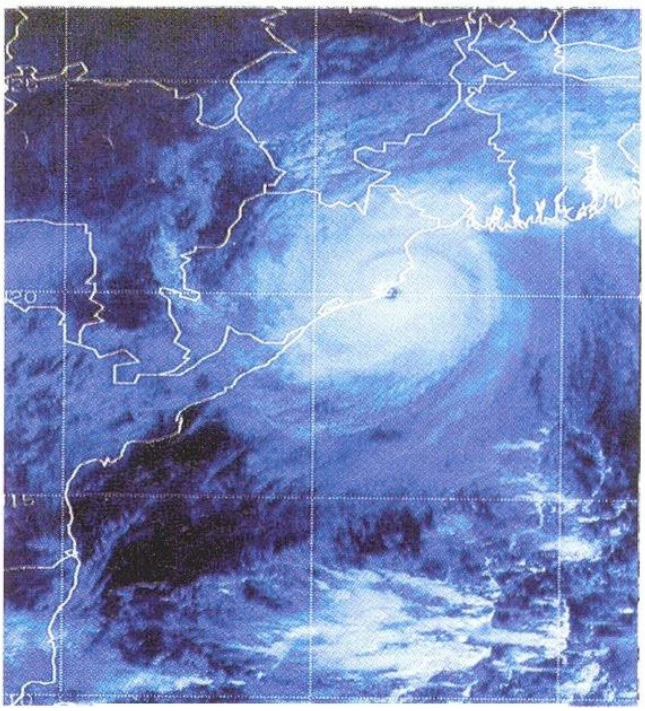
Frequently Asked Questions on Tropical Cyclones and Marine Weather Services



Frequently Asked Questions on Tropical Cyclones

1. **What is a tropical cyclone?**

   A tropical cyclone (**TC**) is a rotational low-pressure system in tropics when the central pressure falls by 5 to 6 hPa from the surrounding and maximum sustained wind speed reaches 34 knots (about 62 kmph). It is a vast violent whirl of 150 to 800 km, spiraling around a centre and progressing along the surface of the sea at a rate of 300 to 500 km a day.

   The word cyclone has been derived from Greek word ‘cyclos’ which means ‘coiling of a snake’. The word cyclone was coined by Henry Piddington who worked as a Rapporteur in Kolkata during British rule. The terms "hurricane" and "typhoon" are region specific names for a strong "tropical cyclone". Tropical cyclones are called “Hurricanes” over the Atlantic Ocean and “Typhoons” over the Pacific Ocean.

2. **Why do ‘tropical cyclones' winds rotate counter-clockwise (clockwise) in the Northern (Southern) Hemisphere?**

   The reason is that the earth's rotation sets up an apparent force (called the Coriolis force) that pulls the winds to the right in the Northern Hemisphere (and to the left in the Southern Hemisphere). So, when a low pressure starts to form over north of the equator, the surface winds will flow inward trying to fill in the low and will be deflected to the right and a counter-clockwise rotation will be initiated. The opposite (a deflection to the left and a clockwise rotation) will occur south of the equator.

   This Coriolis force is too tiny to effect rotation in, for example, water that is going down the drains of sinks and toilets. The rotation in those will be determined by the geometry of the container and the original motion of the water. Thus, one can find both clockwise and counter-clockwise flowing drains no matter what hemisphere you are located. If you don't believe this, test it out for yourself.

3. **What does "maximum sustained wind" mean? How does it relate to gusts in tropical cyclones?**

   India Meteorological Department (IMD) uses a 3 minutes averaging for the sustained wind. The maximum sustained wind mentioned in the bulletins used by IMD is the highest 3 minutes surface wind occurring within the circulation of the system. These surface winds are observed (or, more often, estimated) at the standard meteorological height of 10 m (33 ft) in an unobstructed exposure (i.e., not blocked by buildings or trees).

   The National Hurricane Centre uses a 1-minute averaging time for reporting the sustained. Some countries also use 10 minutes averaging time for this purpose. While, one can utilize a simple ratio to convert from peak 10-minute wind to peak 1 minute wind or 3-minute wind, such systematic differences to make inter-basin comparison of

tropical cyclones around the world is problematic. Howeverthere is no significant difference between the maximum sustained winds reported in different basis with different averaging method.

4. What is the energy potential of a Tropical Cyclone?

Tropical Cyclone can be compared to a heat engine. The energy input is from warm water and humid air over tropical oceans. Release of heat is through condensation of water vapour to water droplets/rain. Only a small percentage (3%) of this released energy is converted into Kinetic energy to maintain cyclone circulation (windfield). A mature cyclone releases energy equivalent to that of 100 hydrogen bombs.

5. How are low pressure system classified in India? What are the differences between low, depression and cyclone?

The low-pressure systems over Indian region are classified based on the maximum sustained winds speed associated with the system and the pressure deficit/ number of closed isobars associated with the system. The pressure criteria are used when the system is over land and wind criteria is used, when the system is over the Sea. The system is called as low if there is one closed isobar in the interval of 2 hPa. It is called depression, if there are two closed isobars, a deep depression, if there are three closed isobars and cyclonic storm if there are four or more closed isobars. The detailed classification based on wind criteria are given in the Table below. Considering wind criteria, the system with wind speed of 17-27 knots is called as depression and the low pressure system with maximum sustained 3 minutes surface winds between 28-33 knots is called a deep depression. The system with maximum sustained 3 minutes surface winds of 34 knots or more is called as cyclonic storm.

System	Pressure deficient hPa w.r.t T No.	Associated wind speed Knots (Kmph)
Low pressure area	1.0	<17(<31)
Depression	1.0- 3.0	17-27 (31-49)
Deep Depression (DD)	3.0 - 4.5	28-33 (50-61)
Cyclonic Storm (CS)	6.1-10.0	34-47 (62-88)
Severe Cyclonic Storm (SCS)	15.0	48-63 (89-117)
Very Severe Cyclonic Storm (VSCS)	20.9-29.4	64-89 (118-166)
Extremely Severe Cyclonic Storm (ESCS)	40.2-65.6	90-119 (167-221)
Super Cyclonic Storm	≥ 80.0	≥ 120 (≥ 222)

6. **Are all cyclonic storms equally dangerous?**

No, all cyclonic storms are not equally dangerous. More the pressure drops at the central region more will be the severity of the storm. The cyclonic storms are generally categorized according to the maximum wind associated with the storm. If the maximum wind is between 34 - 47 knots (about 62-88 kmph) it is called a Cyclonic storm. Severe Cyclonic storm will have maximum wind speed between 48 - 63 knots (about 89-117 kmph). If the maximum wind is 64-89 knots it will be called a very severe Cyclonic storm. If the maximum wind is 90-119 knots it will be called as Extremely Severe Cyclonic storm and when the wind is 120 knots and above it will be called super cyclonic storm. There is very little association between intensity (either measured by maximum sustained winds or by the lowest central pressure) and size (measured by radius of gale force winds)

7. **What is the intensity of a cyclone?**

Intensity of a cyclone can be derived as the near-surface maximum wind speed around the circulation centre, or as the minimum surface pressure at the tropical cyclone pressure centre. The intensity classification of cyclone as per their wind speed and pressure defect is given in the table above.

8. **What are the super cyclone, super-typhoon, a major hurricane and an Intense hurricane?**

When the maximum sustained 3 minutes surface winds are more than 119 knots, the low pressure system is called as “super cyclone” over north Indian Ocean. Similarly, “Super-typhoon" is a term utilized by the U.S. Joint Typhoon Warning Centre for typhoons that reach maximum sustained 1 minute surface winds of at least 130 knots (65 m/s). This is the equivalent of a strong Saffir-Simpsoncategory 4 or category 5 hurricane in the Atlantic basin or a category 5 severe tropical cyclone in the Australian basin.

9. **What is landfall of a cyclone?**

Landfall is the event of a tropical cyclone coming onto land after being over water. A tropical cyclone is classified as making landfall when the center of the storm moves across the coast; in strong tropical cyclones this is when the eye moves over land. This is where most of the damage occurs within a mature tropical cyclone as most of the damaging aspects of these systems are concentrated near the eye-wall. Such effects include the peaking of the storm surge, the core of strong winds comes on shore, and heavy flooding rains. These coupled with high surf can cause major beach erosion. When a tropical cyclone makes landfall, the eye closes in upon itself due to the weakening process, which causes surf to decrease. Maximum sustained wind will naturally decrease as the cyclone moved inland due to frictional differences between

water and land with the free atmosphere.

A "landfall" should not be confused with a direct hit, as a direct hit is where the core of high winds (or eye-wall) comes onshore but the center of the storm may stay offshore. The effects of this are similar to a landfall, as this term is used when the radius of maximum wind within a tropical cyclone moves ashore. These effects are; high surf, heavy rains that may cause flooding, water build up along the coast with minor storm surge, coastal beach erosion, high winds, and possibly severe weather.

10. What is radius of maximum wind of a Tropical cyclone?

The radius of maximum wind (RMW) of a tropical cyclone is defined to be the distance between the center of the cyclone and its band of strongest winds. It is considered an important parameter in atmospheric dynamics and tropical cyclone forecasting.

11. How is the radius of maximum wind determined?

Aircraft

The RMW is traditionally measured by reconnaissance aircraft in the Atlantic basin. It can also be determined on weather map as the distance between the cyclone center and the system's greatest pressure gradient.

A. Satellite

The distance between the coldest cloud top temperature and the warmest temperature within the eye, in infrared satellite imagery, is one method of determining RMW. The reason why this method has merit is that the strongest winds within tropical cyclone tend to be located under the deepest convection, which is seen on satellite imagery as the coldest cloudtops

12. What does the RMW help?

The radius of maximum wind helps determine the direct strikes of tropical cyclones. Tropical cyclones are considered to have made a direct strike to a landmass when a tropical cyclone passes close enough to a landmass that areas inside the radius of maximum wind are experienced on land.

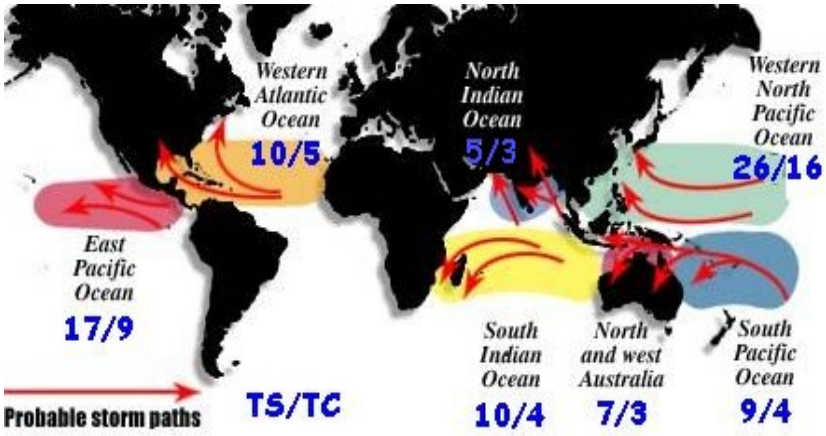
The highest storm surge is normally coincident with the radius of maximum wind. Because the strongest winds within a tropical cyclone lie at the RMW, this is the region of a tropical cyclone which generates the dominant waves near the storm, and ultimately ocean swell away from thecyclone.

13. What is radius of maximum reflectivity?

The radial distance from the Tropical cyclone centre to the point of maximum reflectivity is known as the radius of maximum reflectivity.

14. Where do Tropical Cyclones form?

The tropical cyclones form over ocean basins in lower latitudes of all oceans except south Atlantic and southeast Pacific. The tropical cyclones develop over the warm waters of the Bay of Bengal and the Arabian Sea. The favourable ocean basins for development of cyclonic storms are shown in the figure. TC breeding grounds are located over certain ocean basins. Arrows indicate average trajectories over different basins.

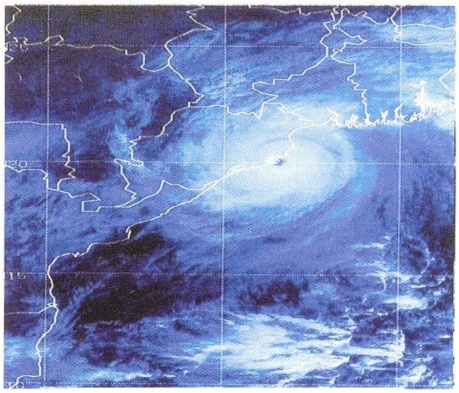


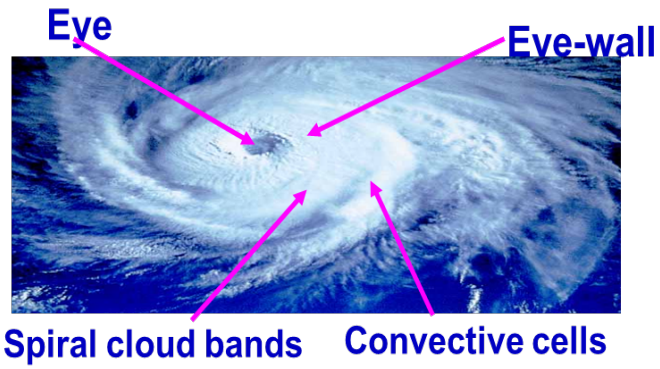
15. What is the size of a tropical cyclone over the north Indian Ocean?

The size of a Tropical Cyclone over Indian seas varies from 50-100 km radius to 2000 km with an average of 300 –600 km.

16. What is the structure of a Tropical Cyclone?

A fully developed tropical cyclone has a central cloud free region of calm winds, known as the "**eye**" of the cyclone with diameter varying from 10 to 50 km. Surrounding the eye is the "**wall cloud region**" characterized by very strong winds and torrential rains, which has the width of about 10 to 150 km. The winds over this region rotate around the centre and resemble the "coils of a snake". Wind speed fall off gradually away from this core region, which terminate over areas of weaker winds with overcast skies and occasional squall. There may be one or more spiral branch in a cyclone where higher rainfall occurs. The vertical extent of the cyclone is about 15 km. The INSAT imagery of Odisha Super cyclone on 29th October, 1999 is shown in the figure below.





17. What is a "CDO"?

"CDO" is an acronym that stands for **"central dense overcast"**. This is the cirrus cloud shield that results from the thunderstorms in the eye-wall of a tropical cyclone and its rain bands. Before the tropical cyclone reaches very severe cyclonic storm (64 knots), typically the CDO is uniformly showing the cold cloud tops of the cirrus with no eye apparent. Once the storm reaches the hurricane strength threshold, usually an eye can be seen in either the infrared or visible channels of the satellites. Tropical cyclones that have nearly circular CDOs are indicative of favourable, low vertical shear environments.

18. What is the "eye"? How is it formed and maintained? What is the "eye-wall"? What are "spiral bands"?

The **"eye"** is a roughly circular area of comparatively light winds and fair weather found at the centre of a severe tropical cyclone. Although the winds are calm at the axis of rotation, strong winds may extend well into the eye. There is little or no precipitation and sometimes blue sky or stars can be seen. The eye is the region of lowest surface pressure and warmest temperatures aloft - the eye temperature may be 10°C warmer or more at an altitude of 12 km than the surrounding environment, but only 0-2°C warmer at the surface in the tropical cyclone. Eyes range in size from 8 km to over 200 km across, but most are approximately 30-60 km in diameter.

The eye is surrounded by the **"eye-wall"**, the roughly circular ring of deep convection, which is the area of highest surface winds in the tropical cyclone. The eye is composed of air that is slowly sinking and the eye-wall has a net upward flow as a result of many moderate - occasionally strong - updrafts and downdrafts. The eye's warm temperatures are due to compressional warming of the subsiding air.

Most soundings taken within the eye show a low-level layer, which is relatively moist, with an inversion above - suggesting that the sinking in the eye typically does not reach

the ocean surface, but instead only gets to around 1-3 km of the surface.

The exact mechanism by which the eye forms remains somewhat controversial. One idea suggests that the eye forms as a result of the downward directed pressure gradient associated with the weakening and radial spreading of the tangential wind field with height (Smith, 1980). Another hypothesis suggests that the eye is formed when latent heat release in the eye-wall occurs, forcing subsidence in the storm's centre (Shapiro and Willoughby, 1982). It is possible that these hypotheses are not inconsistent with one another. In either case, as the air subsides, it is compressed and warms relative to air at the same level outside the eye and thereby becomes locally buoyant. This upward buoyancy approximately balances the downward directed pressure gradient so that the actual subsidence is produced by a small residual force.

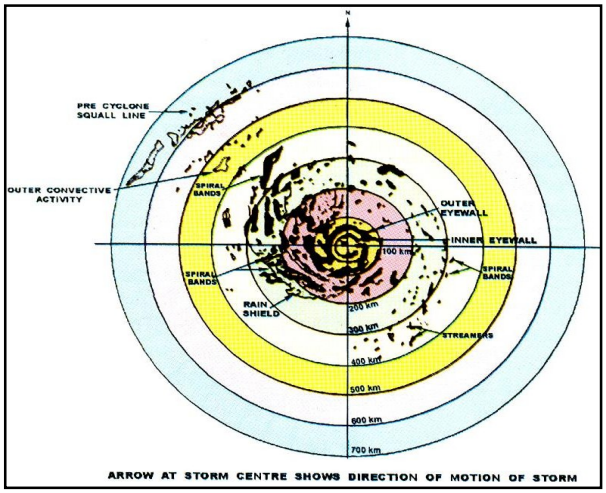
Another feature of tropical cyclones that probably plays a role in forming and maintaining the eye is the eye-wall convection. Convection in tropical cyclones is organized into long, narrow rain bands which are oriented in the same direction as the horizontal wind. Because these bands seem to spiral into the centre of a tropical cyclone, they are called **"spiral bands"**. Along these bands, low-level convergence is a maximum, and therefore, upper-level divergence is most pronounced above. A direct circulation develops in which warm, moist air converges at the surface, ascends through these bands, diverges aloft, and descends on both sides of the bands. Subsidence is distributed over a wide area on the outside of the rainband but is concentrated in the small inside area. As the air subsides, adiabatic warming takes place, and the air dries. Because subsidence is concentrated on the inside of the band, the adiabatic warming is stronger inward from the band causing a sharp contrast in pressure falls across the band since warm air is lighter than cold air. Because of the pressure falls on the inside, the tangential winds around the tropical cyclone increase due to increased pressure gradient. Eventually, the band moves toward the centre and encircles it and the eye and eye-wall form.

Thus, the cloud-free eye may be due to a combination of dynamically forced centrifuging of mass out of the eye into the eye-wall and to a forced descent caused by the moist convection of the eye-wall. This topic is certainly one that can use more research to ascertain which mechanism is primary.

Some of the most intense tropical cyclones exhibit concentric eye-walls, two or more eye-wall structures centered at the circulation centre of the storm. Just as the inner eye-wall forms, convection surrounding the eye-wall can become organized into distinct rings. Eventually, the inner eye begins to feel the effects of the subsidence resulting from the outer eye-wall, and the inner eye-wall weakens, to be replaced by the outer eye-wall. The pressure rises due to the destruction of the inner eye-wall are usually more rapid than the pressure falls due to the intensification of the outer eye-wall, and the cyclone itself weakens for a short period of time.

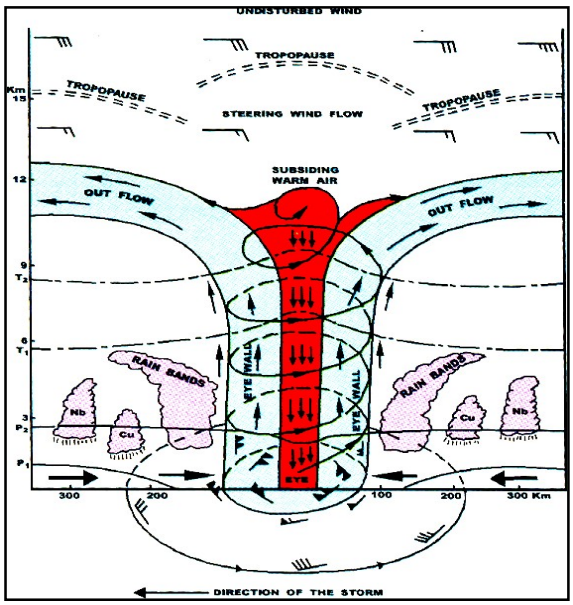
19. How does the cyclone look like in a Radar?

According to Radar imagery, a matured cyclone consists of eye, eye wall, spiral bands, pre-cyclone squall lines and streamers as shown in the above figure.



20. What is the wind structure in a cyclone?

The ideal wind and cloud distribution in a cyclone is shown in the following figure.
The band of maximum winds may vary between 10 and 150 Km. In this belt, speed decreases rapidly towards the eye of the cyclone. But it decreases slowly and in an irregular fashion outward from the eye wall.



21. How do the cyclones form and intensify?

In the tropics, weak pressure waves move from east to west. These are called easterly waves. Under favourable situation, a low pressure area forms over the area of an

easterly trough. This gives rise to low level convergence. If the sea is warm (sea surface temperature $\geq 26.5^0$C) and there is sufficient upper level divergence i.e air is blown off at higher levels from the area of low pressure, the pressure gradually falls. Low level convergence coupled with upper level divergence gives rise to vertical motion taking moist air upwards. These moistures condense at higher levels (middle troposphere) and give out latent heat of condensation. Due to release of heat of condensation the area warms up resulting into further fall in pressure. This process continues and a low pressure system gradually intensifies into a cyclonic storm.

Hence, for tropical cyclogenesis, there are several favourable environmental conditions that must be in place. They are: -

1. Warm ocean waters (of at least 26.5°C) throughout a sufficient depth (unknown how deep, but at least on the order of 50 m). Warm waters are necessary to fuel the heat engine of the tropical cyclone.
2. An atmosphere which cools fast enough with height such that it is potentially unstable to moist convection. It is the thunderstorm activity which allows the heat stored in the ocean waters to be liberated for the tropical cyclone development.
3. Relatively moist layers near the mid-troposphere (5 km). Dry mid levels are not conducive for allowing the continuing development of widespread thunderstorm activity.
4. A minimum distance of at least 500 km from the equator. For tropical cyclogenesis to occur, there is a requirement for non-negligible amounts of the Coriolis force (attributed to earth's rotation) to provide the near gradient wind balance to occur. Without the Coriolis force, the low pressure of the disturbance cannot be maintained. This is the reason why the narrow corridor of width of about 300 km on either side of the equator is free from cyclones. Because of this there is no inter-hemispheric migration of tropical cyclones across the equator.
5. A pre-existing near-surface disturbance with sufficient vorticity (rotation) and convergence. Tropical cyclones cannot be generated spontaneously. To develop, they require a weakly organized system with sizable spin and low level inflow.
6. Low values (less than about 10 m/s or 20 knots) of vertical wind shear between the lower (1.5 km) and the upper troposphere (12 km). Vertical wind shear is the magnitude of wind change with height. Large values of vertical wind shear disrupt the incipient tropical cyclone and can prevent genesis, or, if a tropical cyclone has already formed, large vertical shear can weaken or destroy the tropical cyclone by interfering with the organization of deep convection around the cyclone centre.

The above conditions are necessary but not sufficient, as many disturbances that appear to have favourable conditions do not develop. However, these criteria fit well over the north Indian Ocean.

22. What is the role of easterly wave on cyclogenesis in north Indian Ocean?

It has been recognized since at least the 1930s that lower tropospheric westward

traveling disturbances often serve as the "seedling" circulations for a large proportion of tropical cyclones. These disturbances are known as **easterly waves**.

The waves move generally toward the west in the lower tropospheric trade wind flow. They are first seen usually in October to April. The waves have a period of about 3 or 4 days and a wavelength of 2000 to 2500 km. One should keep in mind that the "waves" can be more correctly thought of as the convectively active troughs along an extended wave train. Though, these waves are generated frequently, but it appears that the number that is formed has no relationship to how much tropical cyclone activity there is over the north Indian Ocean each year. It is currently completely unknown, how, easterly waves change from year to year in both intensity and location and how these might relate to the activity?

