

Mr. Badar Alrumhi
Phone: 00968 24354610 (office)
+968 24354660 (24hrs)
Cell : 00968 99327811
Director of Forecasting &
Early Warning Centre
Fax : 00968 24348501,502 (24 hours)
Email: b.alrumhi@met.gov.om

Mr. Khalid Alwahaibi
Phone: 00968 24354655 (office)
+968 24354660 (24hrs)
Chief of General Forecasting & EWS
Fax : 00968 24348501,502 (24 hours)
Email: k.alwahaibi@met.gov.om

Pakistan

Mr. Sahibzad Khan
Director General
Pakistan Meteorological Department
Headquarters Office, Sector H-8/2,
Islamabad – 44000, Pakistan
Tel: + (92) 51-9250367,
Fax: + (92) 51-9250368
Email: pakmet_islamabad@yahoo.com
Website: <http://www.pmd.gov.pk>

Mr. Abdul Qayoom Bhutto
Director
Marine Meteorology –
Tropical Cyclone Warning Centre (TCWC),
Meteorological Complex, University Road,
Karachi – 75270, Pakistan
Tel: + (92) 21-99261434,
Cell: + (92) 333-7271894
Fax: + (92) 21-99261405, 99261407
Email: aq_1961@yahoo.com
Website: <http://www.pmd.gov.pk>

Dr. Muhammed Hanif
Director
Marine Meteorology –
Tropical Cyclone Warning Centre (TCWC),
Meteorological Complex, University Road,
Karachi – 75270, Pakistan
Tel/Fax: + (92) 21-99261434,
Cell: + (92) 334-5635796
Email: hanifwxc@hotmail.com

Duty Forecasting Officer / Meteorologist,
Main Analysis Centre
Meteorological Complex, University Road
Karachi – 75270, Pakistan
Tel: + (92) 21-99261417
+ (92) 21 99238958 (24 Hours)
Fax: + (92) 21-99261405
Website: [http:// www.pmd.gov.pk](http://www.pmd.gov.pk)

V-9
ANNEX V-A-3

Qatar

Mr Abdullah AlMannai
Director of Qatar Meteorology
Department and Permanent
Representative of Qatar
with WMO

Email: Abdulla.Almannai@caa.gov.qa

Mr Mohammad Al-Kubaisi
Head of Forecasting
and Analysis Section

Email: Mohammad.Alkubaisi@caa.gov.qa

Mr Khalid Al-Jahwari
Meteorology Expert
Qatar Meteorology Department

Email: Khalid.Aljahwari@caa.gov.qa

Website: www.qweather.gov.qa

Saudi Arabia

Mr. Ayman S Ghulam, Ph D
Vice President of Meteorological Affairs
General Authority of Meteorology &
Environmental Protection Kingdom of Saudi Arabia

Phone: 966 12 653 6000
FAX: 966 12 651 1424
email: dms@pme.gov.sa

Sri Lanka

Mr. Athula Kumara Karunanayake
Director-General of Meteorology
Department of Meteorology
Baudhaloka Mawatha
Colombo-7

Phone: Off: (94) 11-2694104
Cell: 94773050535
Fax (94) 11-2698311
E-mail: athu1970@yahoo.com
Homepage: <http://www.meteo.gov.lk>
E-mail: meteo@sltnet.lk

Director, Weather Forecasting and Decision Support

Dr. Shiromani Jayawardena, Director
National Meteorological Center,
Colombo

Phone off: (94) 11-2691443
Cell : 94714398874
Fax (94) 11-2691443
E-mail: shirojaya2000@yahoo.com

Mr. M. M. P. Mendis
Deputy Director, NMC, Colombo

Phone/Fax (94) 11-2682661
E-mail: merilmdi@yahoo.com

Duty Meteorologist, NMC, Colombo

Phone (94) 11-2686686
E-mail: metnmc@gmail.com

Duty Meteorologist, Met office
International Airport, Katunayake

Phone (94) 11-2252721
E-mail: meteo.kia@gmail.com

Duty Meteorologist, Met office
International Airport, Mattala

Fax: (94) 11-2252319
Phone (94) 47-2031488 (47)
Fax: (94) 47-2031489 (47)
E-mail: met.mattala@gmail.com

Thailand

Mr. Nattapon Nattasomboon
Director-General
Thai Meteorological Department
4353 Sukumvit Road
Bang-Na, Bangkok 10260

Phone : (66) 2-399 1425
Fax : (66) 2-399 1426
E-mail : tmd_inter@tmd.go.th
Home page: <http://www.tmd.go.th>