23. Is there any extra-tropical cyclone?

Extra-tropical cyclones are low pressure systems with associated cold fronts, warm fronts, and occluded fronts. The **extra-tropical cyclone** is a storm system that primarily gets its energy from the horizontal temperature contrasts that exist in the atmosphere. Extra-tropical cyclones are low pressure systems with associated cold fronts, warm fronts, and occluded fronts. **Tropical cyclones**, in contrast, typically have little to no temperature differences across the storm at the surface and their winds are derived from the release of energy due to cloud/rain formation from the warm moist air of the tropics. Structurally, tropical cyclones have their strongest winds near the earth's surface, while extra-tropical cyclones have their strongest winds near the tropopause - about 12 km up. These differences are due to the tropical cyclone being "warm-core" in the troposphere (below the tropopause) and the extra-tropical cyclone being "warm-core" in the stratosphere (above the tropopause) and "cold-core" in the troposphere. "Warm-core" refers to being relatively warmer than the environment at any level.

Often, a tropical cyclone will transform into an extra-tropical cyclone as it recurves poleward and to the east. Occasionally, an extra-tropical cyclone will lose its frontal features, develop convection near the centre of the storm and transform into a full-fledged tropical cyclone. Such a process is most common in the north Atlantic and northwest Pacific basins. The transformation of tropical cyclone into an extra-tropical cyclone (and vice versa) is currently one of the most challenging forecast problems.

24. What is the annual frequency of Cyclones over the Indian Seas? What is its intra-annual variation?

The average annual frequency of tropical cyclones in the north Indian Ocean (Bay of Bengal and Arabian Sea) is about 5 (about 5-6 % of the Global annual average) and in the globe is about 80. The frequency is more in the Bay of Bengal than in the Arabian Sea, the ratio being is 4:1. The monthly frequency of tropical cyclones in the north Indian Ocean display a bi-modal characteristic with a primary peak in November and secondary peak in May. The months of May-June and October-November are known to

produce cyclones of severe intensity. Tropical cyclones developing during the monsoon months (July to September) are generally not so intense.

25. What are the averages, most, and least tropical cyclones occurring in this basin?

The most, least and average numbers of cyclonic storms and severe cyclonic storms over the north Indian Ocean is given in the Table below:

Basin	Cyclonic storm			Severe cyclonic storm		
	Most	Least	Average	Most	Least	Average
N Indian Ocean	10	1	5.4	6	0	2.5

- Minimum No. of cyclones in a year – One (1949)
- Maximum No. of cyclones in a year – Ten (1893,1926,1930,1976)
- Out of total disturbances- 35% intensify to Cyclones

16 % intensify to severe cyclones 07% intensify to very severe cyclones

26. How many severe tropical storms occur around the world and over north Indian Ocean every year?

About 20-30 severe tropical storms occur around the world every year. Over the north Indian Ocean, 2-3 severe cyclonic storms form out of total 5-6 cyclonic storms.

27. How many cyclones cross different coastal states of India?

The frequency of severe cyclonic storms is maximum for Andhra Pradesh while that of cyclone is maximum for Orissa. Considering west coast, Gujarat is most vulnerable.

28. Which is the most intense tropical cyclone on record?

Typhoon Tip in the Northwest Pacific Ocean on 12 October, 1979 was measured to have a central pressure of 870 hPa and estimated surface sustained winds of 165 knots (85 m/s). Typhoon Nancy on 12 September, 1961 is listed in the best track data for the Northwest Pacific region as having an estimated maximumsustained wind of 185 knots (95 m/s) with a central pressure of 888 hPa. However, it is now recognized that the maximum sustained winds estimated for typhoons during the 1940s to 1960s were too strong and that the 95 m/s (and numerous 83 to 93 m/s reports) is somewhat too high.

Note that Hurricane Gilbert's 888 hPa lowest pressure (estimated from flight level data) in mid September, 1988 is the most intense [as measured by lowest sea level pressure] for the Atlantic basin, it is almost 20 hPa weaker (higher) than the above Typhoon Tip of the Northwest Pacific Ocean.

While the central pressures for the Northwest Pacific typhoons are the lowest globally, the North Atlantic hurricanes have provided sustained wind speeds possibly

comparable to the Northwest Pacific. From the best track database, both Hurricane Camille (1969) and Hurricane Allen (1980) have winds that are estimated to be 165 knots (85 m/s). Measurements of such winds are inherently going to be suspect as instruments often are completely destroyed or damaged at these speeds.

Odisha super cyclone, 1999, which crossed Odisha coast near Paradip on 29th October, 1999 was the most intense cyclonic storm over north Indian Ocean in the recorded history of the region. The estimated sustained maximum surface wind speed was about 140 knots at the time of landfall and lowest estimated central pressure was 912 hPa.

A few cyclones that have originated over the Bay of Bengal have reached the intensity of Super Cyclones and have caused great devastations to life and property. The estimates of maximum sustained winds of these systems are estimated from satellite imageries. The list of very intense Cyclones in the Bay of Bengal since 1990 is given below:

Place of landfall	Date of landfall	Maximum sustained winds(kmph) - estimated on the basis of satellite imageries
Chittagong	13 November, 1970	224
Chirala,Andhra Pradesh	19 November, 1977	260
Rameshwaram	24 November 1978	204
Sriharikota	14 November, 1984	213
Bangla Desh	30 November, 1988	213
Kavali, Andhra Pradesh	9 November, 1989	235
Machlipatnam, AP	9 May ,1990	235
Chittagong	29 April, 1991	235
Teknaf (Myanmar)	2 May, 1994	204
Teknaf	19 May, 1997	235
Paradip, Odisha	29 October, 1999	260
Bangladesh	15 November, 2007	220
Myanmar	02 May, 2008	200

29. Which are the largest and smallest tropical cyclones on record?

Typhoon Tip had gale force winds 34 knots (17 m/s), which extended out for 1100 km in radius in the Northwest Pacific on 12 October, 1979. Tropical Cyclone Tracy had gale force winds that only extended 50 km radius when it struck Darwin, Australia, on 24 December,1974.

Considering north Indian Ocean, Orissa super cyclone of October, 1999 and the cyclone, 'Ogni' were the largest and smallest cyclones during 1891-2007.

30. Which tropical cyclone over north Indian Ocean have caused the most deaths and most damage?

The death toll in the infamous Bangladesh Cyclone of 1970 has had several estimates, some wildly speculative, but it seems certain that at least 300,000 people died from the associated storm tide [surge] in the low-lying deltas.

31. Why, there are fewer cyclones over the Arabian Sea as compared to the Bay of Bengal?

Cyclones that form over the Bay of Bengal are either those develop in-situ over southeast Bay of Bengal and adjoining Andaman Sea or remnants of typhoons over northwest Pacific and move across south China sea to Indian Seas. As the frequency of typhoons over northwest Pacific is quite high (about 35% of the global annual average), the Bay of Bengal also gets its increasedquota.

The cyclones over the Arabian Sea either originate in-situ over southeast Arabian Sea (which includes Lakshadweep area also) or remnants of cyclones from the Bay of Bengal that move across south peninsula. As the majority of Cyclones over the Bay of Bengal weaken over land after landfall, the frequency of migration into Arabian Sea is low.

In addition to all the above the Arabian Sea is relatively colder than Bay of Bengal and hence inhibits the formation and intensification of the system.

32. Why there are very few Tropical Cyclones during southwest monsoon season?

The southwest monsoon is characterized by the presence of strong westerly winds in the lower troposphere (below 5 km) and very strong easterly winds in the upper troposphere (above 9 km). This results in large vertical wind shear. Strong vertical wind shear inhibits cyclone development.

Also, the potential zone for the development of cyclones shifts to north Bay of Bengal during southwest monsoon season. During this season, the low pressure system up to the intensity of depressions form along the monsoon trough, which extends from northwest India to the north Bay of Bengal. The Depression forming over this area crosses Orissa – West Bengal coast in a day or two. These systems have shorter oceanic stay which is also one of the reasons for their non- intensification into intense cyclones.

33. What is the life period of cyclones? Which tropical cyclone lasted the Longest?

Life period of a tropical cyclone over the north Indian Ocean is 5-6 days. It will have hurricane intensity for 2-4 days as against 6 days of global average. Life period of the longest-lived tropical cyclone in Indian seas is 14 days (2^{nd}-15^{th} Nov, 1886 & 16^{th} - 29^{th} Nov, 1964). Hurricane/Typhoon John lasted 31 days as it traveled both the northeast and northwest Pacific basins during August and September,1994. (It formed in the northeast Pacific, reached hurricane force there, moved across the dateline and was

renamed Typhoon John, and then finally recurved back across the dateline and renamed Hurricane John again.) Hurricane Ginger was a tropical cyclone for 28 days in the north Atlantic Ocean back in 1971. It should be noted that prior to the weather satellite era (1961) many tropical cyclones' life cycles could be underestimated.

34. How are Tropical Cyclones monitored by IMD?

IMD has a well-established and time-tested organization for monitoring and forecasting tropical cyclones. A good network of meteorological observatories (both surface and upper air) is operated by IMD, covering the entire coastline and islands. The conventional observations are supplemented by observational data from automatic weather stations (AWS), radar and satellite systems. INSAT imagery obtained at hourly intervals during cyclone situations has proved to be immensely useful in monitoring the development and movement of cyclones.

35. How is cyclone monitored by satellite technique?

The satellite technique can be used to find out the centre and intensity of the system. It can also be used to find out various derived parameters which are useful for monitoring and prediction of the cyclones and associated disastrous weather.

Dvorak's technique based on pattern recognition in the cloud imagery based on satellite observation is used to determine the intensity of cyclonic storm. For this purpose, a T. No. where T stands for tropical cyclone is assigned to the system. This scale of T Nos. varies from T 1.0 to T 8.0 at the interval of 0.5. The T 2.5 corresponds to the intensity of a cyclonic storm. The detailed classification of cyclonic disturbances (CDs) based on above technique is given below:

36. "T" classification of cyclonic storm and corresponding wind speed and pressure defect (□P)

T./C.I. Number	Classification of CDs	Wind speed in Knots	Wind speed In Kmph	□P	Wind criteria in Knots	Wind criteria in Kmph
T1.0	L				□17	□31
T1.5	D	25	46.3		17-27	31-49
T2.0	DD	30	55.6	4.5	28-33	50-61
T2.5	CS	35	64.9	6.1	34-47	62-88
T3.0		45	83.4	10.0		
T3.5	SCS	55	101.9	15.0	48-63	89-117
T4.0	VSCS	65	120.5	20.9	64-89	118-166
T4.5		77	142.7	29.4		
T5.0	ESCS	90	166.8	40.2	90-119	167-221
T5.5		102	189.0	51.6		

T6.0		115	213.1	65.6		
T6.5	SuCS	127	235.4	80.0	120 and above	222 and above
T7.0		140	259.5	97.2		
T7.5		155	287.3	119.1		
T8.0		170	315.1	143.3		

37. What is the utility of Radar in cyclone monitoring?

The radar can be utilized to find out the location of the cyclonic storm more accurately when the system comes within radar range. In addition, it can find out convective cloud cluster, wind distribution and rainfall rate etc.

38. What is the present network of Cyclone Detection Radars?

A network of Doppler weather RADARs has been established at Kolkata, Paradip, Gopalpur,Visakhapatnam, Machilipatnam, Chennai, Karaikal along the east coast and Thiruvananthapuram, Kochi, Goa, Mumbai and Bhuj along the west coast. An indigenously developed DWR Radar by Indian Space Research Organisation (ISRO) has been installed at Sriharikota and another X Band Radar has been installed at NIOT Chennai and C band Radar at Mumbai.

39. What are the basic differences between conventional analog type of Cyclone Detection Radar and the Doppler Weather Radar?

While conventional weather radar can look deeper into a weather system to provide information on intensity rain-rate, vertical extent, the capability to probe internal motion of the hydrometers and hence to derive information on velocity and turbulence structure has become possible only with the advent of Doppler Weather Radar (DWRs) which provide vital information on radial velocity from which wind field of a tropical disturbance in the reconnaissance area of DWR can be derived. In addition to above, a number of derived parameters useful for cyclone monitoring and prediction are also available from DWR.

40. What are the causes of disaster during cyclone?

The dangers associated with cyclonic storms are generally three-fold.

(i) Very heavy rains causing floods
(ii) Strong wind
(iii)Storm surge

Let us discuss each separately:

The rainfall associated with a Cyclone vary from system to system even with the same intensity. Record rainfall in a cyclonic storm has been as low as trace to as high as 250

cm. It has been found that the intensity of rainfall is about 85 cm/day within a radius of 50 kms and about 35 cm/day between 50 to 100 kms from the centre of the storm. Precipitation of about 50 cm/day is quite common with a C.S. This phenomenal rain can cause flash flood.

The strong wind speed associated with a cyclonic storm. (62-88 kmph) can result into some damage to kutcha houses and tree branches likely to break off. Winds of a severe Cyclonic storm (89-117 kmph) can cause uprooting of trees, damage to pucca houses and disruption of communications. The wind associated with a very severe Cyclonic storm and super cyclonic storm can uproot big trees, cause wide spread damages to houses and installations and total disruption of communications. The maximum wind speed associated with a very severe Cyclonic storm that hit Indian coast in the past 100 years was 260 kmph in Oct, 1999 (Paradip Super cyclone).

The severest destructive feature of a tropical storm is the storm surge popularly called tidal waves. The coastal areas are subjected to storm surge and is accentuated if the landfall time coincides with that of high tides. This is again more if the sea bed is shallow. Storm surge as high as 15 to 20 ft. may occur when all the factors contributing to storm surge are maximum. This storm tide inundates low lying coastal areas which has far reaching consequences apart from flooding. The fertility of land is lost due to inundation by saline water for a few years to come.

41. When does a coastal station start experiencing bad weather associated with a Cyclone?

Coasts come under the influence of bad weather in the form of heavy rain, gale winds (exceeding 65 kmph) when the cyclone moves closer to the coast within 200km. Heavy rainfall generally commences about 9-12 hours before cyclone landfall. Gale force winds commence about 6-9 hours in advance of cyclone landfall. Maximum storm surge may appear at or near the landfall time.

42. What is the amount of rainfall expected during a cyclone? Which sector gets more rainfall? What is the impact of heavy rainfall?

Intensive rainfall occurs to the left of the cyclone. Maximum rainfall occurs close to the centre of the storm. Secondary maximum of rainfall occurs 2º away from Primary maximum to the right of the storm centre. Slow moving/big size cyclones give more rainfall, whereas, fast moving/small size ones give less rainfall. More than 90% of rainfall is limited within 200 Km radius of the storm. Extensive rainfall occurs in the left forward sector for westward moving system and forward sector for northward moving system and right forward sector for those re-curving to east and northeast.

The governing factors for rainfall distribution and intensity are intensity, speed and size of the storm and local effects such as topography and orientation of the coast.

43. What are the largest rainfalls associated with tropical cyclones over NIO?

The rainfall can vary from trace/ nil, when the system moves skirting the coast to maximum rainfall up to 50-60 cm per day. In the recent super cyclone, which crossed Odisha coast near Paradip on 29th October 1999, Paradip recorded 24 hrs. cumulative rainfall of about 52 cm at 0830 IST of 30th October 1999.

44. What may be the wind speed in most severe storm? What is the maximum wind speed recorded along India coast.

45. The wind speed may be as high as 300 kmph. It 250-260 kmph gusting to 280 kmph was estimated near Paradip coast in association with Odisha Super cyclone on 29 Oct. 1999.

46. What is the wind speed at the centre of a storm? What is weather there?

Nearly calm wind with fair weather prevails at the centre of the storm.

47. How is the damage that cyclones cause related with wind?

The amount of damage does not increase linearly with the wind speed. Instead, the damage produced due to wind is approximately proportional to the cube of the wind.

48. Which sector of the cyclone experiences strongest winds?

In general, the strongest winds in a cyclone are found on the right side of the storm. The "right side of the storm" is defined with respect to the storm's motion: if the cyclone is moving to the west, the right side would be to the north of the storm; if the cyclone is moving to the north, the right side would be to the east of the storm, etc. The strongest wind on the right side of the storm is mainly due to the fact that the motion of the cyclone also contributes to its swirling winds. A cyclone with a 145 kmph winds while stationary would have winds up to 160 kmph on the right side and only 130 kmph on the left side, if it began moving (any direction) at 16 kmph. While writing the cyclone warning bulletins, this asymmetry is taken into consideration.

For tropical cyclones in the Southern Hemisphere, these differences are reversed: the strongest winds are on the left side of the storm. This is because the winds swirl clockwise south of the equator in tropical cyclones.

49. What causes each cyclone to have a different maximum wind speed for a given minimum sea-level pressure?

The basic horizontal balance in a tropical cyclone above the boundary layer is between the sum of the Coriolis 'acceleration' and the centripetal 'acceleration', balanced by the horizontal pressure gradient force. This balance is referred to as *gradient balance*, where the Coriolis 'acceleration' is defined as the horizontal velocity of an air parcel, **v**, times the Coriolis parameter, **f**. Centripetal 'force' is defined as the acceleration on a parcel of air moving in a curved path, directed toward the centre of curvature of the

path, with magnitude $\mathbf{v^2/r}$, where **v** is the horizontal velocity of the parcel and **r** the radius of curvature of the path. The centripetal force alters the original two-force geostrophic balance and creates a non- geostrophic gradient wind. There as on those different peak winds can result in different central pressures is caused by the fact that the radius, **r**, of the peak wind varies. A storm with 40 m/s peak winds with a 100 km RMW will have a much lower pressure drop than one with a 25 km RMW.

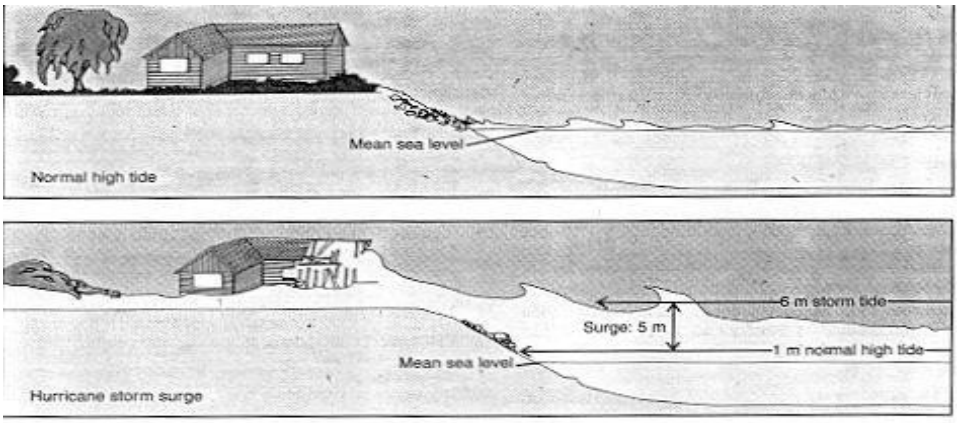
50. Why do very severe cyclone or hurricane force winds start at 64 knots?

51. In 1805-06, Commander Francis Beaufort RN (later Admiral Sir Francis Beaufort) devised a descriptive wind scale in an effort to standardize wind reports in ship's logs. His scale divided wind speeds into 12 Forces (soon after pared down to thirteen) with each Force assigned a number, a common name, and a description of the effects such a wind would have on a sailing ship. And since the worst storm an Atlantic sailor was likely to run into was a hurricane that name was applied to the top Force on the scale.During the 19th Century, with the manufacture of accurate anemometers, actual numerical values were assigned to each Force level, but it wasn't until 1926 (with revisions in 1939 and 1946) that the International Meteorological Committee (predecessor of the WMO) adopted a universal scale of wind speed values. It was a progressive scale with the range of speed for Forces increasing as you go higher. Thus Force 1 is only 3 knots in range, while the Force 11 is eight knots in range. So, Force 12 starts out at 64 knots 974 mph, 33 m/s).

There is nothing magical in this number, and since hurricane force winds are a rare experience chances are the committee which decided on this number didn't do so because of any real observations during a hurricane. Indeed, the Smeaton-Rouse windscalein1759peggedhurricaneforceat70knots(80mph,36m/s). Just the same, when a tropical cyclone has maximum winds of approximately these speeds we do see the mature structure (eye, eyewall, spiral rainbands) begin to form, so there is some utility with setting hurricane force in this neighborhood.

Beaufort Wind Scale	
Force 0	Calm
Force 1	Light Air
Force 2	Light Breeze
Force 3	Gentle Breeze
Force 4	Moderate Breeze
Force 5	Fresh Breeze
Force 6	Strong Breeze
Force 7	Near Gale
Force 8	Gale
Force 9	Strong Gale
Force 10	Storm
Force 11	Violent Storm
Force 12	Hurricane

52. What is a Storm Surge?



Storm Surge is an abnormal rise of sea level as the cyclone crosses the coast. Sea water inundates the coastal strip causing loss of life, large scale destruction to property & crop. Increased salinity in the soil over affected area makes the land unfit for agricultural use for two or three seasons.

Storm surge depends on intensity of the cyclone (Maximum winds and lowest pressure associated with it and Coastal bathymetry (shallower coastline generates surges of greater heights).

53. In which direction of a storm the surge will appear?

The on-shore wind gives rise to storm surge. Thus, the forward right sector of a storm gives rise to storm surge.

54. What is storm tide?

The storm tide is the combination of storm surge and the astronomical tide.

55. What is the interaction of astronomical tide with storm surge?

There is a nonlinear interaction between storm surge and astronomical tide. For example, if 6 m of storm surge occurs during the high tide condition of 2 m height, then the total storm tide may be either greater than or less than 8 m (6m + 2m) i.e., ~7m or ~9m.

56. What is the disaster potential of Storm Surge?

Disaster potential due to cyclones is due to high storm surges occurring at the time of landfall. The storm surges are by far the greatest killers in a cyclone. as sea water inundates low lying areas of the coastal regions causing heavy floods, erosion of beaches and embankments, damage to vegetation and reducing soil fertility. Flooding due to storm surges pollute drinking water sources resulting in shortage of drinking water and causing out-break of epidemics, mostly water borne diseases Very strong winds (Gales) may cause uprooting of trees, damage to dwellings, overhead installations, communication lines etc., resulting in loss of life and property. Past records show that very heavy loss of life due to tropical cyclones have occurred in the coastal areas surrounding the Bay of Bengal. Cyclones are also often accompanied by very intense & heavy precipitation (exceeding 40-50 cm in a day or about 10cm or more per hour in some places)

57. What is the vulnerability our coastline from the point of view of storm surge potential?

Entire Indian coast can be categorized into 4 zones

- Very high risk zones (Surge height >5m)
- High risk Zone (Surge height between3-5m)
- Moderate risk zone (Surge height between 1.5 to3m)
- Minimal risk zone (Surge height <1.5m)
- Accordingly
- The coastal areas and off-shore islands of Bengal and adjoining Bangladesh are the most storm-surge prone (~ 10-13m) –VHRZ
- East coast of India between Paradip and Balasore in Orissa (~ 5-7m) –VHRZ
- Andhra coast between Bapatla and Kakinada holding estuaries of two major rivers Krishna and Godavari (~ 5-7m) –VHRZ
- Tamilnadu coast between Pamban and Nagapattinam (~ 3-5m) –HRZ
- Gujarat along the west coast of India (~ 2-3m)–MRZ

58. Can we predict storm surge?

59. The storm surge is predicted by IMD using nomograms and dynamic model developed by IIT, Delhi and coastal inundation model run by INCOIS, Hyderabad. Both these models taken into consideration different characteristics, the cyclones and the coastal bathymetry to predict the storm surge.

The Advanced Circulation (ADCIRC) model is used for storm surge and inundation forecasts for the Indian coasts. Operationally, ADCIRC model forecasts the maximum water level envelope due to land falling tropical cyclones. Information of position, intensity and track of the tropical cyclone, radius of maximum winds is prepared by cyclone warning centre, IMD Delhi in the real-time. These parameters are used to generate cyclonic wind and pressure fields to be utilized in the storm surge model. The storm surge model is setup for the entire Indian coasts and run every six hours during the life period of the cyclone.

The model guidance commence once the track and landfall are predicted and provided by cyclone warning division.

60. Which tropical cyclone has produced the highest storm surge?

The Bathurst Bay Hurricane, also known as Tropical Cyclone Mahina, struck Bathurst Bay, Australia in 1899. It produced a 13 m (about 42 ft) surge, but other contemporary accounts place the surge at 14.6 m (almost 48 ft). Considering cyclones over north Indian Ocean, cyclone of 1970 has produced maximum storm surge of 13 meters in recent years. Some of the significant storm surges (meters) over the region are mentioned below.

- Hooghly river (WB), October,1737 : 13
- Contai (WB), October,1864 : 10-13
- Bangladesh cyclone, November,1970 : 13
- Paradip,Odisha,October,1971 : 4-5
- Balasore Odisha,May,1989 : 3-6
- Odisha Super Cyclone,October,1999 : 5-6

61. What is ADCIRC model?

Ans: ADCIRC is a (parallel) ADvanced CIRCulation model for oceanic, coastal and estuarine waters developed by Dr. R.A. Luettich, Jr, University of North Carolina at Chapel hill, Institute of Marine Sciences (email: rick_luettich@unc.edu) and Dr. J.J. Westerink, Department of Civil Engineering and Geological Sciences, University OF Notre Dame (email: jjw@photius.ce.nd.edu).

The complete information of ADCIRC model can be seen from the below link
http://www.unc.edu/ims/adcirc/document/Introduction.html

62. 57. What are the strengths of ADCIRC model?

Ans: ADCIRC model has following strengths

- Fully parallelized using message passing interface (MPI)
- It uses unstructured meshes
- Very low numerical damping - allows model parameters to be based on physically relevant values.
- At least second order accurate.
- Loop-level Optimization (increasing execution speed).
- Domain Decomposition.

63. What does ADCIRC model need as input?

A set of files which defines such things as: bathymetry, topography, boundary information, tidal characteristics, nodal attributes (often based on land use data), river inflow, meteorological forcing input, wave radiation stress forcing, and others depending on the geographical area of interest.

64. 59. How can I engage with other ADCIRC users to ask questions and be in touch with the latest developments?

Contact Crystal Fulcher (cfulcher@email.unc.edu) and ask her to subscribe you to the ADCIRC listserv (adcirc@listserv.unc.edu).

65. What is the resolution of the operational storm surge model?

The minimum grid spacing near the coastal regions is 100 m and relaxed to 20 km in the deeper waters.

66. What is the accuracy of the operational storm surge model?

From the operational storm surge forecasts since last one decade using ADCIRC model, it was found that the average error in forecasted storm surge height is + or - 0.15m.

67. How and why to include astronomical tides in the storm surge simulations?

ADCIRC model is already coupled tide model and it uses the LeProvost tide data base for the real-time tide and surge simulations. Storm surge model includes astronomical tide as the phase of the local astronomical tide at the time of cyclone's landfall which can have great control in altering total storm tide height.

68. How and why to consider short waves in the storm surge model?

The contribution of the short waves in the storm surge model is considered by using coupled hydrodynamic and wave model ADCIRC+SWAN. Inclusion of short wave in

the storm surge simulations is important to get the total water level at the coast due to short wave and storm surge.

69. What storm surge products are generated in the real-time?

Peak storm surge height at the coast, inland inundation extent and inundation depth (flood depth) are predicted and presented in text and graphics format.

70. What is probabilistic storm surge (P-Surge) estimation?

Probabilistic storm surge estimation is a process in which computation of storm surge occurrence probabilities at the coastal locations is carried out by considering the track and intensity errors in the deterministic cyclone track forecast.

71. How do you compute probabilistic storm surge?

Based on the climatological track error of the deterministic track forecast, the track will be artificially displaced for every 1 km within the cone of uncertainty on both sides of deterministic track forecast. Each track's intensity will be varied based on the standard intensity forecast error based on the past five years. In this way, 100s of Monte-Carlo simulations are performed to generate the forecasts. From all these simulations probability of exceedence of a given storm surge height (say 2 m) at different locations of the coast are calculated.

72. Whether IMD has any probabilistic storm surge model setup?

IMD has experimentally setting-up of P-Surge guidance system for the Indian coasts.

73. What is a significant wave height and maximum wave height?

Significant wave height (Hs) is a statistical measure used to describe the average height of the highest one-third of the waves in a given sea state. It is a commonly used parameter in oceanography and marine engineering, and is often used to describe the severity of sea conditions. The significant wave height is calculated as the average height of the highest one-third of waves over a period of time.

Maximum wave height (Hmax) is the highest individual wave height measured in a given sea state. This parameter is useful in assessing the potential impact of individual waves on offshore structures, ships, and other marine infrastructure. Hmax can be significantly higher than Hs, especially in extreme weather conditions or in the presence of rogue waves.

74. what is a swell and how it is predicted?

A swell is a type of ocean wave that is generated by distant weather systems, such as storms and hurricanes, and travels across the ocean before arriving at a coastline. Swells are characterized by their long wavelengths, which can range from several

hundred meters to several kilometers, and their relatively uniform shape and direction.
Swells are typically predicted using computer models that incorporate data from a variety of sources, including satellite measurements of sea surface height and wind speed, as well as observations from buoys, ships, and other ocean sensors. These models use mathematical equations to simulate the behavior of ocean waves, taking into account factors such as wind speed and direction, the size and shape of the ocean basin, and the interaction between different types of waves.

75. What is an astronomical tide and how it is predicted?

An astronomical tide is a periodic rise and fall of sea level caused by the gravitational forces of the Moon and the Sun on the Earth's oceans. These tides are also influenced by the rotation of the Earth and the geography of the coastline. The combination of these forces produces a complex pattern of tides that can vary depending on the location and time of year.
Tidal prediction is based on the astronomical theory of tides, which involves calculating the positions of the Moon and the Sun relative to the Earth, as well as the effect of other factors such as the shape of the coastline and the depth of the ocean. Tide tables and charts are created by tidal prediction centers, which use mathematical models to calculate the expected high and low tide heights and times for specific locations over a period of time, usually for a year in advance. These predictions can help boaters, fishermen, and others who rely on the tides for navigation or other activities plan their activities accordingly.

76. How do you measure storm surge and coastal inundation?

Storm surge and coastal inundation can be measured using a combination of techniques, including tide gauges, satellite remote sensing, and numerical modeling.

- Tide gauges are instruments that are used to measure the water level at a particular location. They are often used to monitor storm surge, which is the temporary rise in sea level caused by a storm. Tide gauges can be installed near shore, and they provide real-time data that can be used to monitor and predict the severity of a storm surge.
- Satellite remote sensing is another technique used to monitor storm surge and coastal inundation. This information can then be used to create maps that show the areas those are at risk of flooding.
- Numerical modeling is a third technique used to predict storm surge and coastal inundation. This involves using computer models to simulate the behavior of waves and water levels in response to a storm. These models take into account factors such as wind speed and direction, ocean currents, and the shape of the coastline, and can be used to create detailed predictions of the areas those are at risk of flooding.
- Overall, a combination of these techniques is often used to monitor and predict

storm surge and coastal inundation, in order to provide early warnings and minimize the impact of these natural hazards on coastal communities.

77. How can a common man know the time of occurrence of tide?

A common man can know the time of occurrence of tide by consulting a tide table or a tide chart. These are usually published by government agencies, such as survey of India (SOI), and they provide information on the predicted times and heights of high and low tides for specific locations.

Tide tables typically include information such as the date, time, and height of the next high and low tides, as well as the time of sunrise and sunset, and the phases of the moon.

78. When does maximum astronomical tide occur?

The maximum astronomical tide occurs when the gravitational forces of the Moon and the Sun are aligned in a way that produces the highest possible tidal range for a particular location. The timing of the maximum astronomical tide varies depending on the position of the Moon and the Sun relative to the Earth, as well as the local geography and bathymetry of the coastline.

In general, the maximum astronomical tide occurs during a spring tide, which is when the gravitational forces of the Moon and the Sun are aligned and reinforce each other, producing higher than average tides. Spring tides occur twice a month, around the time of the new moon and full moon.

However, it's important to note that the maximum astronomical tide can also be influenced by other factors, such as the shape of the coastline, the depth of the ocean, and the presence of other bodies of water. Therefore, the timing and height of the maximum astronomical tide can vary significantly from one location to another, and are typically calculated based on local tidal data and mathematical models.

In general, high tide and low tide occur twice each daily, as it shows semi diurnal variation. High tide commences as per the phase of moon. Hence a common man can find out the commencement time of high tide by monitoring “tithi”. The time of commencement of high tide is time of sun rise + day of tithi (eg. Pratipada, Poornima etc) X 48 minutes.

e.g. if sun rise time is 6:00 AM and it is Saptami (7^{th} day). Then high tide will commence as 6:00+ 7X48 minutes = 6:00+ 336 minutes= 6:00 + 5:36 hrs= 11:36 hrs

79. Where can one find storm surge data and storm related products during a tropical event?

Storm surge and inundation graphics:
https://rsmcnewdelhi.imd.gov.in/uploads/archive/7/7_de4241_no_warnings.pdf

80. Where can we find the GIS based storm surge interactive risk maps?

https://ddgmui.imd.gov.in/dwr_img/GIS/previewcyclone.html

81. What should I do for being safe from storm surge?

You need to plan well ahead of time. If you live or work in the coastal area, find out from your local Emergency Services or local council whether you are in a surge-prone area. If you are, decide where you will go in the event of a storm surge. You might have a friend living on higher ground with whom you could go and stay. Wherever your nearest safe high ground cyclone shelter might be, work out the safest way to get there.

82. What are the wave models used by IMD?

In collaboration with INCOIS, IMD is issuing sea, swell and total wave height forecasts during cyclones and normal days. Simulating Waves Near shore (SWAN) and Wave Watch-3 models run by INCOIS are used operationally.

83. What is total wave height?

Total wave height is the combined height of the sea and the swell that mariners experience on open water. It may also be referred as the combined sea and swell or significant wave height.

84. What are different wind thresholds for a tropical cyclone over NIO?

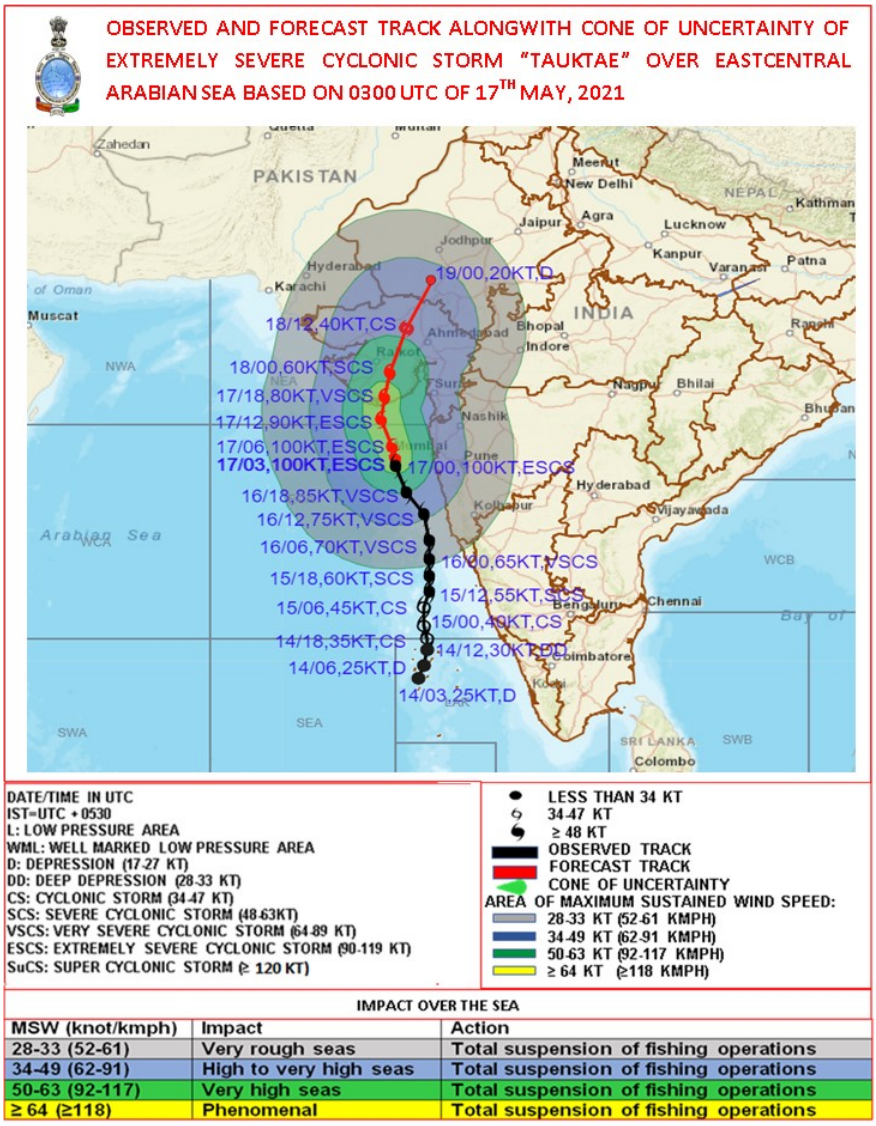
The RSMC, New Delhi provide wind information about the cyclonic storm for the different wind speed thresholds based on the damage potential of the strong/gale winds. The MSW speed values are 28, 34, 50 and 64 kts.

85. What are quadrant winds? How the wind distribution of the cyclone is defined?

The information about the rotational wind speeds and forward movement of tropical cyclone is provided in terms of quadrant winds. Four quadrants of each cyclonic storm may be defined relative to the direction the storm is moving (left, right, front and back) or relative to the geographic directions (North, South, East and West).

A semicircle is two adjacent quadrants. For example, the "SE and SW semicircle" implies the region spanning bearings of 090 to 270 centered about the location of the Low. The adjacent figure explains the locations of different quadrants.

The maximum sustained winds (MSW) at 10 m above sea surface are evaluated at various locations in the four quadrants around the storm. Then, the distance values notifying the radial extent and bearing of the MSW for different thresholds divided into quadrants provide a picture of wind distribution and a guidance to size, structure (symmetry/asymmetry) and severity of storms.



IMPACT OVER THE SEA

MSW (knot/kmph)	Impact	Action
28-33 (52-61)	Very rough seas	Total suspension of fishing operations
34-49 (62-91)	High to very high seas	Total suspension of fishing operations
50-63 (92-117)	Very high seas	Total suspension of fishing operations
≥ 64 (≥118)	Phenomenal	Total suspension of fishing operations

86. What is the damage potential of a deep depression (28 – 33 knots) and the suggested actions?

Structures: Minor damage to loose/unsecured structures

Communication & power: None

Road/Rail: Some breaches in Kutcha Road due to flooding

Agriculture: Minor damage to Banana trees and near coastal agriculture due to salt spray. Damage to ripe paddy crops

Marine Interests: Very rough seas. Sea waves about 4-6 m high.

Coastal Zone: Minor damage to Kutcha embankments

Overall Damage Category: **Minor**

Suggested Actions: Fishermen advised not to venture into sea

87. What is the damage potential of a cyclonic storm (34 - 47 knots or 62 to 87 kmph) and what are the suggested actions?

Structures: Damage to thatched huts

Communication and power: Minor damage to power and communication lines due to breaking of tree branches.

Road/Rail: Major damage to Kutcha and minor damage to Pucca roads.

Agriculture: Some damage to paddy crops, Banana, Papaya trees and orchards.

Marine Interests: High to very high sea waves about 6-9 m high.

Coastal Zone: Sea water inundation in low lying areas after erosion of Kutcha embankments

Overall Damage Category: Minor to Moderate

Suggested Actions: Fishermen advised not to venture into sea

88. What is the damage potential of a severe cyclonic storm 48-63 Knots (88 - 117 Kmph) and what are the suggested actions?

Structures: Major damage to thatched houses/huts. Roof tops may blow off. Unattached metal sheets may fly.

Communication and power: Minor damage to power and communication lines.

Road/Rail: Major damage to Kutcha and some damage to Pucca roads and Flooding of escape routes.

Agriculture: Breaking of tree branches, uprooting of large avenue trees. Moderate damage to Banana and Papaya trees: Large dead limbs blown from trees.

Marine Interests: Phenomenal seas with wave height 9-14 m. Movement in motor boats unsafe.

Coastal Zone: Major damage to coastal crops. Storm surge up to 1.5 m (area specific) causing damage to embankments/ salt pans. Inundation up to 5 Km in specific areas.

Overall Damage Category: Moderate

Suggested Actions: Fishermen advised not to venture into sea. Coastal hutment dwellers advised to move to safe places. Others in affected areas to remain indoors.

89. What is the damage potential of a very severe cyclonic storm (64-90Knots or 118-167 Kmph) and what are the suggested actions?

Structures: Total destruction of thatched houses/ extensive damage to Kutcha houses. Some damage to Pucca houses. Potential threat from flying objects.

Communication and power: Bending/ uprooting of power and communication poles.

Road/Rail: Major damage to Kutcha and Pucca roads. Flooding of escape routes. Minor disruption of railways, overhead power lines and signaling systems.

Agriculture: Widespread damage to standing crops plantations, orchards, falling of green coconuts and tearing of palm fronds blowing down bushy trees like mango.

Marine Interests: Phenomenal seas with wave heights more than 14m. Visibility severely affected. Movement in motor boats and small ships unsafe.
Coastal Zone: Storm surge up to 2 m, Inundation up to 10 Km in specific areas. Small boats, country crafts may get detached from moorings.
Overall Damage Category: Large
Suggested Actions: Fishermen not to venture into sea. Evacuation from coastal areas needs to be mobilized. People advised to remain indoors. Judicious regulation of rail and road traffic needed.

90. What is the damage potential of a very severe cyclonic storm (91-119 Knots or 168-221 Kmph) and what are the suggested actions?

Structures: Extensive damage to all types Kutcha houses, some damage to old badly managed Pucca structures. Potential threat from flying objects.
Communication and power: Extensive uprooting of power and communication poles.
Road/Rail: Disruption of rail / road link at several places.
Agriculture: Extensive damage to standing crops plantations, orchards. Blowing down of Palm and Coconut trees. Uprooting of large bushy trees.
Marine Interests: Phenomenal seas with wave heights more than 14m. Movement in motor boats and small ships notadvisable.
Coastal Zone: Storm surge up to 2 – 5 m, Inundation may extend up to 10-15 Km over specific areas. Large boats and ships may get torn from their moorings, country crafts may get detached from moorings
Overall Damage Category: Extensive
Suggested Actions: Fishermen not to venture into sea. Evacuation from coastal areas essential. Diversion / suspension of rail traffic may be required.

91. What is the damage potential of a super cyclonic storm 120 Knots (222 Kmph) & above? What are the suggested actions?

Structures: Extensive damage to non-concrete residential and industrial building. Structural damage to concrete structures. Air full of large projectiles.
Communication and power: Uprooting of power and communication poles. Total disruption of communication and power supply.
Road/Rail: 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.
Agriculture: Total destruction of standing crops / orchards, uprooting of large trees and blowing away of palm and coconut crowns, stripping of tree barks.
Marine Interests: Phenomenal seas with wave heights more than 14m. All shipping activity unsafe.
Coastal Zone: Extensive damage to port installations. Storm surge more than 5m,

Inundation up to 40 Km in specific areas and extensive beach erosion. All ships torn from their moorings. Flooding of escape routes.
Overall Damage Category: Catastrophic
Suggested Actions: Fishermen not to venture into sea. Large scale evacuations needed. Total stoppage of rail and road traffic needed in vulnerable areas.

92. What is the meaning of widespread / fairly wide spread /scattered / isolated rainfall?

The rainfall distribution are based on classification stated in following table

DISTRIBUTION	NO. OF PLACES	DESCRIPTION
Isolated	One or two places	<25% of area gets rainfall
Scattered	A few places	(26 –50)% of area gets rainfall
Fairly Widespread	A many places	(51 – 75)% of area gets rainfall
Wide Spread	Most place	(76 – 100)% of area gets rainfall

93. What do you mean by heavy rainfall, very heavy rainfall and extremely heavy rainfall?

The rainfall intensity mentioned in the bulletin is based on the following criteria:

Descriptive term used	Rainfall amount in mm
No rain	0.0
Very light rainfall	Trace - 2.4
Light rainfall	2.5 – 15.5
Moderate rainfall	15.6 – 64.4
Heavy rainfall	64.5 – 115.5
Very heavy rainfall	115.6 – 204.4
Extremely heavy rainfall	>204.5
Exceptionally heavy rainfall	When the amount is a value near about highest recorded rainfall at or near the station for the month or season. However, this term will be used only when the actual rainfall amount exceeds 12 cm.

94. How do we decide the probability of heavy rainfall?

"Probability of heavy rainfall" forecast is the unconditional probability that a location will receive an amount of rain that equals or exceeds 64.5 mm of rainfall in a day.

The approach is to use a forecasting ensemble. Essentially, in multi-model ensemble (MME) method we utilize several forecasting models to predict the future values of the rainfall time series. Then, we can estimate the exceedance probability by computing the ratio of models that forecast a value that exceeds the heavy rainfall threshold for a specific duration. In other way, several time series of rainfall forecasts i.e., ensemble of forecasts are generated from a single modeling system using relevant technique and then the probability of heavy rainfall at a certain time duration is computed from relative numbers of ensemble members out of all members predicting heavy rainfall.

In a separate approach different from the ensemble method, the machine learning, we can do this, for example, by using different learning algorithms or different training sets.

The probabilistic forecast of heavy rainfall is desirable because it carries more information to support decision-making, especially when the stakes are high. The forecast “there’s a 10% chance of heavy rain” is more informative than simply stating “it will rain heavily”, though most likely it won’t be a case of heavy rain. A risk averse person might be keen to take action accordingly.

95. What is the normal movement of a Tropical Cyclone?

Tropical cyclones move as a whole. They casually move west- northwestwards or northwestwards in the northern hemisphere. The average speed is 15-20 kmph (360-480 km per day). They may change their direction of movement towards north. During this change their speed of movement decreases to 10 kmph or even less. A larger fraction of such storms later turns towards northeast and move northeastwards very fast at a speed of 25 kmph or more.

96. What are fast- and slow-moving cyclones?

When the speed of movement is 10-14 kmph, it is called as slow-moving cyclone. It is called as moderately moving cyclone, if the speed of movement is 15- 25 kmph. If the speed of movement is more than 25 kmph, is called as fast-moving cyclone.

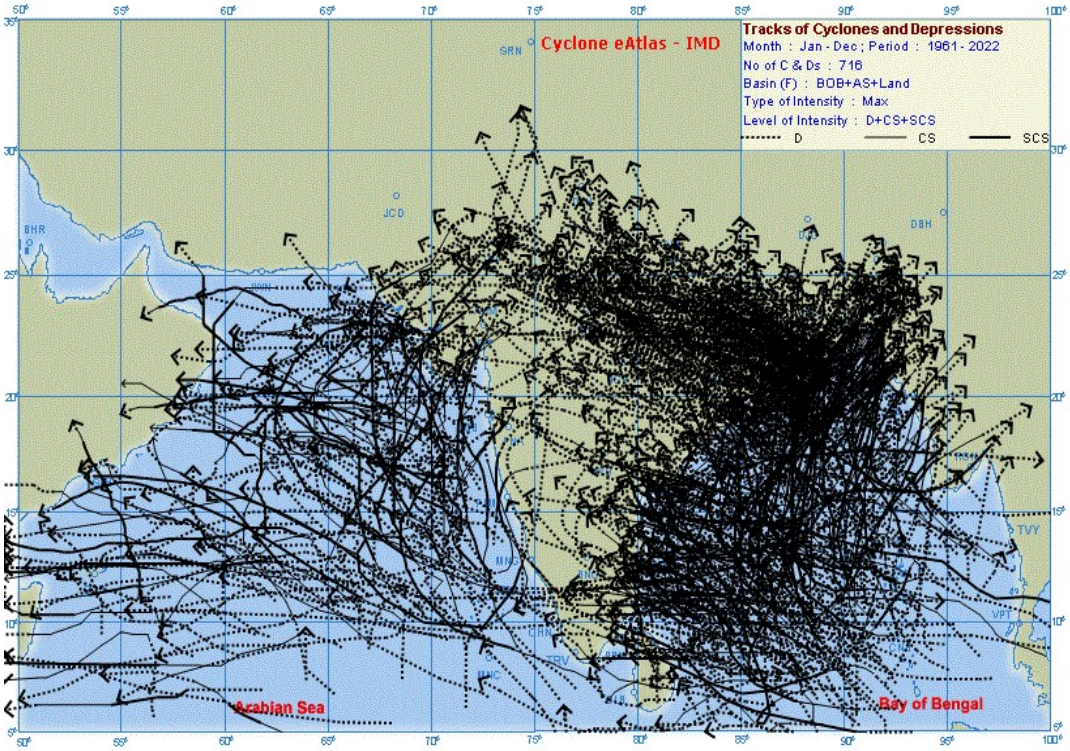
97. How track prediction is done in IMD?