United Arab Emirates

Mr. Abdulla Ahmed Al Mandous www.qweather.gov.qa
Executive Director, National Centre for Meteorology and Seismology,
Abu Dhabi, Post Box No. 4815, United Arab Emirates
Phone: +971 2222 7777, Fax: : +971 2666 1575

Yemen

- (1) Mr. Mohammed S. Hamid Alzuraiqi
PR of Yemen with WMO
Assistant Deputy Chairman for Meteorology,
Civil Aviation & Meteorology Authority,
Yemen Meteorological Service (CAMA/YMS)
Republic of Yemen
Phone: + 967 1 419771
Cell:+ 967-777228636
Fax: + 967 1 419770
Email: yms@yms.gov.ye
Home page: <http://www.yms.gov.ye>
- (2) **Mr. Rashed Al Areqi**
Director, Public Weather Service
Yemen Meteorological Service
Republic of Yemen
Phone: + 967736021713
FAX: + 967 1 419770
Email: rash_areqi@yahoo.com

Focal Points of the Forecast Center (in accordance to Para. 9.5 of PTC -36th final report)

Bangladesh

Kawsar Parvin
Deputy Director
Storm Warning Centre
Dhaka

Phone: Off: (880) 2-9114388
Res: (880) 2-9126806
Fax: (880) 2-58152019

E-mail: kawsarpervin@yahoo.com, swc@bmd.gov.bd

India :

Dr. Rajendra Kumar Jenamani
Scientist-F and
Head RSMC, New Delhi

Phone: Off: (91)11-24652484,
(91) 11-24631913
Mob: (91) 9971022981
E-mail: cwdhq2008@gmail.com
jenamanirk@gmail.com

Duty Officer

Phone:(91) 11-24631913 (24 hrs)

Dr. Ananda Kumar Das
Scientist-E and
Head Cyclone Warning Division

Phone: Off: (91)11-24652484,
(91) 11-24631913
Mob: (91) 9868126275
E-mail: cwdhq2008@gmail.com
akuda.imd@gmail.com

Duty Officer

Phone: (91) 11-24631913 (24 hrs)

Mrs. Monica Sharma
Scientist-D and

Phone: Off: (91)11-43824304
(91) 11-24631913
Mob: (91) 9990389494

E-mail: cyclonewarningdivision@gmail.com
moniimd@gmail.com

Duty Officer

Phone: (91) 11-24631913 (24 hrs)

Iran

Maldives

Ali SHAREEF
Deputy Director General,
Maldives Meteorological Service,
Hulhule' 22000,
Maldives.

Phone: Off: (960) 332 6200
Fax: (960) 332 0021, 334 1797
Res: (960) 332 2829
Mobile: (960) 7771828
Email: shareef@meteorology.gov.mv

Ahmed Rasheed
Meteorologist
Maldives Meteorological Service,
Hulhule' 22000,
Maldives.

Phone: Off: (960) 332 3084
Fax: (960) 332 0021, 3315509
Mobile: (960) 7768565
Email: rasheed@meteorology.gov.mv

Duty Forecaster
Meteorological Watch Office
National Meteorological Centre

Phone: Off: (960) 332 3084
Fax: (960) 331 5509,
Mobile: (960) 796 7171
Email: metmdv@gmail.com

Myanmar

Dr. Tin Mar Htay
 Department of Meteorology
 and Hydrology
 Office No. (5) Ministry of Transport
 Nay Pyi Taw, Myanmar

Phone: Off: (95) 67 3 411526
 Fax: (95) 67 3411527
 Mobile: (95) 9 250954664
 Email: tmahrtay@gmail.com

Sultanate of Oman

Mr. Khalid Alwahaibi

 Chief of General Forecasting & EWS
 Directorate General of Meteorology
 Public Authority for Civil Aviation
 P.O.BOX 1, P. C. 111
 Muscat

Phone: 00968 24354655
 (Office: +968 24354660 (24hrs)
 Fax: 00968 24348501,502 (24 hrs)
 Email : k.alwahaibi@met.gov.om

Pakistan

Mr. Abdul Qayoom Bhutto
 Director
 Marine Meteorology-
 Tropical Cyclone Warning Centre
 Meteorological Complex, University Road
Karanchi-75270, Pakistan

Tel : +(92) 21 - 99261434
 Fax: + (92)-21- 99261405
 Cell: +(92) 333-7271894
 Email: aq_1961@yahoo.com