Various Techniques are available for Track Prediction of the storm as mentioned below:

(i) Methods based on climatology, persistence and both Climatology & Persistence (CLIPER)
(ii) Synoptic Techniques – EmpiricalTechniques
(iii) SatelliteTechniques
(iv) Statistical Techniques using climatology, persistence and synoptic AnalogueTechniques

(v) Numerical weather prediction models

The tracks of the cyclonic storms over north India Ocean during 1961-2022 are shown below:

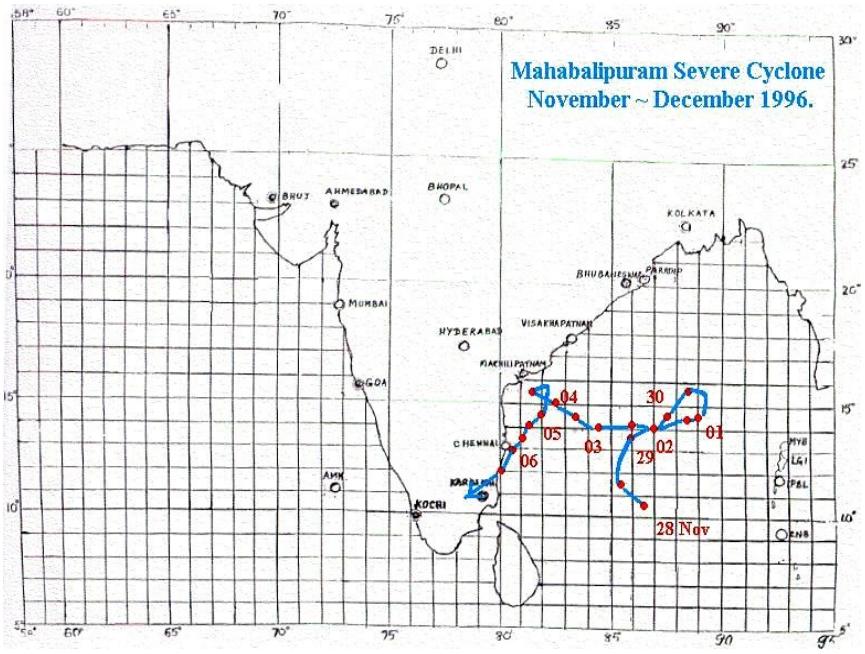


98. What are the abnormal characteristics associated with Tropical Cyclones?

Majority of Tropical Cyclones are associated with some sort of abnormal behavior such as

- Rapidly changing trends in motion and intensity
- Remaining quasi-stationary close to landfall
- Development or intensification close to a populated coastline
- Approaching a vulnerable coastline at an acute angle so that even minor forecast errors introduce large landfall uncertainties
- Threatening the coastal community during high pitch of seasonal activity such as harvesting, festivals, holidays etc.

Two examples of such cyclones are shown below.



99. How does IMD predict intensity of the cyclone?

Subjective techniques like Climatology, Synoptic and Satellite (Dvorak) techniques and radar techniques are used. Though the performance of NWP models in intensity prediction is not satisfactory, they provide valuable guidance in intensity prediction also.

100. What is the role of upper tropospheric westerly trough?

An Upper tropospheric westerly trough is important for tropical cyclone forecasting as they can force large amounts of vertical wind shear over tropical disturbances and tropical cyclones which may inhibit their strengthening. There are also suggestions that these troughs can assist tropical cyclone genesis and intensification by providing additional forced ascent near the storm centre and/or by allowing for an efficient outflow channel in the upper troposphere. The location of this trough and its intensity can also influence the movement of the storm and hence can be used for cyclone track forecasting.

101. Why Tropical Cyclones weaken over land after landfall?

After just a few hours, a tropical cyclone over land begins to weaken rapidly because the storm lacks the moisture and heat sources that the ocean provided. This depletion of moisture and heat hurts the tropical cyclone's ability to produce thunderstorms near the storm centre. Without this convection the cyclone cannot survive. However, there are instances like Orissa super cyclone of October 1999, which maintained its intensity of cyclonic storm even 24 hours after landfall. During this period, it remained practically

stationary over coastal Orissa.

102. Doesn't the friction over land kill tropical cyclones?

No, during landfall, the increased friction over land acts - somewhat contradictory - to both decrease the sustained winds and also to increase the gusts felt at the surface. The sustained winds are reduced because of the dampening effect of larger roughness over land (i.e., bushes, trees and houses over land versus a relatively smooth ocean). The gusts are stronger because turbulence increases and acts to bring faster winds down to the surface in short (a few seconds) bursts.

103. What is rapid intensification/weakening?

The Rapid Intensification (RI) of tropical cyclone is defined as an increase of intensity 30 kt (15.4 ms-1) during 24 hrs, which represents approximately the 93rd percentile of 24 hrs intensity changes of tropical cyclones that developed over North Indian Ocean Basin.

When the tropical cyclone weakens unusually within its life time changing the intensity by 30 kt in 24 hours, it is defined as rapid weakening.

104. What is cone of uncertainty?

The COU represents the probable position of a cyclonic disturbance (CD)/TC's circulation centre, and is formed by enclosing the area swept out by a set of circles centered at each forecast point along the forecast track—06, 12, 18, 24, 36, 48, and 72 hours for a three-day forecast. The radius of each circle is equal to the average of historical official forecast errors over a 5-year such as 20(35), 40(75), 60(115) and 80(150) nautical miles (km) for 06, 12, 18 and 24 hr forecasts respectively.

105. What are various NWP models used in Tropical Cyclone forecasts?

NWP Models in operational use for tropical cyclone forecast are described below.

A. Global Models

Global Forecast System (GFS):

The Global Forecast System (GFS), adopted from National Centre for Environmental Prediction (NCEP) was implemented at India Meteorological Department (IMD), New Delhi (HPCS) at T1534 (~ 12 km in horizontal over the tropics) with global data assimilation for the forecast up to 10 days. The model is run four times in a day (00, 06, 12 and 18 UTC).

Global ensemble Forecast Systems (GEFS):

A very high resolution (12 km grid scale) state-of-the-art global Ensemble Prediction Systems (EPS) developed at IITM, Pune based on GFS model of IMD are operational 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.

NCMRWF Unified Model (NCUM):

The global unified model NCUM is a grid point model which has a non-hydrostatic dynamic with a deep atmosphere suitable for all scales. NCUM is operational with ~12 km horizontal resolution and generate forecasts for 10 days available at 00, 06, 12, 18 UTC.

NCMRWF Ensemble Prediction System (NEPS-G):

NCMRWF Ensemble Prediction System (NEPS-G) is a global medium range probabilistic forecasting system. 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.

B. Forecasts from other GDPFS centers:

The forecast products and guidance from other Global Data Processing and Forecasting System (GDPFS) centers. Some of them are 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).

C. Regional Forecast System

Non-hydrostatic mesoscale modeling system WRFDA-WRF-ARW:

The mesoscale forecast system Weather Research and Forecast WRFDA (with regional GSI data assimilation is being operated 4 times a day to generate mesoscale analysis at 3 km horizontal resolution at 06 hourly interval.

Coupled Hurricane WRF- Hybrid Coordinate Ocean Model (HWRF-HYCOM):

The coupled HWRF -HYCOM is operational with triple nested (18x6x2 km) atmospheric component for tropical cyclone forecasting includes vortex initialization and regional data assimilation, coupler for two-way coupling between atmosphere and ocean components. 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. It is run 4 times a day in cyclic mode with 6 hrly cycles.

High Resolution Rapid Refresh Modeling System (HRRR):

The High-Resolution Rapid Refresh system based on WRF-ARW model with WRFDA (3DVAR-FGAT) data assimilation using radar observations is operationalized in IMD for three different domains (North-West, East & North-East and South-Peninsular India) with horizontal resolution of 2 km. The HRRR produce forecasts up to 12 hours

with two hours interval.

NCMRWF Unified Model -Regional (NCUM-R):

It is a regional model having a horizontal grid resolution of ~4km with 90 vertical levels. DWR observations of radial wind and rainfall intensity estimates are also used in the regional data assimilation of NCUM-R.

D. 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.

Genesis Potential Parameter (GPP):

A cyclone genesis parameter, termed the genesis potential parameter (GPP), is operationally used for distinction between non-developing and developing systems at their early development stages.

Multi-model ensemble (MME) technique:

The 9 models are from Bureau of Meteorology, Australia (BoM), Environment and Climate Change Canada (ECCC), ECMWF, IMD-GFS, JMA, KMA, UKMO, NCEP-GFS and NCMRWF-NCUM are nine International Institutes model outputs (contributing to the TIGGE) are chosen based on availability at the ECMWF-TIGGE

Statistical Dynamical model for Cyclone Intensity Prediction (SCIP):

A statistical-dynamical model (SCIP) has been implemented for real time forecasting of 12 hourly intensities up to 120 hours. The model parameters are derived based on past model analyses and are derived from the forecast fields of IMD-GFS model for real-time application.

Rapid Intensification (RI) Index:

A rapid intensification index (RII) is developed for tropical cyclones over the Bay of Bengal. The RII uses large-scale characteristics of tropical cyclones to estimate the probability of rapid intensification (RI) over the subsequent 24-h.

Decay of Intensity after the landfall:

The decay model has been used for real time forecasting of decaying intensity (after landfall) of TCs.

106. What is the accuracy of forecasts for tropical cyclone issued by IMD?

The accuracy of the forecasts for tropical cyclones may be expressed in terms individual error and skill in predicting track, intensity and landfall point & time.

During last 5 years (2018-2022) for 24, 48 and 72 hrs lead period, the average track forecast errors were 74 km, 112 km & 153 km respectively; the average intensity forecast error based on AE were 7.4 knots, 10.5knots and 14.0 knots respectively; landfall point error (LPE) were 26.2 km, 39.9km and 75.6 km respectively; the LTEs

were 2.8hrs, 4.5hrs& 8.0hrsrespectively.

107. How much is the improvement during last 5 years (2018-2022)?

During last 5 years (2018-22) compared to previous 5 years (2013-17), the track forecast skill portrayed an improvement of 12%, 10% and 7%; the LPE showed an improvement of 38%, 58% and 38%; the LTEs showed an improvement of 22% and 17.4 % and the average intensity forecast skill based on AE showed a marginal improvement for 24, 48 and 72 hrs lead period respectively.

108. What is the organizational set up in IMD for Cyclone forecasting and Warning?

The Cyclone Warning Organization in India has a 3-tier system to cater to the needs of the maritime States. These are: Cyclone Warning Division set up at IMD Head Quarters to co-ordinate and supervise cyclone warning operations in the country and to advise the Govt. at the apex level; Area Cyclone Warning Centres at Chennai, Mumbai and Kolkata and Cyclone Warning Centres at Visakhapatnam, Ahmedabad and Bhubaneswar. The cyclone warning work is also supervised and coordinated by the Forecasting Division at Pune.

109. What is early warning system for Cyclone?

Early warning system is a framework of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately in timely manner to reduce the possibility of loss of life and properties.

110. What is pre-genesis track & intensity forecast?

The track and intensity forecast is usually issued by IMD with the genesis of a depression. Recently, in 2022, IMD has introduced pre-genesis forecasts for track and intensity. This is the forecast with probable track and intensity of a probable cyclonic storm issued at a stage of a well-marked low pressure system. In other words, the forecast of a likely cyclonic storm is generated with a longer lead time while the genesis stage for the storm is yet to be observed.

111. What is IBF of cyclone?

Impact-based forecasting is a second-generation early warning product that enables realization of the shift in paradigm from what the weather will be to what the weather will do. IBF of cyclone introduced long back in IMD, was based on historical damages in association with strong wind, heavy rainfall and storm surge due to a cyclone. Since 2021, IMD had introduced dynamic IBF considering modeling of associated hazards, impact modeling and risk assessment based on data of meteorological hazards, secondary hazard like flood, geospatial information and socio-economic (exposures)

information.

112. What are the tropical cyclone hazards?

A hazard is defined as a hydrometeorological-based, geophysical or human-induced element that poses a level of threat to life, property or the environment.
Hazards associated with a cyclone include strong wind, heavy rainfall, storm surge and high waves.

113. What are the vulnerabilities due to cyclones?

Vulnerability refers to the susceptibility of exposed elements, such as human beings and their livelihoods and property, to suffer adverse effects when affected by a hazard. Vulnerability is related to predisposition, sensitivities, fragilities, weaknesses, deficiencies, or lack of capacities that favour adverse effects on the exposed elements. Vulnerability is situation specific, interacting with the hazard to generate risk. Therefore, vulnerability may also be time and space dependent.

There are therefore physical vulnerabilities and socio-economic vulnerabilities due to a cyclone. The physical one includes the physiography/topography of the region, bathymetry of the coasts. The socio-economic vulnerabilities depend on exposure conditions, population, population density, types of infrastructure, education and awareness and social status.

114. What is exposure?

Exposure refers to who and what may be affected in an area in which hazardous events may occur. If the population and economic resources were not located in (exposed to) potentially dangerous settings, no disaster risk would exist. Exposure is a necessary, but not sufficient, determinant of risk. It is possible to be exposed, but not vulnerable, for example, by living on a floodplain but having sufficient means to modify building structure and behaviour to mitigate potential loss. However, to be vulnerable to a hazard, it is also necessary to be exposed. Exposure is time and space dependent.

115. What is risk?

Risk is defined as the probability and magnitude of harm on human beings and their livelihoods and assets because of their exposure and vulnerability to a hazard. The magnitude of harm may change due to response actions to either reduce exposure during the course of the event or reduce vulnerability to relevant hazard types in general.
Risk is the product of hazard and vulnerability. It depends on the level of forecast

uncertainty of hydrometeorological hazards, the degree of vulnerability and the level of exposure.

116. What are the different bulletins issued by IMD in connection with the cyclone?

1) Weather and Sea area bulletins.
2) Bulletins for Indian Navy.
3) Bulletins for Departmental Exchange.
4) PortWarnings
5) Fisherieswarnings
6) Four StageWarnings
7) Bulletins for AIR
8) Bulletins for Press
9) Coastal bulletins
10) Warnings to Designated/ Registered Officials
11) Aviation Warnings

117. What is 4-stage warning system for Tropical Cyclones?

Expectations of Disaster Managers are longer lead time and improved accuracy of landfall forecast. But the present state of art has limitations to make the above requirements go hand in hand. Lead time depends on the formation and duration of cyclone itself which may vary considerably from one cyclone to another. However, since pre-monsoon cyclone season of 1999, IMD introduced a 4-Stage warning system to issue cyclone warnings to the disaster managers. They are as follows:

A. Pre-Cyclone Watch

Issued when a depression forms over the Bay of Bengal irrespective of its distance from the coast and is likely to affect Indian coast in future. The pre-cyclone watch is issued by the name of Director General of Meteorology and is issued at least 72 hours in advance of the commencement of adverse weather. It is issued at least once aday.

B. Cyclone Alert

Issued at least 48 hours before the commencement of the bad weather when the cyclone is located beyond 500 Km from the coast. It is issued every three hours.

C. Cyclone Warning

Issued at least 24 hours before the commencement of the bad weather when the cyclone is located within 500 Km from the coast. Information about time /place of landfall are indicated in the bulletin. Confidence in estimation increases as the cyclone comes closer to the coast

D. Post landfall outlook

It is issued 12 hours before the cyclone landfall, when the cyclone is located within 200 Km from the coast. More accurate & specific information about time /place of landfall

and associated bad weather indicated in the bulletin. In addition, the interior distraction is likely to be affected due to the cyclone are warned in this bulletin.

118. How frequently IMD issues these bulletins?

When cyclone is beyond the range of coastal cyclone detection radar, (more than 400 km away from coast), cyclone warnings are issued 6 times a day to air stations and each warning is broadcast at frequent intervals interrupting routine programme. When the cyclone comes within radar range and tracked by radar, cyclone warnings are issued every hour to air stations. During cyclone period, concerned air stations keep round the clock watch for broadcasting cyclone warnings.

119. Is there any order in mentioning the disastrous weather in the bulletin?

A certain order depending upon the intensity and proximity of the system to the coast will be observed during cyclone period while indicating the adverse weather.
In case of a cyclone expected to strike the coast in

- About12hrs: tidal wave / gales / heavy rainfall
- Next 12-24 hrs: gales / tidal wave / heavy rainfall
- About 24hrs: rain / gales / tidal wave

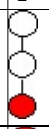
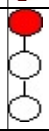
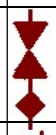
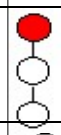
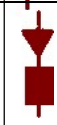
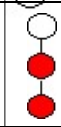
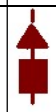
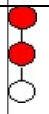
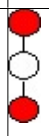
120. What is port warning?

The strong winds and high seas pose dangers to port. Moreover, if a storm is at high seas the ships moving out of the port may fall into danger. Therefore, the port is informed accordingly and advised to hoist signals which can be seen by mariners both during day and night. There are eleven such signals. The significant features of this warning are as follows.

- Port officers are warned about disturbed weather likely to affect their Ports by IMD.
- On receipt of warnings, Port officials hoist appropriate visual signals so that they are visible from adistance.
- Ports are warned 5 to 6 times a day during period of cyclonic storm.
- Warning contains information about location, intensity, expected direction, expected landfall point and type of signal the Port should hoist.
- Uniform system of storm warning signals introduced from 1st April 1898. There are different types of signals for different ports as mentioned below.

1) GENERAL SYSTEM : General Ports (eleven signals)
2) EXTENDEDSYSTEM: Extended Ports (Six section signals+11 Signals)
3) BRIEFSYSTEM :Brief ports (III, IV, VII, X, XI signals)
4) MINORPORTS :Special messages. No signals are hoisted.

121. PORT WARNINGS

Signal/ Flag No.		NAME	Symbols		Description
			Day	Night	
1.	Distant bad weather	DC1			Depression far at sea. Port NOT affected.
2.		DW2			Cyclone for at sea. Warning for vessels leaving port.
3.	Local bad weather	LC3			Port Threatened by local bad weather like squally winds.
4.		LW4			Cyclone at sea. Likely to affect the port later.
5.	Danger	D5			Cyclone likely to cross coast keeping port to its left
6.		D6			Cyclone likely to cross coast keeping port to its right.
7.		D7			Cyclone likely to cross coast over/near to the port.
8.	Great danger	GD8			Severe cyclone to cross coast keeping port to its left
9.		GD9			Severe cyclone to cross coast keeping port to its right
10.		GD10			Severe cyclone to cross coast keeping port to its right.
11.		XI			Communication failed with cyclone warning office.

122. What is fishermen warning?

A fisherman warning is warning message for fishermen who ply on coastal areas or may go out at sea. Dangers to fisherman due to storm are strong winds and associated high seas, due to which fishing boats may capsize. Hence, the fishermen are issued warning when one of the following conditions of weather is expected along and off anycoast

(i) Strong off-shore and on-shore winds (or with appropriate direction), speed exceeding 45kmph
(ii) Squally weather – frequent squalls with rain; or persistent type of strong gusty winds (>20kts; 36kmph) accompanied byrain.
(iii) Galesand
(iv) State of sea very rough or above (wave heights are four meters or more).

123. The warnings are disseminated to fishermen through

- Port
- Fisheries officials and
- AIR broadcast daily three / four times in local language. The warnings are broadcast as a routine four times a day (morning (0600 hrs), mid-day, evening (1800 hrs) and mid-night) from the air stations in the local language. During a cyclonic storm, such warnings are covered in the cyclone bulletins sent to the air stations at hourly or 3 hourly intervals for frequent broadcast. The fisheries warnings issued in mid-day are incorporated in the 'general weather bulletin' by forecasting offices in maritime states.
- IMD websites
- SMC to registered fishermen
- MobileApps, Common Alert Protocol

124. The fishermen warning contains information about

(i) Synoptic situation
(ii) Squally and gale wind
(iii) Sea condition
(iv) Signals hoisted and
(v) Advice not to go out in to the sea.

125. What is sea area bulletin?

Issued by ACWC for deep sea. Normally twice a day (based on 03 and 12UTC

- Thrice a day in case of depression/ deep depression (additional bulletin based on 18 UTC)
- Six times a day in case of a cyclone. There is also provision of special bulletin.

- The bulletin contains significant system, expected weather, wind, state of sea, port warning etc.

126. What is coastal weather bulletin?

Issued by area cyclone warning centre/ cyclone warning centre for coastal shipping

- Normally twice a day (based on 03 and 12UTC
- Issued based on sea areabulletin
- Thrice a day in case of depression/ deep depression (additional bulletin based on 18 UTC)
- Six times a day in case of a cyclone. There is also provision of specialbulletin
- The bulletin contains significant system, expected weather, wind, state of sea, port warning etc

127. How does IMD mention state of sea in the bulletins?

This is mentioned subjectively in plain language like rough sea, very rough sea etc. based on the prevailing wind over the sea surface as mentionedbelow.

Descriptive Term	Height Metres	Wind Speed Knots (Kmph)	In beaufort Scale
CALM (GLASSY)	0	0	0
CALM (RIPPLED)	0 - 0.1	1 - 3 (2 - 6)	1
SMOOTH (WAVELESS)	0.1 - 0.5	4 - 10 (7 - 19)	2 - 3
SLIGHT	0.5 - 1.25	11 - 16 (20 - 30)	4
MODERATE	1.25 - 2.5	17 - 21 (31 - 39)	5
ROUGH	2.5 - 4.0	22 - 27 (41 - 50)	6
VERY ROUGH	4.0 - 6.0	28 - 33 (52 - 61)	7
HIGH	6.0 - 9.0	34 - 40 (63 - 74)	8
VERY HIGH	9.0 - 14.0	41 - 63 (76 - 117)	9 - 11
PHENOMENAL	OVER 14	64 OR ABOVE (119 OR ABOVE)	12

128. What is meaning of the reference time mentioned in the bulletin?

The meaning of different reference times mentioned in the bulletin are given below.

- EARLYHOURS 0000 - 0400 HRS.IST
- MORNING 0400 - 0800 HRS.IST
- FORENOON 0800 - 1200 HRS.IST

- AFTERNOON 1200 - 1600 HRS.IST
- EVENING 1600 - 2000 HRS.IST
- NIGHT 2000 - 2400 HRS.IST
- EARLYMORNING 0400 - 0600 HRS.IST
- AROUNDNOON 1100 - 1300 HRS.IST

129. How are Cyclone Warnings disseminated?

The different telecommunication channels used are as follows

- Landline
- Telephone
- Telefax
- VHF/HFRT (Internal)
- Police Wireless
- AFTN (Aviation)
- Internet(e-mail)
- Websites
- Radio/TV network
- Mobile Apps
- Common Alert Protocol
- Websites
- Social Media

130. What are the bulletins available in the website? What is the website address?

There are different types of bulletins wrt cyclones. These are available on various websites of IMD including cyclone specific website (www.rsmcnewdelhi.imd.gov.in) These are as follows.

i. Extended range Outlook for cyclogenesis for next two weeks
ii. Daily Tropical Weather Outlook
iii. National Bulletin (Bulletin for India coast)
iv. RSMC bulletin
v. Bulletins for ships in high seas for Met Area VIII(N) under Global Maritime Safety system
vi. Tropical Cyclone Advisory for Civil Aviation in text and graphical form
vii. Quadrant Wind bulletin giving wind distribution around the centre of the cyclone in text and graphical form
viii. Storm surge guidance
ix. Fishermen warning bulletin in text and graphical form
x. Sea Area bulletins for ships in high seas
xi. Coastal weather bulletin
xii. Port Warnings

131. Who are the recipients of Cyclone Warnings?

Warnings are issued for general public, fishermen, farmers and different categories of users such as central and state government officials responsible for disaster mitigation and relief, industrial and other establishments located in the coastal areas, ports, coastal shipping, railways, aviation, transport, communication and power authorities.

132. How a common man gets information about a cyclonic storm?

Local AIR broadcast hourly (or more frequently) bulletins in local language as well as in Hindi and English. The bulletins give the location of the Cyclonic storm, its direction of movement, place and time of landfall and details of adverse weather expected over the areas likely to be affected by the storm. AIR, New Delhi issues bulletins thrice in a day giving similar information. Apart from that, the cyclone warning messages are sent to the collectors of the districts likely to be affected and the chief secretary of concerned state. The state Govt. takes necessary steps to inform the local population through their machinery such as police wireless etc. They make necessary arrangement for evacuation from coastal area and for removal of the population to other places.

133. On the event of any doubt about approach of a cyclonic storm to whom a common man can approach to get authentic information in absence of relevant AIR bulletins)?

If feasible, all the information is available in IMD's dedicated website for tropical cyclones (www.rsmcnewdelhi.imd.gov.in). All websites of IMD also have the cyclone information. Cyclone track and intensity is also available on GIS map. Normally all collectors of coastal districts (subjected to adverse weather due to cyclonic storm) are intimated by sending warning messages through fax. They in turn inform junior officers under their control to take necessary action. These informations will be therefore available with the state Govt. officials. More over if any one is having phone facilities he may contact nearest cyclone warning centre/ Area cyclone warning centre or Cyclone Warning Division at IMD Head Quarters, New Delhi to get most authentic information about storms over Bay of Bengal.

134. How does IMD keep liaison with State officials?

Area Cyclone Warning Centres (ACWCs) and Cyclone Warning Centres (CWCs) maintain liaison with the concerned state Governments in state and district levels on cyclone related activities. The cyclone warning bulletins are communicated to the Chief Secretary, Revenue Secretary, Special Relief Commissioner, State control room, State Disaster Management Authority and concerned district collectors every three hourly. In addition, the Chief Secretary is personally briefed by Director, ACWC/CWC regularly. Before the cyclone season, ACWC/CWC organizes the pre-cyclone preparedness meeting under the chairmanship of Chief Secretary where all the high

state Govt. officials from various departments participate.

135. What are the devastations which cannot be protected by a common man and has to be mentally prepared to accept the loss?

Inundations caused by storm surge, uprooting of trees and damage caused by that, flooding of low-lying areas due to heavy rain and damage to houses and communication due to very strong winds.

136. How to understand that the cyclonic storm has weakened / moved away?

With the approach of a storm squally weather commences. On the other land the storm weakens or goes away from the station the /weather gradually improves.
The rainfall decreases. the wind speed weakens and gradually sky clears. However, one should be very careful about the situation when the centre of the storm technically known as the "eye" of the storm passes through the station. The station will first experience very severe weather with approaching cyclone. When the eye of the storm passes over the station the weather becomes practically fair with light winds and little or no clouds at all. During night stars may he visible. But after a lapse of few minutes (say 10-15 minutes) very severe weather again commences. This time the wind blows from exactly the opposite direction. A sharp change from very severe weather to fair weather may be an indication that the eye of the storm is approaching thestation.

137. What are the "pre-cyclone/during the cyclone/post cyclone" responsibilities of a common man?

A. Steps to be taken before the cyclone

1. Check houses, secure loose tiles by cementing wherever necessary, repair doors and windows.
2. Check the area around the house -remove dead or dying trees, anchor removable objects like lumber piles, loose bricks, garbage cans, sign-boards, loose zinc sheets etc.
3. Keep some wooden boards ready so that glass windows can beboarded.
4. Keep a hurricane Lantern filled with kerosene, flash light and enough dry cells.
5. Promptly demolish condemned buildings.
6. Those who have radio sets should ensure that the radio is fully serviceable in the case of transistors an extra set of batteries should be kept handy.

B. Steps to be taken during the cyclone.

1. Keep your radio on and listen to latest weather warnings and advisories from the nearest All India Radio station. Pass the information to others.
2. Avoid being misled by rumors. Pass only the. Official information you have got from the radio to others.
3. Get away from low lying beaches or other locations which may be swept by

high tides or storm waves. Leave sufficiently early before your way to high ground gets flooded. Do not delay and run the risk of being marooned.

4. If your house is out of danger from high tides and flooding from the river, and it is well-built, it is then probably the best place during weather and storm. However, please act promptly if asked to evacuate.
5. Be alert for high water in areas where streams of rivers may flood due to heavy rains.
6. Board up glass windows or put storm shutters in place. Use good wooden planks Securely fastened. Make-shift boarding may do more damage than none at all. Provide strong suitable support for outside doors.
7. If you do not have wooden boards handy paste paper strips on glasses to prevent splinters flying into the, house.
8. Get extra food, especially things which can be eaten without cooking or with very little preparation. Store extra drinking water in suitable covered vessel.
9. If you are in one of the evacuation areas, move your valuable articles to upper floors to minimize flood damage.
10. Have hurricane lantern, flash lights and/or other emergency light in working condition and keep them handy.
11. Check on everything that might blow away or be torn loose. Kerosene tins, cans, agricultural implements, garden tools, road signs and other objects become weapon of destruction in strong winds. Remove them and store them in a covered room.
12. Be Sure that a window or door can be opened on the lee side of the house i.e. the side opposite the one facing the wind.
13. Make provisions for children and adults requiring special diets.
14. If the centre of' ‘eye' of the storm passes directly over your place, there will be a lull in the wind and rain, lasting for half an hour or more. During this period stay in safe place. Make emergency repairs during the lull period if necessary, but remember that strong wind will return suddenly from the opposite direction, frequently with even greater violence.
15. Be calm. Your ability to meet emergency will inspire and help others.

C. <u>Steps to be taken after Cyclone.</u>

1. They should remain in shelters until informed by those in charge that they may return home.
2. Any loose and dangling wire from the lamp post should be strictly avoided.
3. People should keep away from disaster areas unless they are required to assist.
4. Anti-social elements should be prevented from doing mischief and reported to the police.
5. Cars, buses lorries and carts should be driven carefully.
6. The houses and dwellings should be cleared of debris.
7. The losses should be reported to the appropriate authorities.

8. Relatives should be promptly informed about the safety of persons in the disaster area.

138. How IMD coordinates with National Disaster Management Division (NDM) of the Ministry of Home Affairs?

IMD has established linkages/institutional arrangements with disaster management agencies both at the centre and in the states. During normal weather conditions two bulletins are transmitted to Control Room of National Disaster Management Division (NDM). In a case of depression develops over north Indian Ocean which has the potential to affect Indian coast, special bulletins at-least three times a day are issued to NDM. When the system intensifies into a cyclonic storm, the cyclone warning bulletins are every three hourly. At present 4 stage warning procedure as discussed earlier is followed for issuing bulletins to NDM Control Room. When the system weakens or not going to affect Indian coast, a dewarning message is also issued to NDM Control Room. The cyclone warning bulletins are also passed on to State Government Authorities/District Collectors who are in constant touch with Cyclone Warning Centres. The centres and local committees consisting of various departments dealing with disaster management issues meet at the time of crisis and take necessary follow upactions.

139. What is the role of IMD Tropical Cyclone management of north Indian Ocean Rim countries?

A Regional Specialized Meteorological Centre (RSMC) has been established at IMD, New Delhi. It is one of the six such centres recognized by the WMO under a global system for monitoring tropical cyclones. As an international commitment, through the WMO/ESCAP Panel on Tropical Cyclones, tropical cyclone advisories are issued by RSMC, New Delhi to the Panel Member countries during the tropical cyclones in the Bay of Bengal and the Arabian Sea. The other ESCAP Panel countries are Thailand, Myanmar, Bangladesh, Pakistan, Sri Lanka, Maldives and Oman.

140. What are the bulletins issued by RSMC, New Delhi?

RSMC New Delhi issues the following bulletins

- Tropical Weather Outlook for WMO/ESCAP Panel member countries
- Special Tropical Weather Outlook for WMO/ESCAP Panel member countries
- Tropical Cyclone Advisory for Panel member countries
- Tropical Cyclone Advisory for InternationalAviation

RSMC, New Delhi is also designated as Tropical Cyclone Advisory Centre (TCAC) and issues cyclone advisories for International Aviation as per the guidelines of ICAO. These advisories are issued every six hours based on observations at 0000, 0600, 1200 and 1800UTC.

141. When are the bulletins issued by RSMC, New Delhi?

- Tropical Weather Outlook is issued daily at 1130 hrs IST (06UTC).
- Special Tropical Weather Outlook is issued when there is a depression or deep depression over North Indian Ocean.
- Tropical Cyclone Advisory is issued when there is a tropical Cyclone of any intensity over North Indian Ocean.
- Tropical Cyclone Advisory for International Aviation, which is called TCAC bulletin, is issued when there is a tropical Cyclone of any intensity over North Indian Ocean.

142. What is UTC? How do I tell at what time a satellite picture was taken?

UTC stands for **Universal Time Coordinated**, what used to be called Greenwich Mean Time (**GMT**) and Zulu Time (**Z**). This is the time at the Prime Meridian (0° Longitude) given in hours and minutes on a 24 hour clock. For example, 0000 UTC is 0530 hours IST. The Greenwich Royal Observatory at Greenwich, England (at 0° Longitude) was where naval chronometers (clocks) were set, a critical instrument for calculating longitude. This is why **GMT** became the standard for world time. Meteorologists have used **UTC** or **GMT** times for over a century to ensure that observations taken around the globe are taken simultaneously.
On most satellite pictures and radar images the time will be given as **UTC**, **GMT**, or **Z** time.

143. What is relation between kmph and knots (or m/s)?

For winds:

1 mile per hour = 0.869 international nautical mile per hour (knot)
1 knot = 1.852 kilometers per hour
1 knot = 0.5144 meter per second
1 meter per second = 3.6 kilometers per hour

144. Why are tropical cyclones named?

Tropical cyclones are named to provide easy communication between forecasters and the general public regarding forecasts, watches, and warnings. Since the storms can often last a week or longer and that more than one can be occurring in the same basin at the same time, names can reduce the confusion about what storm is being described. The first use of a proper name for a tropical cyclone was by an Australian forecaster early in the 20th century. He gave tropical cyclone names "after political figures whom he disliked. By properly naming a hurricane, the weatherman could publicly describe a politician (who perhaps was not too generous with weather-bureau appropriations) as 'causing great distress' or 'wandering aimlessly about the Pacific.'" (Perhaps this should be brought back into use)

During World War II, tropical cyclones were informally given women's names by US Army Air Corp and Navy meteorologists (after their girlfriends or wives) who were monitoring and forecasting tropical cyclones over the Pacific. From 1950 to 1952, tropical cyclones of the North Atlantic Ocean were identified by the phonetic alphabet (Able-Baker-Charlie-etc.), but in 1953 the US Weather Bureau switched to women's names. In 1979, the WMO and the US National Weather Service (NWS) switched to a list of names that also included men's names.

The Northeast Pacific basin tropical cyclones were named using women's names starting in 1959 for storms near Hawaii and in 1960 for the remainder of the Northeast Pacific basin. In 1978, both men's and women's names were utilized.

The Northwest Pacific basin tropical cyclones were given women's names officially starting in 1945 and men's names were also included beginning in 1979. Beginning on 1 January 2000, tropical cyclones in the Northwest Pacific basin are being named from a new and very different list of names. The new names are Asian names and were contributed by all the nations and territories that are members of the WMO's Typhoon Committee. These newly selected names have two major differences from the rest of the world's tropical cyclone name rosters. One, the names by and large are not personal names. There are a few men's and women's names, but the majority are names of flowers, animals, birds, trees, or even foods, etc, while some are descriptive adjectives. Secondly, the names will not be allotted in alphabetical order, but are arranged by contributing nation with the countries being alphabetized.

The Southwest Indian Ocean tropical cyclones were first named during the 1960/1961 season.

The Australian and South Pacific region (east of 90E, south of the equator) started giving women's names to the storms in 1964 and both men's and women's names in 1974/1975.

The North Indian Ocean region tropical cyclones are being named since October 2004. 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 is presented below:

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 December 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	Sapakye e	Zabagji	Wetwun	We'wum	Mwaihou t	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	Verambh a	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	Watad	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.**

List of approved names of tropical cyclones over the north Indian Ocean (in 2004). All these names have already been used till May, 2020.

WMO/ESCAP 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	--	Mahasen	--
Thailand	Mukda	Muuk-dar	KhaiMuk	Ki-muuk	Phet	Pet	Phailin	Pi-lin

WMO/ESCAP 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	Bulbul
Sri Lanka	Priya	--	Asiri	Aa'siri	Gigum	Gi'gum	Soba	--
Thailand	Komen	Goh-men	Mora	Moh-rar	Phethai	Pay-ti	Amphan	Um-pun

145. How can I nominate a new name for the list?

The names to be included in the list must meet some fundamental criteria. They should be short and readily understood when broadcast. Further the names must be culturally sensitive and not convey some unintended and potentially inflammatory meaning. Typically, over the historical record, about one storm each year causes so much death

and destruction that its name is considered for retirement. The suggested name may be communicated to Director General of Meteorology, India Meteorological Department, Mausam Bhavan, Lodi Road, New Delhi-110003.

146. Can we tame a tropical Cyclone to reduce its damage potential?

Considering the huge energy potential of the Cyclones, all experiments in US under the Project "Storm Fury" to tame them have turned futile. The best solution is not to try to alter or destroy the tropical cyclones, but just learn to co-exist better with them. Since we know that coastal regions are vulnerable to the storms, enforce building codes that can have houses stand up to the force of the tropical cyclones. In this regard the Building Material Technology Promotion Council (BMTPC), Ministry of Urban affairs has brought out a vulnerability map in consultation with IMD which is very useful for disaster manager's.

147. What are the different methods tried to modify the cyclone?

- Seeding with silveriodide.
- Placing a substance on the oceansurface.
- By nukingthem.
- By cooling the surface waters with deep oceanwater.
- By adding a water absorbing substance.

148. What are the future plans of IMD to strengthen the Cyclone warning setup?

- Strengthening of surface, upper air and space based observational network.
- Augmentation of numerical models, especially probabilistic models
- Augmentation of Hazard, impact and risk assessment models
- Improvement in dissemination with dedicated mobile app and full implementation of common alert protocol

149. What is accumulated cyclone energy (ACE) of a tropical cyclone?

Accumulated cyclone energy (ACE) is an index used to measure the activity of a cyclone season. It is calculated by summing up the squares of the maximum sustained wind 10 m above ground (V_{max}) in the cyclone observed every six hours at 00, 06,12 and 18 UTC during the life period of the cyclone. Mathematically,

$ACE = \Sigma V_{max}^2$ in kt^2

Thus ACE depends on the intensity (MSW) and life period of the storm. ACE is the measure of damage potential of the storm.

150. What is Power Dissipative Index (PDI) of tropical cyclone?

The Power Dissipation Index (PDI) measures the activity of cyclones by accounting for cyclone strength, duration, and frequency. Like ACE, it also uses three parameters:

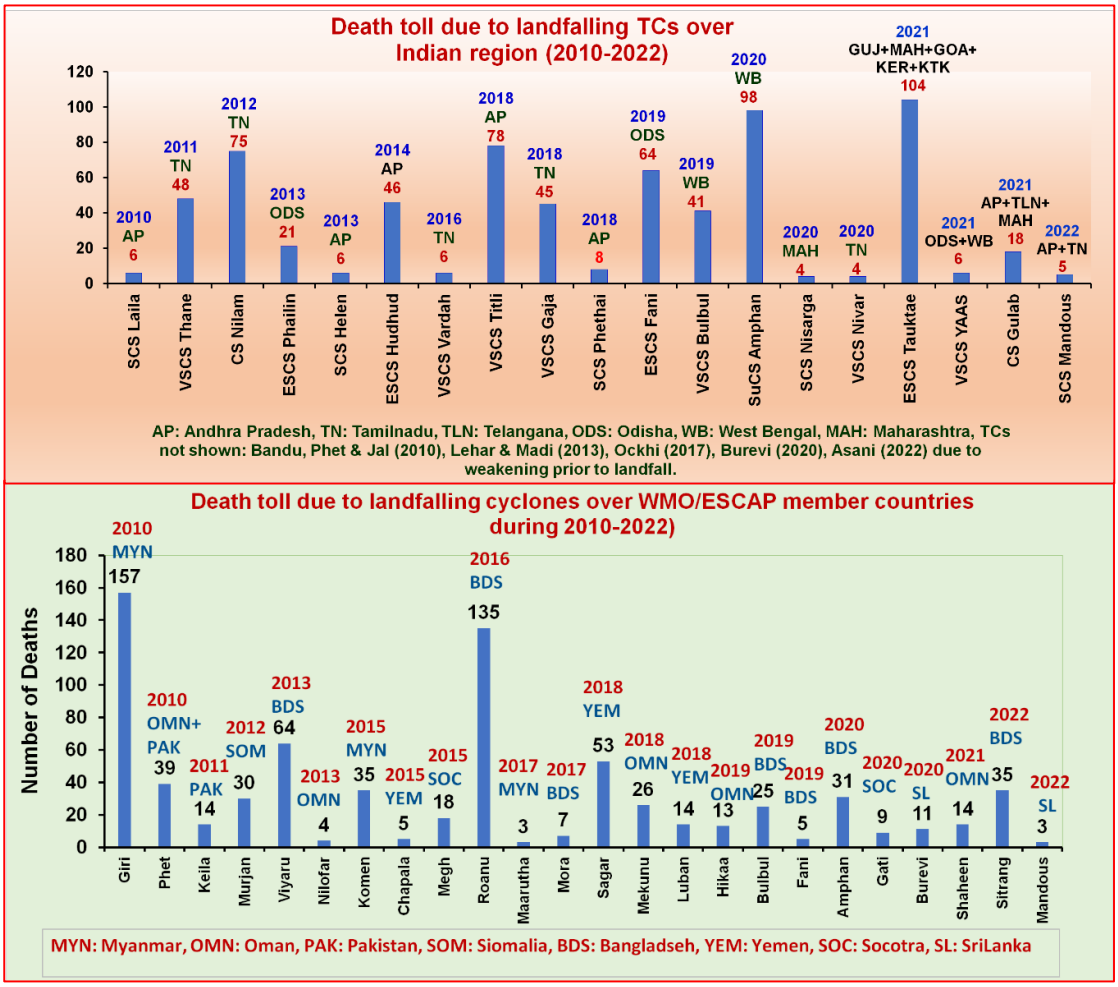
frequency, duration and intensity, as given in thefollowing equation.

$PDI = \Sigma V_{max}^3$ in kt^3

Here (V_{max}) is the maximum sustained wind speed at about 10 meter above ground. Sometimes, it is believed that this index to be a better representation of TC threat than intensity alone. PDI is calculated for each cyclone and also annual average basis, as the averageclearly depicts whether intense TC frequency is increased or not in reality. The PDI is the measure of the loss.

151. What is death toll due to cyclones in recent years?

Statistics show that the death toll due to cyclones has decreased significantly in recent years to less than 100 not only in India, but also in member countries.



152. 144. What is resilience to cyclone?

As per the definition of National Disaster Management Authority of India, resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodateto and recover from the effects of a hazard in a timely and efficient manner, including through thepreservation and restoration of its essential basic structures and functions.

The resilience to the cyclone depends on the efficiency of EWS, confidence on the EWS by the public and disaster managers, adequate response actions in different phases like pre, during and post cyclone disaster. It also depends on cyclone disaster resilient infrastructures which are taken up as a part of long term preparedness. The resilience could include the finance mechanism supporting recovery from the impact of cyclone hazards. Thus, apart from cyclone warning the loss forecast can help the improvement in resilience.

153. Is there any GIS platform for cyclone warning?

Yes, there is interactive display for cyclone warning is available in the IMD main website under cyclone section.

The Direct link is given below

https://ddgmui.imd.gov.in/dwr_img/GIS/cyclone.html

This portal will get updated automatically once CWD start issuing updates.

154. How can one find his village/town on the tropical cyclone warning map?

As this is GIS based platform has information up to street level/location specific details over the map which can find by zooming to respective region and search location is also available in this platform by which user can directly go to that location

155. 147. How can one get the distance of his place from the cyclonic storm?

In cyclone warning portal distance tool is there by which user can find out distance between any two points in kilometers.

FAQs Marine Weather Services

1. Which is the first service to marine community by India Meteorological Department (IMD)?

After the two severe cyclonic storms hit the east coast coast of India (Kolkata in October and Machilipatnam in November) in 1864, first storm warning system was developed for Kolkata Port in 1865 (even before the establishment of IMD in 1875. **Thus, port warning is the first and oldest service to marine community by IMD and Kolkata Port is the first port from where this service was first launched.**

2. What are the marine weather services provided by IMD?

IMD provides following services for marine community:

(i) Cyclone Warning and storm surge warning

(ii) Bulletins for ships in deep sea under Global Maritime Distress Safety System

(iii) Sea area bulletins for ships in deep sea beyond 40 nm

(iv) Coastal weather bulletins for ships in sea upto 40 nm

(v) Port warnings for 120 ports along the east & west coast of India

(vi) Fishermen warnings

(vii) Coastal Weather Forecast

(viii) Nowcast for coastal stations

(ix) Observations from coastal observatories, island stations, ships and buoys on website for general public, forecasters and research community

(x) Customised location specific impact based forecast in association with tropical cyclones for offshore industries

(xi) Bulletins for Indian Navy

(xii) Severe weather guidance under Severe Weather Forecasting Programme for Bay of Bengal, Arabian Sea and 9 member countries

(xiii) Warnings for designated and registered users

(xiv) Bulletins for Radio/TV

(xv) Bulletins for offshore & onshore industries

3. What is the organisational structure of IMD to manage services to Marine community at national level?

IMD has a well established organisational network countrywide to manage it's services to Marine community. The entire work wrt these warnings is undertaken by Cyclone Warning Division (CWD) and Marine Services Division (MSD) at National level and 7 sub-offices including 3 Area Cyclone Warning Centres (ACWCs) at Chennai, Mumbai, Kolkata and 4 Cyclone Warning Centres at Bhubaneswar, Visakhapatnam, Thiruvananthapuram and Ahmedabad. The organisational structure is presented in Fig. 1. Detailed area of responsibility of each of the sub-office is given in Table 1:

Table 1: Area of responsibility of various sub-offices catering to cyclone and marine warnings

Area of Responsibility			
Centre	**Sea Area**	**Coastal Area**	**Coastal states**
ACWC Kolkotta	Bay of Bengal	West Bengal, Andaman & Nicobar islands	West Bengal, Andaman & Nicobar islands
ACWC Chennai	-	Tamil Nadu & Puducherry	Tamil Nadu & Puducherry
ACWC Mumbai	Arabian Sea	Maharashtra, Goa	Maharashtra, Goa
CWC Bhubaneshwar	-	Odisha	Odisha
CWC Visakhapatnam	-	Andhra Pradesh	Andhra Pradesh
CWC Thiruvananthapuram	-	Kerala, Karnataka	Kerala, Karnataka & Lakshadweep
CWC Ahmedabad	--	Gujarat, Diu, Daman, Dadra & Nagar Haveli	Gujarat, Diu, Daman, Dadra & Nagar Haveli

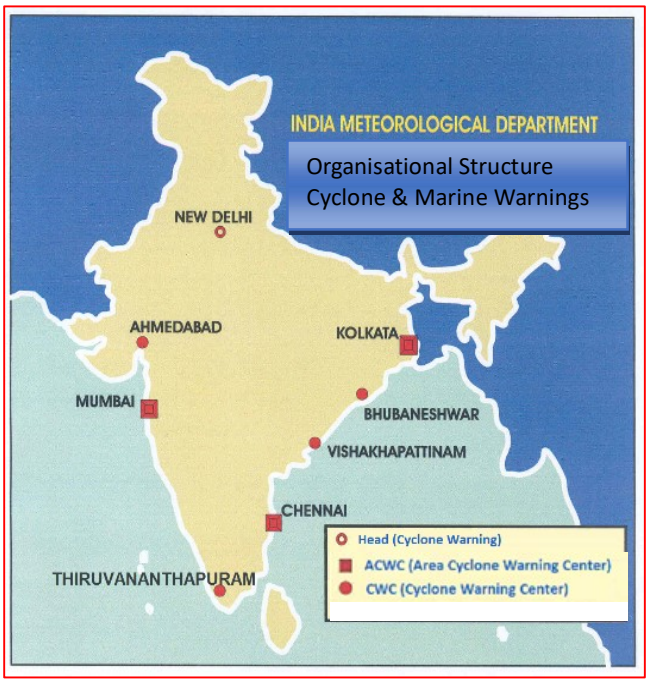


Fig. 1: Organisational structure of IMD for management of cyclone and marine warnings at national level

4. What is the role of IMD for marine community at international level ?

At international level IMD contributes as:

- One among the six WMO designated Regional Specialised Meteorological Centres (RSMCs) globally mandated to provide cyclone warnings for their area of responsibility. IMD provides cyclone warnings for the entire Bay of Bengal & Arabian Sea and 13 WMO/ESCAP Panel member countries including Thailand, Myanmar, Bangladesh, India, Sri Lanka, Maldives, Pakistan, Iran, Oman, Qatar, United Arab Emirates, Saudi Arabia and Yemen. IMD also provides cyclone advisories to Somalia. The map showing area of responsibility is presented in Fig. 2.