Mr. Muhammad Hanif
 Director,
 National Weather Forecasting Centre,
 Pakistan Meteorological Department,
 Head quarters Office, Sector H-8/2,
Islamabad- 44000, Pakistan

Tel: +92-51-9250595
 +92-51-9250363-4 (24 Hours)
 Fax: +92-51-9250368,
 Cell: +92-0334 5635796
 Email: hanifwxc@hotmail.com
 pmd@pmd.gov.pk
 PMD website:

<http://www.pmd.gov.pk>

Qatar

Gulf Marine Center

Phone: (+974)44480405
 : (+974)40102239
 Email: Met.Media@caa.gov.qa

Saudi Arabia**Sri Lanka**

Mr. A. K. Karunanayake
 Director General
 Department of Meteorology
 COLOMBO 7,
 SRI LANKA

Phone/Fax NO. (94)11-2694104
 Email: athu1970@yahoo.com

Dr. Shiromani Jayawardena
 Director
 National Meteorological Centre
 Department of Meteorology
 COLOMBO 7, SRI LANKA

Phone No.: (94)11-2691443
 Fax No.: (94)11-2698311
 Email: shirojaya2000@yahoo.com

Mr. M. M. P. Mends
 Deputy Director
 National Meteorological Centre
 Department of Meteorology

Phone No.: (94)11-2682661
 Fax No.: (94)11-2698311
 Email: merilmidi@yahoo.com

COLOMBO 7, SRI LANKA
 Duty Meteorologist
 National Meteorological Centre
 Department of Meteorology
 COLOMBO 7, SRI LANKA

Phone No. (94)11-2684746/ (94)11-2686686
 Fax No.: (94)11-2691443
 E-mail: metnmc@gmail.com

Thailand

Ms. Chalalai Jamphon
 Director, Weather Forecast Division
 Thai Meteorological Department
 4353 Sukumvit Road
 Bang-Na
 Bangkok 10260
 THAILAND

Phone: (66) 2-398 9801
 Fax : (66) 2-399 4001
 (24 hours)
 E-mail: chalalaj@yahoo.com
tmd_inter@tmd.go.th
 Home page: <http://www.tmd.go.th>

Mr. Chaichan Sitthiworanun
 Acting Director, Central Weather Forecast
 Sub-division, Weather Forecast Division
 Thai Meteorological Department
 4353 Sukumvit Road
 Bang-Na
 Bangkok 10260
 THAILAND

Phone: (66) 2-398 9830
 Fax: (66) 2-398 9836
 (66) 2-398 9816
 (24 hours)
 E-mail: ttoon11@gmail.com
 Home page: <http://www.tmd.go.th>

United Arab Emirates:

Majed Naser Alshkeili
 Head of Marine Forecast Section
 National Center of Meteorology (NCM)
 Ministry of Presidential Affairs (MOPA)
 P.O Box 4815 | Abu Dhabi | United Arab Emirates

Tel + 971 2 2227330
 Fax + 971 2 6661575
 Mob + 971 50 6620028
 Email: malsheikili@ncms.ae
 Website | www.ncm.ae

Yemen

Mr. Mohammed S. Hamid Alzuraiqi
 PR of Yemen with WMO
 Assistant Deputy Chairman for Meteorology,
 Civil Aviation & Meteorology Authority,
 Yemen Meteorological Service (CAMA/YMS)
 Republic of Yemen

Phone: + 967 1 419771
 Cell:+ 967-777228636
 Fax: + 967 1 419770
 Email: yms@yms.gov.ye

Home page:<http://www.yms.gov.ye>

Mr. Rashed Al Areqi
 Director, Public Weather Service
 Yemen Meteorological Service
 Republic of Yemen

Phone: + 967736021713
 FAX: + 967 1 419770
 Email: rash_areqi@yahoo.com

PTC Secretariat

WMO Tropical Cyclone programme (TCP)

Mr Taoyong Peng
 Chief, Tropical Cyclone Programme Division
 WDS Department, WMO, Geneva

Tel.+(41 22) 730 8145
 Fax : +(41 22) 730 8021
 E-Mail: tpeng@wmo.int

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.
- (iv) 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.
- (v) The online version of e-Atlas is available at IMD Website at Cyclone Page under the URL: www.rmchennaieatlas.tn.nic.in.
- (vi) All the annual reports on cyclonic disturbances are available for the period of 1990 onwards in the RSMC, New Delhi website.
- (vii) Bulletins of cyclonic storms since 2011 are available on RSMC 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 (30-60nm; 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)
- 109-110 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 (2digit 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.