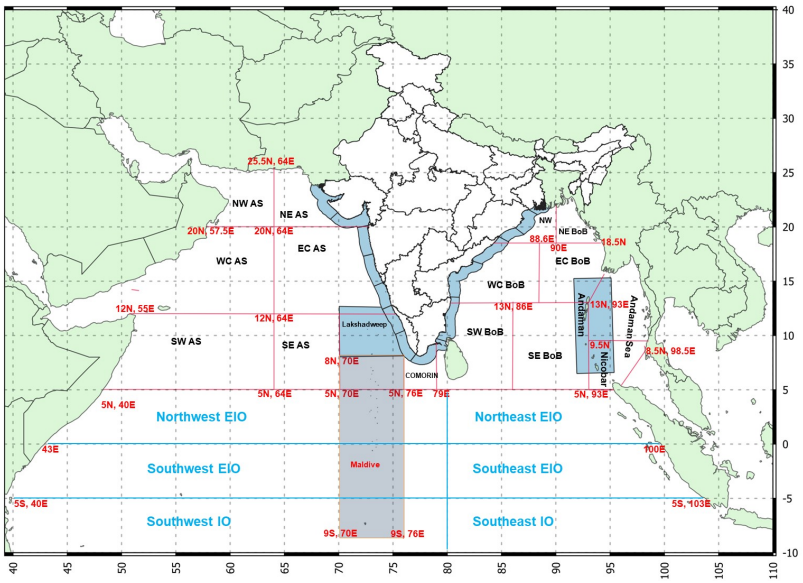


Fig. 2: Area of responsibility of RSMC New Delhi

- IMD is one among the 16 National Meteorological & Hydrological Services (NMHSs) across globe notified by International Maritime Organisation (IMO) to provide advisory under Global Maritime Distress Safety System (GMDSS) for the safety of life at sea (SOLAS) for Met Area VIII(N). The map showing area of responsibility is presented in Figure 3 (a). For administration purpose Met Area VIII (N) is further subdivided as shown in Fig 3 (b).

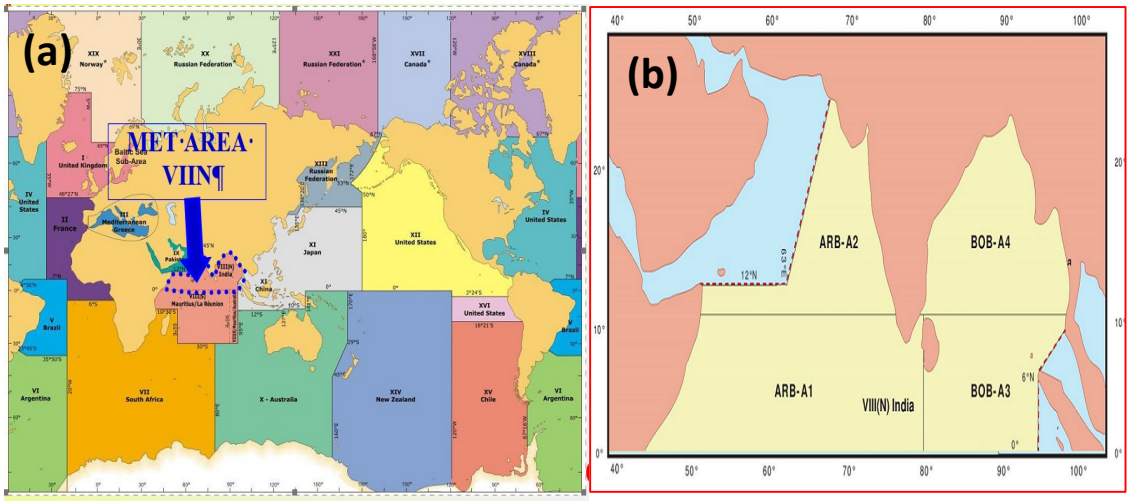


Fig. 3 (a): Area of responsibility for Met Area VIII (N) and (b) Sub-divisions of Met Area VIII (N)

- IMD also acts as one of the global centres identified by WMO to provide severe weather guidance on heavy rainfall, strong winds, high waves, storm surge and cyclonic disturbance under Severe Weather Forecasting Programme (SFWP). The area of responsibility is presented in Fig.4.

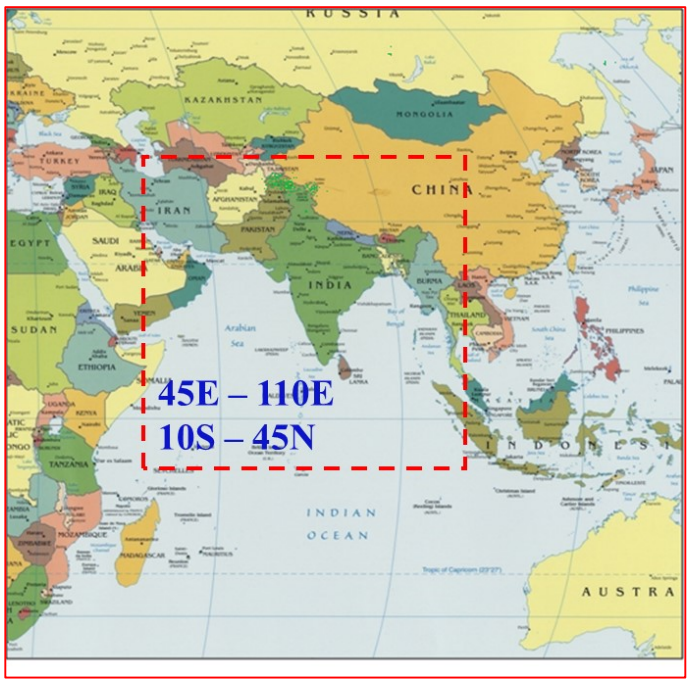


Fig. 4: Area of responsibility for severe weather guidance

5. Who are the users for marine bulletins ?

Following are the user agencies for marine weather services of IMD:
i) Merchant mariners
ii) Navy and Indian Coast Guard
iii) Port authorities
iv) Harbour managers
v) Offshore asset managers
vi) Shipping
vii) Oil and gas explorers
viii) Fishermen, Fisheries officials
ix) Sports persons
x) Surfers and Tourists

6. What are the websites on which the marine advisories are available?

Marine advisories are available on following sites:

National websites:

Mausam website: www.mausam.imd.gov.in.

RSMC website: www.rsmcnewdelhi.imd.gov.in

Maritime States Offices websites:

Area Cyclone Warning Centre, RMC Kolkata: RMC Kolkata (imd.gov.in)

Area Cyclone Warning Centre, RMC Mumbai: RMC Mumbai (imd.gov.in)

Area Cyclone Warning Centre, RMC Chennai: RMC Chennai (imd.gov.in)

Cyclone Warning Centre, MC Bhubaneswar: Odisha (imd.gov.in)

Cyclone Warning Centre, MC Amravati: Amaravati (imd.gov.in)

Cyclone Warning Centre, MC Thiruvananthapuram: Kerala (imd.gov.in)

Cyclone Warning Centre, MC Ahmedabad: Gujarat (imd.gov.in)

(MC: Meteorological Centre)

7. What are cyclone warnings ?

Cyclones are intense low pressure systems developing over the warm oceanic areas with strong winds of maximum sustained wind speed (MSW) ≥ 62 kmph, circulating around it's centre in anticlockwise (clockwise) direction in northern (southern) hemisphere.

IMD issues warnings wrt these systems in various temporal scales when the system is over sea till it becomes insignificant to cause any adverse weather as per details below:

- At the stage of a cyclonic circulation, low pressure area, well marked low pressure area (MSW ≤ 30 kmph) normal bulletins 4 times daily are issued by National Weather Forecasting Centre (NWFC) based on 0530, 0830, 1430 and 1730 hrs IST and a special message is issued once daily (based on 0830 hours IST observations) by Cyclone Warning Division (CWD).
- Once it becomes a depression (MSW 31-61 kmph), frequency of bulletins increases and Cyclone Warning Division provides numbered bulletins five times daily based on 0530, 0830, 1130, 1730, 2330 hrs IST.
- When it becomes a cyclonic storm (MSW≥62 kmph), frequency further increases and 3 hourly bulletins are issued based on 0530, 0830, 1130, 1430, 1730, 2030, 2330 and 0230 hrs IST.
- Different types of user specific bulletins are issued wrt cyclone warnings by the IMD.

8. What are the marine meteorological parameters?

Marine meteorological parameters include following:

(a) Wind speed and direction

(b) Atmospheric pressure, tendency & characteristics

(c) Weather-present and past

(d) Clouds (amount, type and height of base)

(e) Visibility

(f) Air temperature

(g) Humidity

(h) Precipitation

(i) Sea-surface temperature

(j) Ocean sea-wave/swell-height, period/direction

(k) Sea ice and/or ice accretion on board ship, when appropriate

All the above parameters are observed by the ships plying on sea. In addition, the ships also mention the course and speed of ships in the bulletin/message issued by them normally every six hrs and every three hrs during cyclone period.

9. **What are the marine meteorological forecast products?**

IMD provides forecast for

(i) Wind,

(ii) Weather,

(iii) Visibility,

(iv) Significant wave height

(v) Cyclonic disturbances and

(vi) Storm surge and

(vii) Swell

10. What is significant wave height?

Significant wave height is defined as the average height of the highest one-third waves in a wave spectrum. Its value roughly approximates to visually observed wave height.

11. What are the terminologies used by IMD for (i) rainfall intensity, (ii) rainfall distribution, (iii) maximum sustained wind speed and category of cyclonic disturbance, (iv) state of sea and (v) visibility ?

The criteria for rainfall intensity is given in Table 2 and rainfall distribution & horizontal visibility are presented in Table 3,

Table 2: Criteria for rainfall intensity

Descriptive term used	Rainfall amount in mm
No rain	0.0
Very light rain	0.1- 2.4
Light rain	2.5 – 15.5
Moderate rain	15.6 – 64.4
Heavy rain	64.5 – 115.5
Very heavy rain	115.6 – 204.4
Extremely heavy rain	204.5 or more
Exceptionally heavy rain	When the amount is a value near about highest recorded rainfall at or near the station for the month or season. However, this term will be used only when the actual rainfall amount exceeds 12 cm.

Table 3: Distribution of rainfall and associated visibility

Rainfall	Area extent of rainfall	Horizontal visibility (NM)	Nomenclature
Fair (no rainfall)	No rain (Dry)	10-8	Very Good
Isolated (One or two places)	≤25% of area gets rainfall	8-6	Good
Scattered (at a few places)	(26-50)% of area gets rainfall	6-4	Moderate
Fairly widespread (at many place)	(51-75)% of area gets rainfall	4-2	Poor
Widespread (at most places)	(76-100)% of area gets rainfall	< 2	Very poor

The strong winds associated with tropical cyclones (TCs) also disturb the state of sea from rough (significant wave height of 2.5 m) to phenomenal (significant wave height more than 14 m). Wave height as high as 14.0 m or above can be observed in case of VSCS or above intensity storms. The condition of Sea, significant wave height associated with maximum sustained wind speeds (MSWs), are given in Table 4.

Table 4: Maximum sustained wind speed and associated wave height and sea state

Sea state descriptive Term	Significant wave Height (m)	Maximum sustained Wind speed (kts)
Smooth (waveless)	0.1-0.5	4-10
Slight	0.5-1.25	11-16
Moderate	1.25-2.5	17-21
Rough	2.5-4.0	22-27
Very rough	4.0-6.0	28-33
High	6.0-9.0	34-47
Very high	9.0-14.0	48-63
Phenomenal	Over 14	64 or above

The wind direction is described by 16 points of compass as given in Fig.5

Cardinal Direction	Degree Direction
N	348.75 - 11.25
NNE	11.25 - 33.75
NE	33.75 - 56.25
ENE	56.25 - 78.75
E	78.75 - 101.25
ESE	101.25 - 123.75
SE	123.75 - 146.25
SSE	146.25 - 168.75
S	168.75 - 191.25
SSW	191.25 - 213.75
SW	213.75 - 236.25
WSW	236.25 - 258.75
W	258.75 - 281.25
WNW	281.25 - 303.75
NW	303.75 - 326.25
NNW	326.25 - 348.75

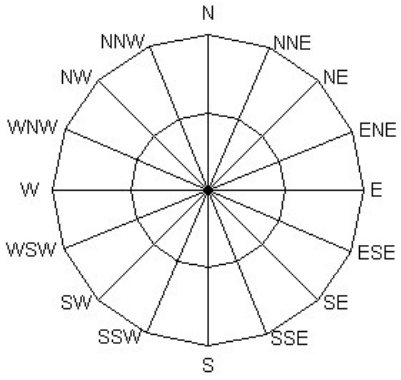


Figure 5: Wind direction and criteria

12. Which models are used for marine weather forecast?

Following models are utilised to prepare marine weather forecast

- Atmospheric Global Models (IMD GFS, GEFS, NCEP GFS, ECMWF, UKMO, JMA Model) and their MME
- Atmospheric Regional Models (WRF, NCUM)
- AdCirc Storm Surge Model
- Ocean models : MOM, POM, HYCOM, ROMS
- ECMWF wave model
- Coupled model: HWRF

(GFS: Global Forecast System, GEFS: Global Ensemble Forecast System, NCEP: National Centre for Environment Prediction, ECMWF: European Centre for Medium Range Weather Forecasting, UKMO: United Kingdom Meteorological Office, JMA: Japan Meteorological Agency, MME: Multi Model Ensemble, WRF: Weather Research Forecast, NCUM: NCMRWF Unified Model, NCMRWF: National Centre for Medium Range Weather Forecasting, AdCirc: Advanced Circulation, MOM: Modular Ocean Model, POM: Princeton Ocean Model, HYCOM: Hybrid Coupled Ocean Model, ROMS: Regional Ocean Modeling System and HWRF: Hurricane Weather Research & Forecast)

13. What information is shared in GMDSS bulletin. What is the periodicity of this bulletin? What is the validity period of this bulletin? Where can one get this information? How is it transmitted to ships in deep sea?

Content: This bulletin has two parts. Part 1 discusses the significant weather system and Part 2 discusses wind, weather, visibility, wave height, port warnings for 24 hours and 48 hours

validity period for different sea area A1, A2, A3 and A4 over Bay of Bengal and Arabian Sea under Met Area VIII (N) (Fig. 3(b)).

Frequency: IMD is transmitting daily two GMDSS bulletins for Met. Area VIII(N), at 0900 UTC and 1800 UTC. During Cyclone period additional bulletins (4) are also issued based on 00, 03, 06, 12 & 18 UTC for GMDSS broadcast depending on the requirement.

Validity: Valid for next 24 and 48 hours from time of issue of bulletin

Type of bulletin: Text, graphical and Web-GIS

Mode of transmission: This bulletin is prepared by MSD of NWFC, New Delhi and transmitted to Tele-communication Division (Regional Telecommunication Hub (RTH), New Delhi) for further transmission by e-mail to the Local Earth Station (LES) of VSNL in Ghaziabad. They in turn transmit the message to International Maritime satellite (INMARSAT). This bulletin is also sent to Naval Headquarter and Navy Western Command by email from MSD at HQ.

Websites: Various websites of IMD including www.rsmcnewdelhi.imd.gov.in, www.mausam.imd.gov.in contain this bulletin.

Sample GMDSS Bulletin issued by MSD, New Delhi during cyclone Tauktae

GLOBAL MARITIME 152330
DATE 15-05-2021 GMDSS BULLETIN-II 151800
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 15 MAY 2021.

PART-I STORM WARNING

THE SEVERE CYCLONIC STORM "TAUKTAE" (PRONOUNCED AS TAU"TE) OVER EASTCENTRAL ARABIAN SEA MOVED NEARLY NORTHWARDS WITH A SPEED OF ABOUT 13 KMPH DURING PAST 06 HOURS AND LAY CENTRED AT 1500 UTC OF TODAY, THE 15 TH MAY, 2021 OVER EASTCENTRAL ARABIAN SEA NEAR LATITUDE 14.2 DEG N AND LONGITUDE 72.7 DEG E, ABOUT 190 KM SOUTH-SOUTHWEST OF PANJIM-GOA, 550 KM SOUTHSOUTHWEST OF MUMBAI, 780 KM SOUTH-SOUTHEAST OF VERAVAL (42909) AND 910 KM SOUTH-SOUTHEAST OF KARACHI (41780). IT IS VERY LIKELY TO INTENSIFY FURTHER INTO A VERY SEVERE CYCLONIC STORM DURING NEXT 12 HOURS AND INTENSIFY FURTHER. IT IS VERY LIKELY TO MOVE NORTH-NORTHWESTWARDS AND REACH GUJARAT COAST DURING 0000-0400UTC OF 18TH AND CROSS GUJARAT COAST BETWEEN PORBANDAR AND NALIYA AROUND 0900-1200UTC OF 18TH MAY, 2021 (.)

THE ASSOCIATED MAXIMUM SUSTAINED WIND SPEED IS 60 KNOTS GUSTING TO 70 KNOTS. THE ESTIMATED CENTRAL PRESSURE IS 984 HPA. SEA CONDITION IS VERY HIGH (.)

PART-II (.)

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
1)WINDSPEED AND DIRECTION: 1) E OF 61 DEG E: CYCLONIC 70/80 KTS (.)
2)REST AREA: SW-LY 10/20 KTS (.)
II)WEATHER: 1) E OF 68 DEG E: WIDESPREAD RA/TS(.)
2)S OF 15 DEG N TO W OF 68 DEG E: FAIRLY WIDESPREAD RA/TS (.)
3)REST AREA: FAIR (.)
III)VISIBILITY: 11) E OF 68 DEG E: 3-2 NM (.)
2)S OF 15 DEG N TO W OF 68 DEG E: 4-3 NM (.)
3)REST AREA: 10-8 NM (.)
IV)WAVE HEIGHT: 1) E OF 61 DEG E: OVER 14.0 MTR (.)
2)REST AREA: 2.0-3.0 MTR (.)

A2-FORCAST FOR 48 HOURS
1)WINDSPEED AND DIRECTION: 1) E OF 63 DEG E TO N OF 14 DEG N: CYCLONIC 75/85 KTS (.)
2)REST AREA: SW/W-LY 10/20 KTS (.)
II)WEATHER: 1) S OF 14 DEG N TO THE E OF 60 DEG E: WIDESPREAD RA/TS(.)
2)N OF 14 TO 22 DEG N TO THE E OF 68 DEG E: WIDESPREAD RA/TS(.)
3)REST AREA: FAIR (.)
III)VISIBILITY: 1) S OF 14 DEG N TO THE E OF 60 DEG E: 3-2 NM(.)
2)N OF 14 TO 22 DEG N TO THE E OF 68 DEG E: 3-2 NM (.)
3)REST AREA: 10-8 NM (.)
IV)WAVE HEIGHT: 1) E OF 63 DEG E TO N OF 14 DEG N: OVER 14.0 MTR (.)
2)REST AREA: 2.0-3.0 MTR (.)
TOO:15/2330
---

14. What information is shared in Sea Area bulletin. What is the periodicity of this bulletin? What is the validity period of this bulletin? Where can one get this information? How is it transmitted to ships in deep sea?

This bulletin is issued for ships plying in deep seas.

Content:

- Part 1: Information on weather system, location, speed of movement, extent of area affected, wind speed & direction in various sections of affected area
- Part II: Synoptic weather situation
- Part III: Forecast of (i)weather, (ii) wind, (iii) visibility and (iv) sea condition.
- Part IV: Weather analysis.
- Part V: Observational data from ships in WMO codes.
- Part VI: Selected stations data & upper air reports.

Frequency:

- Issued twice daily based on 0300 & 1200 UTC by IMD Kolkata for Bay of Bengal & IMD Mumbai for Arabian Sea.
- During Depression, additional bulletin is issued based on 1800 UTC.
- During cyclone, additionally at three more bulletins are based on 0000, 0900 and 1500 UTC.

Validity: Next 12 hours from time of issue of bulletin

Type of bulletin: Text, graphical (Fig. 6) and Web-GIS platform

Mode of transmission: Broadcast by Navtex stations, put up on National and Maritime states websites

Available in: Websites of IMD

Sample Sea Area bulletin issued during cyclone Tauktae on 14th May by :

Area Cyclone Warning Centre, Mumbai
(Regional Meteorological Centre, Mumbai)
SEA AREA BULLETIN

Tuesday, 11 May 2021

AURORA OBSERVATIONS:

Sea Area forecast valid for 12 hours starting from 0900 UTC of 11/05/2021

Part One:

TTT Warning	**Nil**

Part Two:

Synoptic Situation	**A LOW PRESSURE AREA IS VERY LIKELY TO FROM OVER SOUTHEAST ARABIAN SEA AROUND 14TH MAY MORNING. IT IS VERY LIKELY TO MOVE NORTHNORTHWESTWARDS ACROSS SOUTHEAST ARABIAN SEA AND ADJOINING LAKSHADWEEP AREA AND INTENSIFY GRADUALLY. IT MAY INTENSIFY INTO A CYCLONIC STORM OVER EAST CENTRAL ARABIAN SEA AROUND 16TH MAY AND CONTINUE TO MOVE NORTH•NORTHWESTWARDS. WEATHER SEASONAL OVER REST ARABIAN SEA .**

Part Three :

North East Arabian Sea :

Wind	**Mainly Westerly 10 to 15 knots gusting to 20 knots.**
Weather	**Fair.**
Visibility	**Good.**

Sea Condition	**Moderate.**

East Central Arabian Sea

Wind	**Northwesterly to Northerly 10 to 15 knots gusting to 20 knots.**
Weather	**Fair.**
Visibility	**Good.**
Sea Condition	**Moderate.**

West Central Arabian Sea:

Wind	**Anticyclonic 05 to 10 knots gusting to 15 knots.**
Weather	**Fair.**
Visibility	**Good.**
Sea Condition	**Slight to Moderate.**

South East Arabian Sea: North of Latitude 7 Degree North

Wind	**Northwesterly to Westerly 10 to 15 knots gusting to 20 knots.**
Weather	**Fairly widespread Rain or Thundershowers.**
Visibility	**Moderate becoming poor in Rain or Thundershowers.**
Sea Condition	**Moderate.**

South East Arabian Sea: South of Latitude 7 Degree North

Wind	**Mainly Southwesterly 10 to 15 knots gusting to 20 knots.**
Weather	**Widespread Rain or Thundershowers.**
Visibility	**Moderate becoming poor in Rain or Thundershowers.**

PART SIX	**11034**	**99942**	**339**	**31695**	**41802**	**10316**

Sea Condition	**Moderate.**

South West Arabian Sea: North of Latitude 7 Degree North

Wind	**Variable 05 to 10 knots.**
Weather	**Widespread Rain or Thundershowers.**
Visibility	**Moderate becoming poor in Rain or Thundershowers.**
Sea Condition	**Moderate.**

South West Arabian Sea: South of Latitude 7 Degree North

Wind	**Mainly Southwesterly 10 to 15 knots gusting to 20 knots.**
Weather	**Widespread Rain or Thundershowers with isolated squall.**
Visibility	**Moderate becoming poor in Rain or Thundershowers and very poor in squall.**
Sea Condition	**Moderate.**

GMDSS Area :

Wind	**Mainly Southwesterly 10 to 15 knots gusting to 20 knots.**
Weather	**Widespread Rain or Thundershowers.**
Visibility	**Moderate becoming poor in Rain or Thundershowers.**
Sea Condition	**Slight to Moderate.**

PART FOUR	**Nil.**

PART FIVE	**Nil.**

40041	539	32596	42703	10300	40068	634
32996	02305	10290	40073	731	32596	12903
10294	40074	754	32996	02909	10304	40054
838	31596	33206	10290	40085	840	32596
42902	10296	40086	909	32597	32703	10304
40080	933	32997	21401	10336	40058	
99943	057	31596	20000	10294	40089	109
32597	23604	10300	40107	110	31596	63604
10306	40096	117	32597	40000	10296	40070
192	31596	10000	10301	40086	226	32597
20901	10294	40045	284	31496	50905	10284
40086	311	22596	80000	10300	40079	314
22597	80000	10296	40091	369	32497	50902
10298	40089	371	22497	70000	10278	40097
PPAA	61101	43353	44385	04003	06513	09024

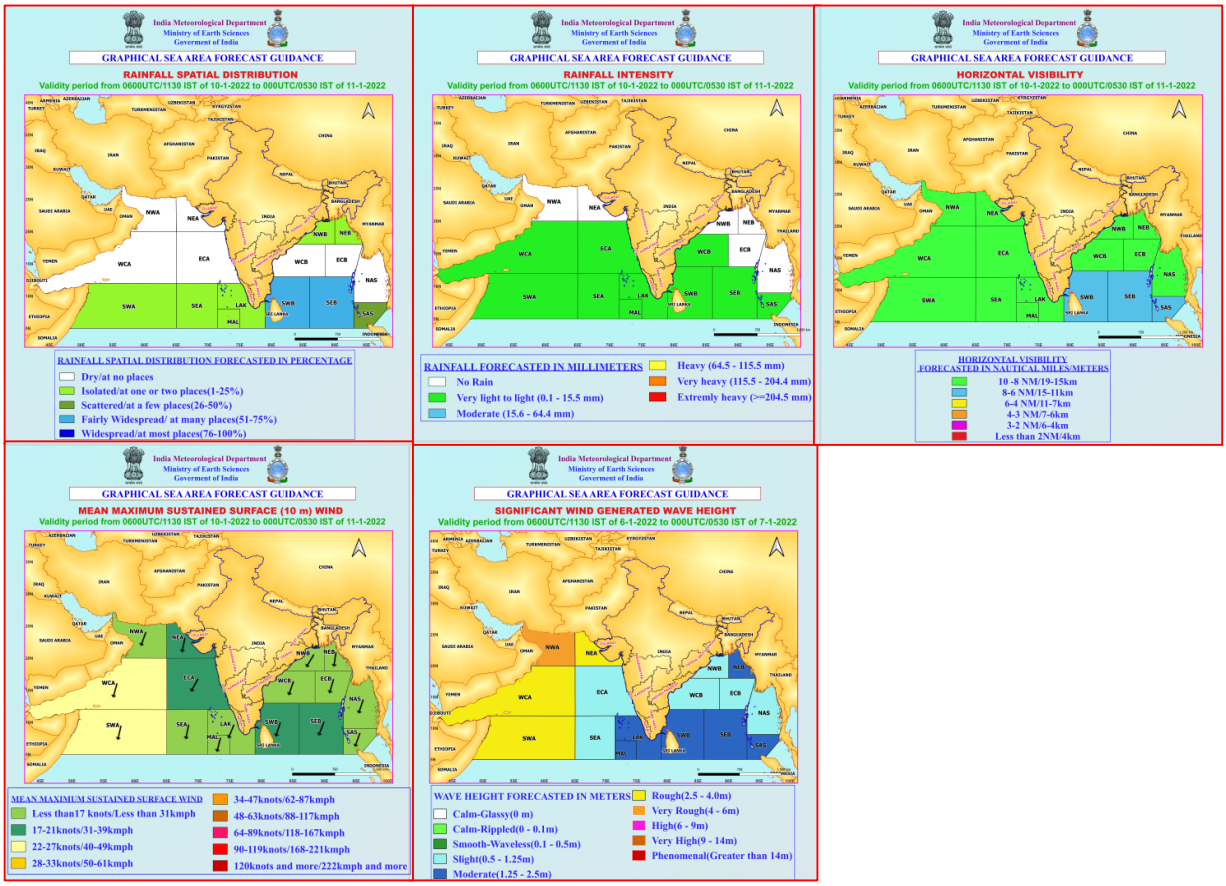


Fig. 6: Sample Sea Area bulletin in graphical format

15. What information is shared in Coastal Weather Bulletin. What is the periodicity of this bulletin? What is the validity period of this bulletin? Where can one get this information? How is it transmitted to ships in sea?

Coastal Weather bulletin is issued for ships in coastal waters (within 40nm from shoreline).

Content: This bulletin has three parts:

- ❖ Part 1: Information about storm
- ❖ Part II: Synoptic weather situation
- ❖ Part III: Information about wind, weather, visibility, sea condition and port signal

Frequency:

- Issued twice based on 0300 UTC and 1200 UTC at 0900 & 1800 UTC by the ACWCs - Kolkata, Chennai, Mumbai and CWCs - Visakhapatnam, Bhubaneshwar, Thiruvananthapuram and Ahmedabad covering the areas under their responsibility in normal situation.
- In case of depression over the sea, it will be issued 3 times a day with additional bulletin based on 1800 UTC.
- In case of cyclone lying over sea, it is issued based on 0000, 0300, 0600, 1200, 1800 UTC.

Validity: Next 12 hours from time of issue of bulletin

Type of bulletin: Text, graphic (Fig. 7) and Web-GIS

Mode of transmission: Broadcast by NAVTEX stations and websites

NAVTEX Coastal Stations	
1. Veraval	5. Vakalpudi(AP)
2. Vengurla Point	6. Balasore(Odisha)
3. Muttanpoint(TN)	7. Keating Point(A&N)
4. Porto Novo(TN)	8. Control Centre, Mumbai

Available in: IMD websites

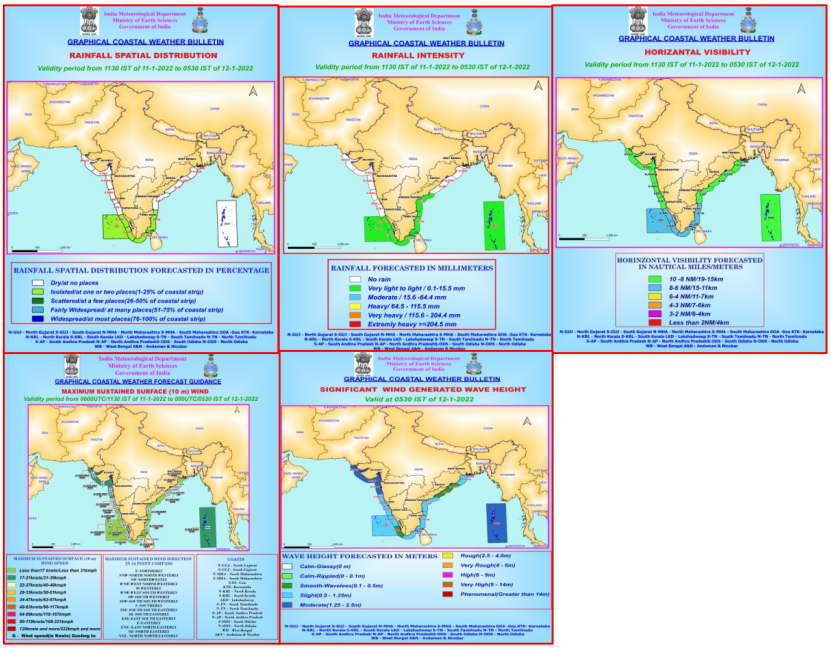


Fig. 7: Sample Coastal Weather bulletin in graphical format

Sample Coastal Weather Bulletin is given below:

India Meteorological Department/ भारत मौसम विज्ञान विभाग

ACWC KOLKATA / ए .सी .डब्लू .सी कोलकाता

Coastal Weather Bulletin

Daily Two Bulletin Valid for 12 hrs from 21 UTC of 2023-04-25 to 09 UTC of 2023-04-26

Synoptic Situation	Weather seasonal over Bay of Bengal and Andaman sea.
Andaman area	
Wind	North/ North Easterly, 5 - 10 Knots
Weather	Isolated Rain/ Thunderstorm Rain Or Thundershower Likely To Occur At One Or Two Places.
Visibility	Good Becoming Moderate 08 To 06 Km Reducing To 04 Km In Rain.
Sea Condition	Smooth
Port Signal	NIL at all Ports
West Bengal coast	
Wind	North/ South, 5 - 10 Knots Variable; 05 To 10 Knots.
Weather	Scattered Rain/ Thunderstorm Rain Or Thundershower Likely To Occur At A Few Places Over East Midnapore Coasts And At One Or Two Places Over South 24 Parganas Coasts.
Visibility	Good 08 To 06 Km Reducing To 04 Km In Rain.
Sea Condition	Smooth
Port Signal	NIL at all Ports
Time of Issue	21:05 IST of 2023-04-25

16. What information is shared in Port Warnings. What is the periodicity of this bulletin? What is the validity period of this bulletin? Where can one get this information?

The IMD (through the ACWCs/CWCs) maintains a port warning service by which the port offices are warned about the disturbed weather likely to affect their ports. IMD issues port warnings for 120 Ports **(Fig. 8).**

Fig. 8: 120 Ports for which IMD issues Port Warnings along the East & West coasts, Andaman & Nicobar and Lakshadweep Islands

Criteria for Port warnings:

Distant Signals: There are two distant signals viz. DC1 and DW2.

DC1: Distant Cautionary Signal No. 1: This signal is hoisted at a port when the system out at sea (>500 km away) is a depression or a deep depression and the local weather at the port itself is not likely to be affected immediately. However, the ships leaving the port may run into danger during their voyage. To inform them about expected danger during their voyage, DC1 is hoisted.

DW2: When the system has intensified into a cyclonic storm and still out at sea (>500 km away) and no bad weather is likely at the port.

Local signals: There are two local signals viz. LC3 and LW4.

LC3: When the port is likely to experience squally weather. Squally weather refers to a weather situation with maximum sustained wind speed (MSW) ≥ 20 knots alongwith fairly widespread (51-75% area receiving rainfall) to widespread (76-100% area receiving rainfall) rainfall over a region. Such conditions are associated with low pressure systems or onset and strengthening of monsoon.

LW4: When a cyclonic storm has actually formed, LW IV is hoisted at ports which could possibly be struck later by the storm, since the existence of a storm can often be determined before its direction of motion can be fixed. It is a preliminary stage when the direction of motion of the system is yet to be fixed with certainty. Usually it is avoided to issue LW4. A meteorologist prefers to issue either LC3 of the danger signal (D5, D6, D7)

Danger Signals: Danger signals are hoisted when the storm is of slight or moderate intensity (D5, D6 and D7) and Great Danger Signals (GD8, GD9, GD10, GD XI) when the storm is of severe intensity.

D5 is hoisted when the cyclone is likely to cross coast keeping port to it's left.

D6 is hoisted when the cyclone is likely to cross coast keeping port to it's right.

D7 is hoisted when the cyclone is likely to cross coast over/near port.

GD8 is hoisted when the severe cyclone is likely to cross coast keeping port to it's left.

GD9 is hoisted when the severe cyclone is likely to cross coast keeping port to it's right.

GD10 is hoisted when the severe cyclone is likely to cross coast over/near port.

GDXI is hoisted when there is complete failure of communication with cyclone warning office, but the port authority feels the threat due to cyclone.

Content of Port Warnings: The port warning bulletin issued by IMD contains information about the current location & intensity of the cyclonic disturbance in terms of maximum sustained wind speed and estimated central pressure and forecast about movement, intensification & landfall of the system. It also contains information about the warning signal to be hoisted on the port. Details of the signals are given in **Fig. 9**. The signal to be hoisted is decided by IMD based on the intensity of the cyclonic disturbance and the distance of the disturbance from the port. On receiving the port warning, the appropriate visual signals are hoisted by Port Authorities prominently on signal masts so that they are visible from a

distance. Mariners and other sea-faring people, including fishermen who may not be literate, are generally aware of the meaning of these signals and the port authorities are always ready to explain them whenever necessary. Example of Port warning issued during cyclone Tauktae is presented in **Fig. 10**.

Mode of dissemination: Port warnings are disseminated by IMD directly to Port Authorities by FAX, Email and Phone. Police W/T facilities can also be used for passing the port warning messages. These are also uploaded on various websites of IMD.

Periodicity:

- 2 times a day based on 0300 and 1200 UTC in case of distant disturbances,
- 3 times a day based on 0300, 1200 and 1800 UTC in case of squally weather likely over port and
- 5 times a day based on 0000, 0300, 0600, 1200 and 1800 UTC in case of cyclone warning for the port.

Available on: IMD websites (National & Maritime States) and Port Masts

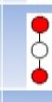
Signal No.	Type	Name	Symbols		Description
			Day	Night	
1	DISTANT BAD WEATHER	DC1			Depression far at sea. Port NOT affected.
2		DW2			Cyclone far at sea. Warning for vessels leaving port.
3	LOCAL BAD WEATHER	LC3			Port Threatened by local bad weather: squally winds.
4		LW4			Cyclone at sea. Likely to affect the port later.
5	DANGER	D5			Cyclone likely to cross coast keeping port to its left.
6.		D6			Cyclone likely to cross coast keeping port to its right.
7.		D7			Cyclone likely to cross coast over/near to the port.
8.	GREAT DANGER	GD8			Severe cyclone to cross coast keeping port to its left.
9.		GD9			Severe cyclone to cross coast keeping port to its right.
10.		GD10			Severe cyclone to cross coast over/very near to port.
11.		XI			Communication failed with cyclone warning office.
DC : Distant Cautionary, DW : Distant Warning, LC: Local Cautionary, LW : Local Warning, D : Danger, GD: Great Danger					

Fig. 9: Port warning signals for day and night

Sample port warning issued by ACWC Mumbai during cyclone Tauktae is given below:

Regional Meteorological Centre, Mumbai
Saturday, 15 May 2021
Port Warning for Maharashtra-Goa Coast

THE CYCLONIC STORM "TAUKTAE" (PRONOUNCED AS TAU'TE) OVER EASTCENTRAL AND ADJOINING SOUTHEAST ARABIAN SEA & LAKSHADWEEP AREA MOVED NEARLY NORTH-NORTHWESTWARDS WITH A SPEED OF ABOUT 09 KMPH DURING PAST 06 HOURS AND LAY CENTRED AT 0000 UTC OF 15 TH MAY, 2021 OVER EASTCENTRAL AND ADJOINING SOUTHEAST ARABIAN SEA NEAR LATITUDE 12.5°N AND LONGITUDE 72.5°E, ABOUT 160 KM NORTH-NORTHWEST OF AMINI DIVI, 350 KM SOUTH-SOUTHWEST OF PANJIM-GOA, 960 KM SOUTH-SOUTHEAST OF VERAVAL AND 1050 KM SOUTH-SOUTHEAST OF KARACHI.

IT IS VERY LIKELY TO INTENSIFY FURTHER INTO A SEVERE CYCLONIC STORM DURING NEXT 12 HOURS AND INTO A VERY SEVERE CYCLONIC STORM DURING THE SUBSEQUENT 12 HOURS. IT IS VERY LIKELY TO MOVE NORTH-NORTHWESTWARDS AND CROSS GUJARAT COAST BETWEEN PORBANDER AND NALIYA DURING 0900-1500 UTC OF 18TH MAY.

KEEP HOISTED LC III (LOCAL CATUIONARY SIGNAL NO III) AT ALL PORTS FROM BANKOT TO MARMUGAO. HOIST DW-II (DISTANT WARNING SIGNAL NO II) AT ALL PORTS FROM DAHANU TO SRIVARDHAN.

Fig. 10: Sample Port Warning issued by Area Cyclone warning Centre Mumbai for Maharashtra-Goa coasts.

17. What is the difference between warning for fisheries officials and warnings for fishermen?

The bulletin for fisheries official is similar to the bulletin to disaster managers with precise information about location in terms of lat/long. But the warning for fishermen is in a simple language. There is no mention of quantitative lat/long for location. To them location in terms of distance & direction from famous station is given.

18. What information is shared with public in Fishermen Warnings. What is the periodicity of this bulletin? What is the validity period of this bulletin? Where can one get this information? How is it transmitted to ships in deep sea?

Fishermen warnings are issued for entire north Indian Ocean to the north of Equator (Fig. 11). Sample Fishermen Warning by Area Cyclone Warning Chennai during cyclone Mandous issued on 7th December is presented in Fig.12.

Criteria for fishermen warnings: Fishermen warnings are issued whenever any one of the following is expected

a) Squally weather (maximum sustained wind speed (MSW) ≥ 20 knots alongwith fairly widespread (51-75% area receiving rainfall) to widespread (76-100% area receiving rainfall) rainfall over a region

b) MSW ≥ 45 kmph

c) Significant wave height ≥ 4.0 m i.e. state of sea is very rough and above

d) There is a depression or above intensity cyclonic disturbance over an area

Area of responsibility: Entire Bay of Bengal and Arabian Sea to the north of Equator

Contents of fishermen warning bulletin:

1. **In case of cyclonic disturbance**

- ❖ Information about the current location and intensity of depression/cyclone over the sea area with no mention of lat./long.
- ❖ Forecast movement and intensity
- ❖ Wind forecast over sea area
- ❖ Sea condition forecast over sea area
- ❖ Storm surge information, if any
- ❖ Port signal hoisted in different Ports
- ❖ Advisory for fishermen

2. **In case of significant weather system**, the fishermen warning will contain information about expected winds over sea area, waves, swell and the advisory

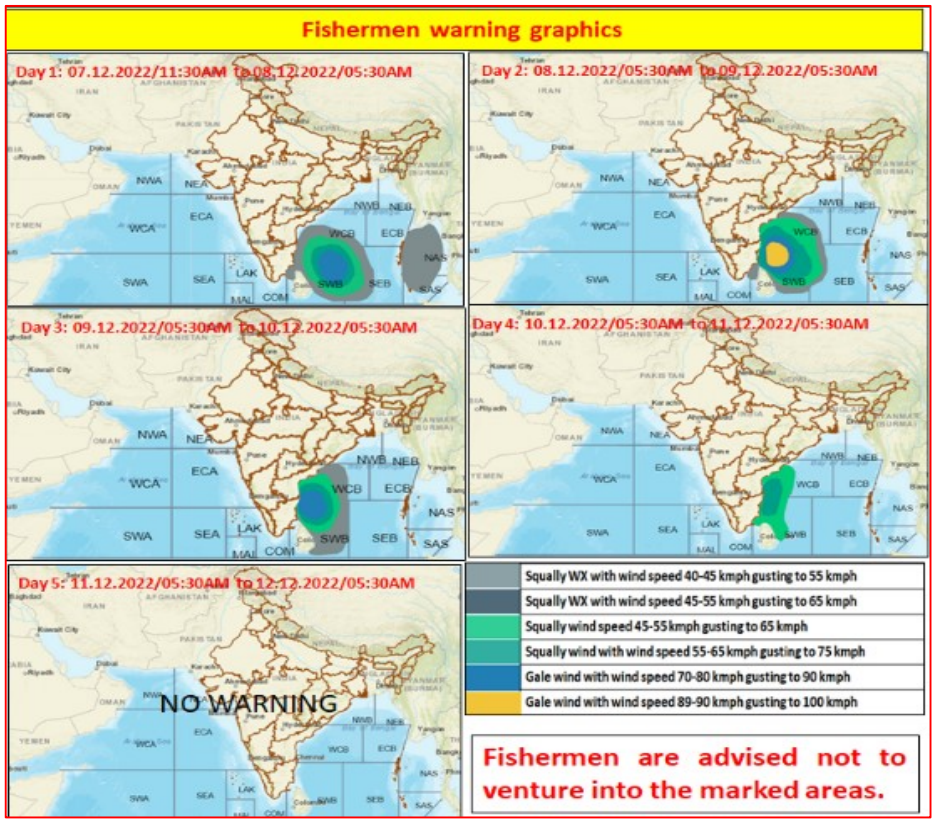


Fig. 11: Sample Fishermen warning graphics bulletin

Mode of transmission: Telephone/FAX/email to AIR/Doordarshan stations in the maritime states and fisheries officials, SMS to registered fishermen, MobileApps, Common Alert Protocol

Mode of message: Text, graphical, voice messages

இந்திய அரசு
இந்திய வானிலை ஆய்வு துறை
மண்டல வானிலை ஆய்வு மையம்
6, கல்லூரி சாலை
சென்னை - 600006
தொலைபேசி : 044- 28271951

GOVERNMENT OF INDIA
INDIA METEOROLOGICAL DEPARTMENT
Regional Meteorological Centre
6, College Road
Chennai–600006
Phone: 044- 28271951

DATE: 07-12-2022 | **Time of Issue: 1730 HOURS IST**

FISHERMEN WARNING

DAY	FOR TAMIL NADU AND PUDUCHERRY COASTS
Day 1(07.12.2022)	Squally wind, speed reaching 50-60 kmph gusting to 70 kmph prevailing over Southwest Bay of Bengal, would increase gradually becoming 60-70 kmph gusting to 80 kmph from 07th evening.
Day 2(08.12.2022)	Gale wind, speed reaching 70-80 kmph gusting to 90 kmph, over Southwest Bay of Bengal from 08th morning and 80-90 kmph gusting to 100 kmph during 08th evening to 09th morning. Squally wind, speed reaching 40-50 kmph gusting to 60 kmph, likely to commence along & off Tamilnadu and Puducherry coast from 08th December morning, becoming 50-60 kmph gusting to 70 kmph from 08th December evening. Squally wind, speed reaching 40-50 kmph gusting to 60 kmph, likely over Gulf of Mannar from 08th December evening.
Day 3(09.12.2022)	Gale wind speed reaching 70-80 kmph gusting to 90 kmph very likely along & off Tamilnadu-Puducherry coast and 50-60 kmph gusting to 70 kmph over Gulf of Mannar.
Day 4(10.12.2022)	Squally wind speed reaching 50-60 kmph gusting to 70 kmph likely along & off Tamilnadu-Puducherry coast.
Fishermen are advised not to venture into the above mentioned sea areas and fishermen out in deep sea are advised to return to the coast immediately.	

DAY	FOR OTHER THAN TAMIL NADU AND PUDUCHERRY COASTS
Day 1(07.12.2022)	Squally wind, speed reaching 50-60 kmph gusting to 70 kmph prevailing over Southeast Bay of Bengal.
Day 2(08.12.2022)	Squally wind, speed reaching 40-45 kmph gusting to 55 kmph is likely to prevail over Southeast Bay of Bengal. Squally wind, speed reaching 40-50 kmph gusting to 60 kmph, likely to commence along & off south Andhra Pradesh and north Sri Lanka coasts coast from 08th December morning, becoming 50-60 kmph gusting to 70 kmph from 08th December evening.
Day 3(09.12.2022)	Gale wind speed reaching 70-80 kmph gusting to 90 kmph very likely along & off south Andhra Pradesh and north Sri Lanka coasts.
Day 4(10.12.2022)	Squally wind speed reaching 50-60 kmph gusting to 70 kmph is likely along & off south Andhra Pradesh and north Sri Lanka coasts.
Fishermen are advised not to venture into the above mentioned sea areas and fishermen out in	

HIGH WAVE WARNING ISSUED BY INCOIS

Tamilnadu North: High waves in the range of 2.8 - 4.2 meters are predicted during 17:30 hours on 06-12-2022 to 23:30 hours of 07-12-2022 along the Vedaranyam to Pulicat of Northern Tamil Nadu. Current speeds vary between 100 - 125 cm/sec.

Tamilnadu South: High waves in the range of 2.7 - 4.0 meters are predicted during 17:30 hours on 06-12-2022 to 23:30 hours of 07-12-2022 along the Kolachal to Kilakarai of Southern Tamil Nadu.
Current speeds vary between 60 - 100 cm/sec.

Andhra coast: High waves in the range of 2.8 - 4.1 meters are forecasted during 17:30 hours on 06-12-2022 to 23:30 hours of 07-12-2022 along the coast of Andhra Pradesh between Dugarajapatnam to Baruva. Current speeds vary between 100 - 120 cm/sec.

Fig. 12: Sample Fishermen warning text bulletin

Frequency of warnings:

(i) Warnings are broadcast four times a day (morning, mid-day, evening and night) by AIR in local language.

(ii) During cyclone, issued every 3 hourly for frequent broadcast.

Mode of transmission:

i. Warnings are uploaded on website (www.mausam.imd.gov.in, www.rsmcnewdelhi.imd.gov.in, websites of all coastal offices of IMD
ii. Appended with other warning bulletins.
iii. Transmitted to fishery officials and registered fishermen through SMS/WhatsApp/Mobile App
iv. Also transmitted through satellite based NaVIC system developed by ISRO

19. What is the difference between warning for fisheries officials and warnings for fishermen?

The bulletin for fisheries official is similar to the bulletin to disaster managers with precise information about location in terms of lat/long. But the warning for fishermen is in a simple language. There is no mention of quantitative lat/long for location. To them location in terms of distance & direction from famous station is given.

20. What is probability of exceedance of MSW ≥ 45 kmph and ≥65 kmph ?

Probability of exceedance refers to probability that various models are showing an area to have winds of particular threshold. Probability of exceedance of MSW ≥ 45 kmph and ≥65 kmph refers to the probability of occurrence of the winds of these thresholds as low, (1-33%), moderate (34-67%) and high (68-100%) in a particular area. This **product is available on Mausam, RSMC and Regional websites of coastal offices. Typical example is presented in Fig.13**

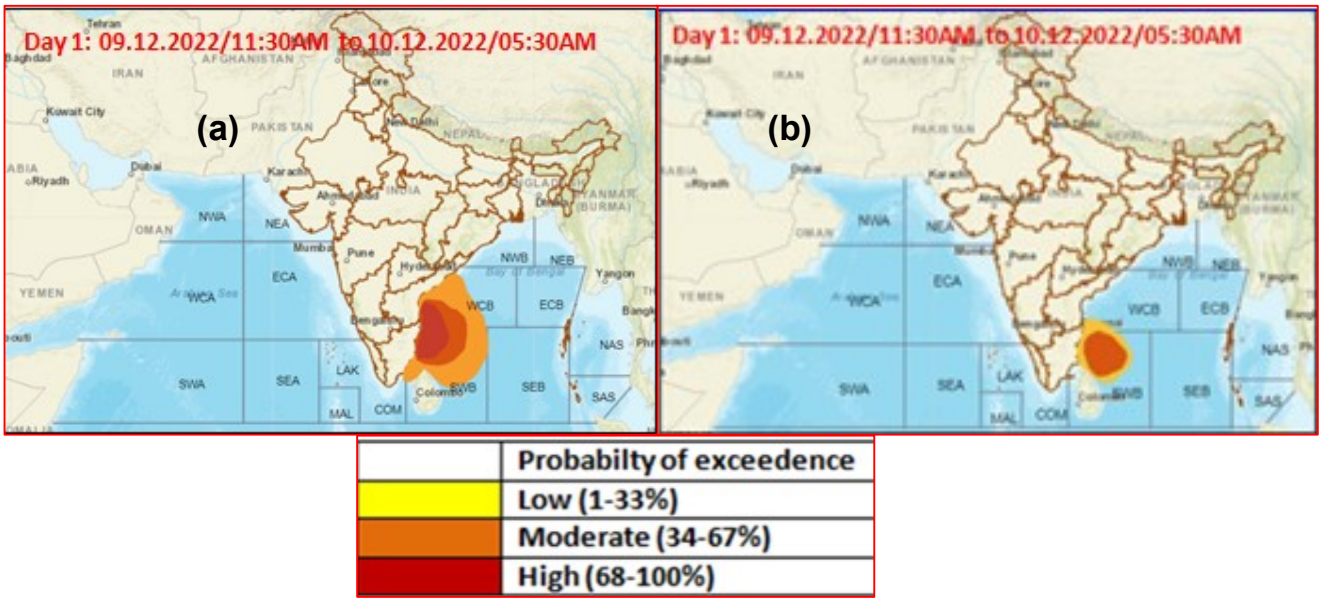


Fig. 13: Typical probability of exceedance of winds more than (a) 45 kmph and (b) 65 kmph issued on 9th December, 2022

21. How will one get fishermen warnings?

Fishermen warnings are uploaded on National websites of IMD (www.mausam.imd.gov.in and www.rsmcnewdelhi.imd.gov.in) and websites of all maritime states. These advisories are also shared with Fisheries Officials. In addition SMS alerts are also sent to fishermen by INCOIS and IMD and through satellite based NAVIC systems.

22. What is coastal station forecast? Where can one get coastal station forecast?

IMD provides coastal station forecast for 325 stations along the east and west coast of India **(Fig. 14).**

Content: Forecast of Wind speed, wind direction, weather, visibility, sea condition and port warning

Validity: For next 5 days

Availability for common man: Mausam Website and Maritime States website

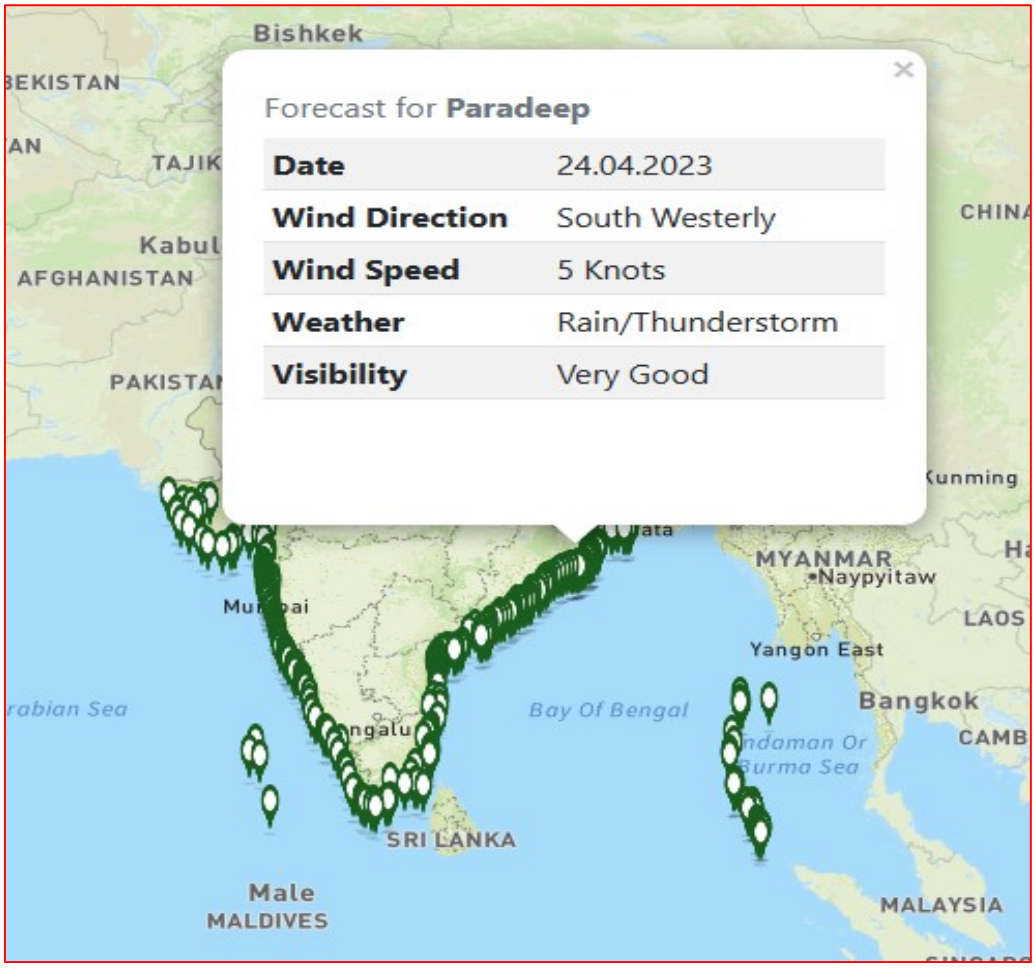


Fig.14: Coastal Station Forecast for 325 stations

23. Where can I get nowcast for coastal stations? How many stations are covered under this scheme? What are the parameters that are forecast under this scheme?

Common man can get nowcast for coastal stations on Mausam website and Maritime States website **(Fig. 15).**

No. of stations covered: 140

Content: Weather information

Validity: Next 3 hours and **Frequency**: Updated every three hours round the clock

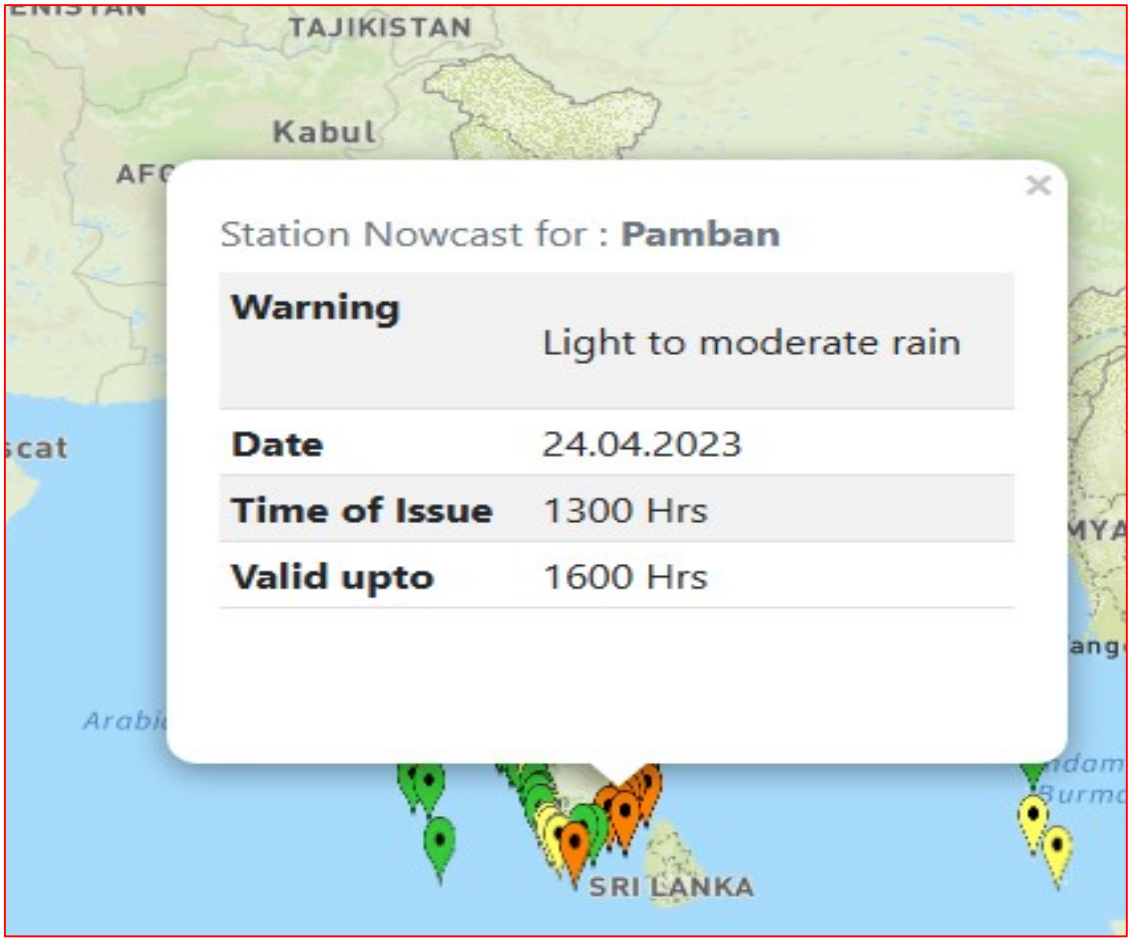


Fig.15: Nowcast for 140 coastal stations

24. Where can one get realtime coastal observations?

Realtime observations from coastal observatories, ships and meteorological buoys are also displayed on IMD website (Fig. 16).

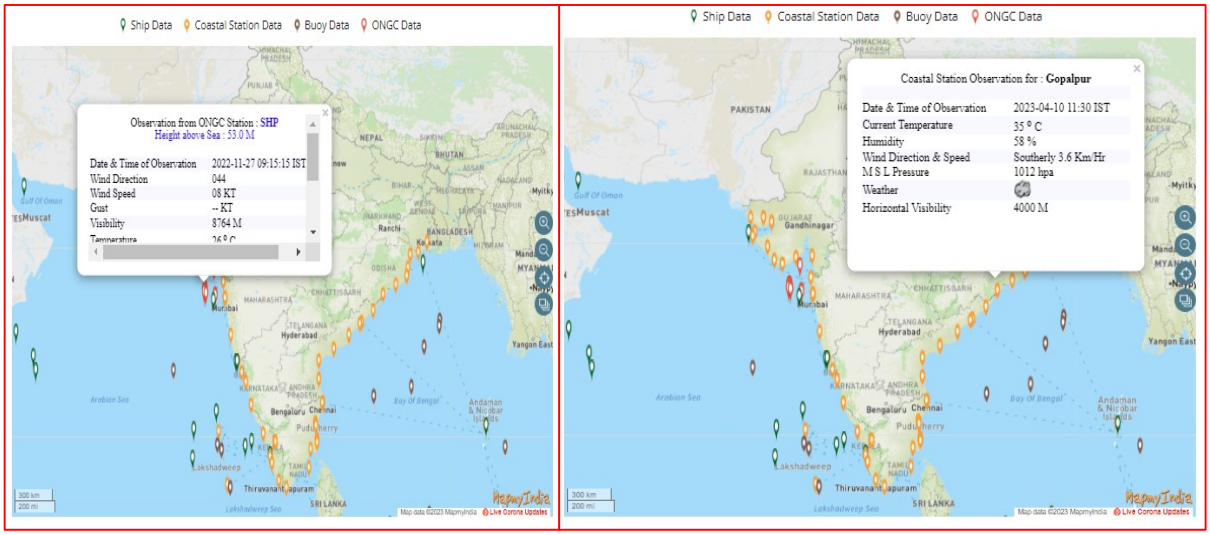


Fig. 16: Realtime display of observations from coastal observatories, ships, buoys and other stations

25. IMD introduced customised location specific impact based forecast in association with tropical cyclones for offshore industries. What information is shared in this bulletin? How can one get this bulletin?

IMD commenced location specific customised impact based forecast for offshore industries in the country from October, 2022. Typical example is presented in Fig. 17.

Content: This bulletin discusses following points:

- ❖ Current location, intensity and movement of cyclonic disturbance and forecast of track, intensity and movement.
- ❖ Quantitative track, intensity forecast, uncertainty in path & intensity, significant wave height and state of sea
- ❖ Customised information about distance of cyclone from the specific rig locations, time of arrival of cyclone at nearest location to the rig, shortest distance at this time, corresponding intensity, significant wave height & state of sea and uncertainty in distance & intensity.

Frequency: 4 times daily based on 0530, 1130, 1730 and 2330 hrs IST

Validity: Next 5 days

Dissemination; sent by email and whatsapp to specific group decided by Directorate General of Hydrocarbons, Indian Coast guard and Indian Navy

Customised Services for E & P Operators (MOU signed among IMD, INCOIS & DGH on 22nd March)

(a)

Table 1: GENERAL forecast in association with cyclonic disturbance over the Bay of Bengal based on 1130 hrs IST of 8th December, 2022

FORECAST HOUR	DATE/TIME (IST)	POSITION		FORECAST INTENSITY CATEGORY	FORECAST MOVEMENT		FORECAST WIND (KT)		UNCERTAINTY IN FORECAST		SIGNIFICANT WAVE HEIGHT (M)	STATE OF SEA
		LAT (°N)	LONG (°E)		SPEED (KMPH)	DIRECTION	MSW	GUST	PATH (NM)	INTENSITY (KT)		
0	08.12.22/1130	9.7	83.5	CS			45	55	10	10	9.0-14.0	Very High
6	08.12.22/1730	10.2	82.9	SCS	14	NW	50	60	20	10	9.0-14.0	Very High
12	08.12.22/2330	10.7	82.3	SCS	14	NW	50	60	30	10	9.0-14.0	Very High
18	09.12.22/0530	11.2	81.7	CS	14	NW	45	55	40	10	9.0-14.0	Very High
24	09.12.22/1130	11.6	81.2	CS	12	NW	40	50	45	5	9.0-14.0	Very High
36	09.12.22/2330	12.3	80.3	CS	10	NW	40	50	55	5	9.0-14.0	Very High
48	10.12.22/1130	12.7	79.7	D	7	NW	25	35	70	5	2.5-4.0	Rough

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

(b)

Customised Services for E & P Operators

FORECAST HOUR	DATE /TIME (IST)	POSITION		FORECAST INTENSITY CATEGORY	WIND (KT)		RADII OF INFLUENCE (NM)													
							R28				R34				R50				R64			
		LAT (°N)	LONG (°E)		MSW	GUST	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE
0	08.12.22/1130	9.7	83.5	CS	45	55	140	140	120	110	75	75	65	55								
6	08.12.22/1730	10.2	82.9	SCS	50	60	140	140	120	110	75	75	65	55	50	50	35	40				
12	08.12.22/2330	10.7	82.3	SCS	50	60	140	140	120	110	75	75	65	55	50	50	35	40				
18	09.12.22/0530	11.2	81.7	CS	45	55	140	140	120	110	75	75	65	55								
24	09.12.22/1130	11.6	81.2	CS	40	50	140	140	120	110	75	75	65	55								
36	09.12.22/2330	12.3	80.3	CS	40	50	140	140	120	110	75	75	65	55								
48	10.12.22/1130	12.7	79.7	D	25	35																

(c)

TABLE 4: CYCLONIC DISTURBANCE FORECAST FOR BAY OF BENGAL & MAJOR AREAS OF E&P OPERATIONS BASED ON 1130 hrs IST of 8th December, 2022

SI	DESCRIPTION Name (Lat^0 N/ Long^0 E)	LOCATION		CURRENT LOCATION FROM CENTRE OF CYCLONIC DISTURABANCE		FORECAST PARAMETERS WHEN THE INSTALLATION WOULD BE NEAREST TO THE CYCLONE PATH							
		LAT (^{0}N)	LONG (^{0}E)	DISTANCE (NM)	DIRECTION	DATE/ TIME (IST) OF OCCURRENCE	DISTANCE OF RIG FROM PATH	DIRECTION OF RIG FROM PATH	UNCERTAINITY IN DISTANCE OVER PATH (NM)	MSW OVER RIG(KTS)	UNCERTAINITY IN MSW OVER RIG (KT)	SIGNIFICANT WAVE HEIGHT	STATE OF SEA
BAY OF BENGAL AREA													
1.	South West Bay of Bengal (SWB) (13.25/81.50)	9.7	83.5	244	NNW	09.12.22/2030	89	NE	52.5	33	5	4 - 6	Very Rough
2.	West Central Bay of Bengal (WCB) (15.00/83.00)	9.7	83.5	320	N	09.12.22/2030	225	NE	52.5	<27	5	<4	Rough
3.	East Central Bay of Bengal (ECB) (14.25/92.00)	9.7	83.5	570	ENE	08.12.22/1130	570	ENE	10	<27	5	<4	Rough
4.	North West Bay of Bengal (NWB)-1 (18.50°	9.7	83.5	542	NNE	09.12.22/2330	479	NE	55	<27	5	<4	Rough

Color Code for generating impact based forecast:

ZONE	PARAMETERS
GREEN	NORMAL SITUATION, NO FORECAST OF CYCLONE
YELLOW	(1) A TROPICAL CYCLONE FORECAST: THE STORM CENTRE WITHIN 800 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 300 NM FROM LOCATION
ORANGE	(1) A TROPICAL CYCLONE FORECAST: THE STORM CENTRE WITHIN 600 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 200 NM FROM LOCATION AND (3) SUSTAINED WIND SPEED ALONG THE PATH IS FORECAST TO EXCEED 50 KTS
RED	(1) A TROPICAL CYCLONE FORECAST: THE STORM CENTRE WITHIN 300 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 150 NM FROM LOCATION AND (3) SUSTAINED WIND SPEED ALONG THE PATH IS FORECAST TO EXCEED 65 KTS

Notes:
(1) Under each zone, all three parameters are to be fulfilled to declare the rig under that zone
(2) The distance from Forecast Track in Sl No.2 of each zone is the minimum distance of the rig from the track/path when it is passing through;i.e., when it is closest to the rig

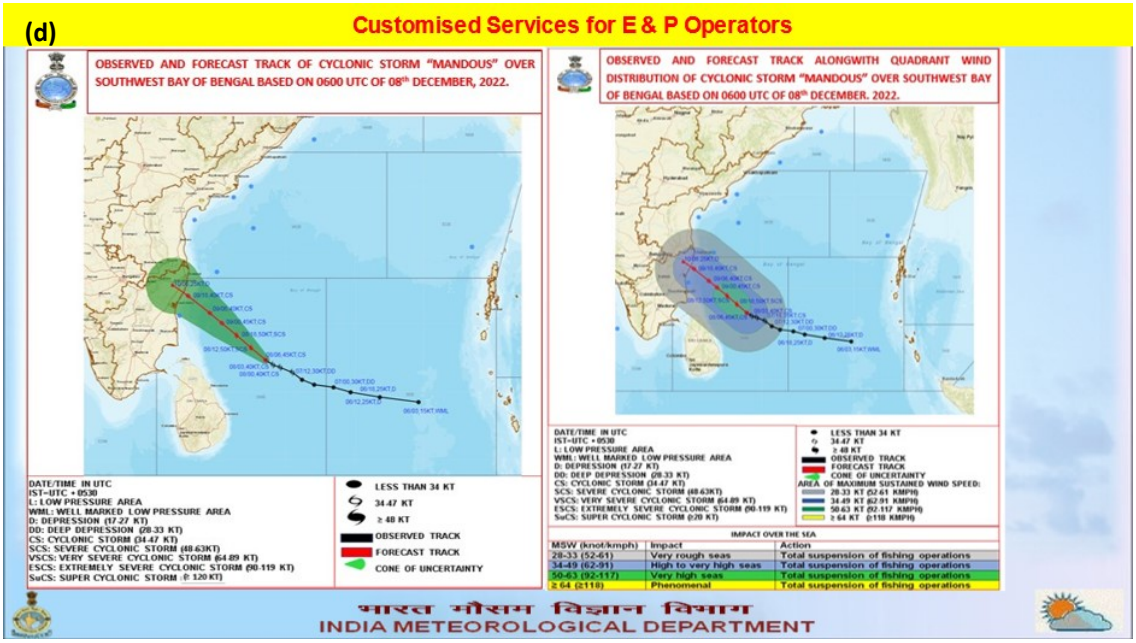


Fig. 17 (a-d): Typical sample bulletin issued for offshore industries

26. What is Fleet Forecast?

Fleet forecast bulletins are issued exclusively for broadcast to Indian Naval ships. Area of responsibility is given in Fig. 18.

Content: The forecast covers surface wind, visibility, weather, state of sea and an *outlook* for the next 12 hours.

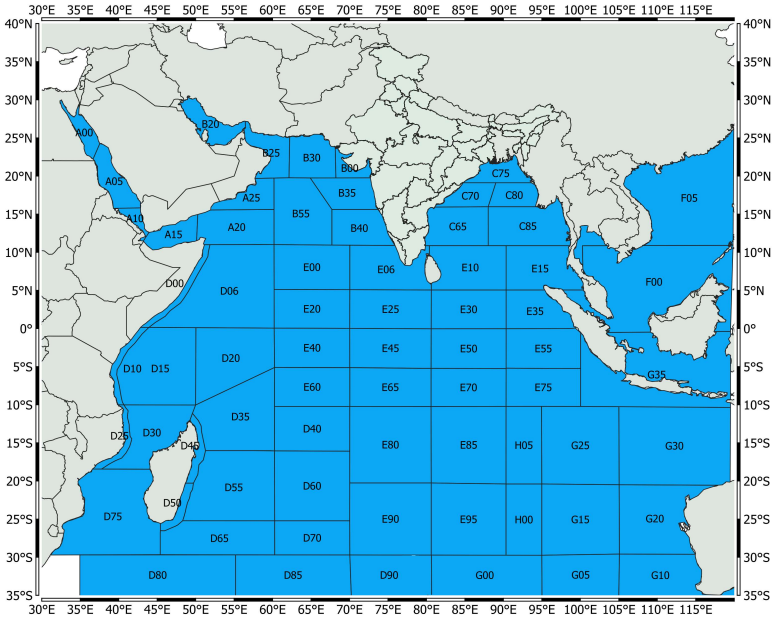


Fig. 18: Area of responsibility for Fleet forecast bulletin for Indian Navy

Frequency: The special bulletins are issued twice daily at 1430 and 2330 hrs IST. An additional bulletin is issued during the depressions and cyclones lying over the north Indian Ocean at 0230 hrs IST.

Mode of transmission: This bulletin is sent to Naval Headquarter, Navy Western & Eastern Command by email from Marine Service Division at HQ by email.

27. What information is shared with public under severe weather forecasting programme? Who are the beneficiaries of this guidance? What is the role of IMD in this scheme?

Under severe weather forecasting programme, IMD provides following information:

- Precipitation: ≥ 50 & 100 mm in 24 hrs ending at 0300 UTC of day
- Strong winds: ≥ 17 & 34 kt
- High waves : ≥ 2.5 m
- Storm Surge : ≥ 1m
- Location & Intensity of CDs

Area of responsibility: 45E – 110E and 10S – 45N

Beneficiaries: 9 member countries including Thailand, Myanmar, Bangladesh, India, Bhutan, Nepal, Sri Lanka, Maldives and Pakistan

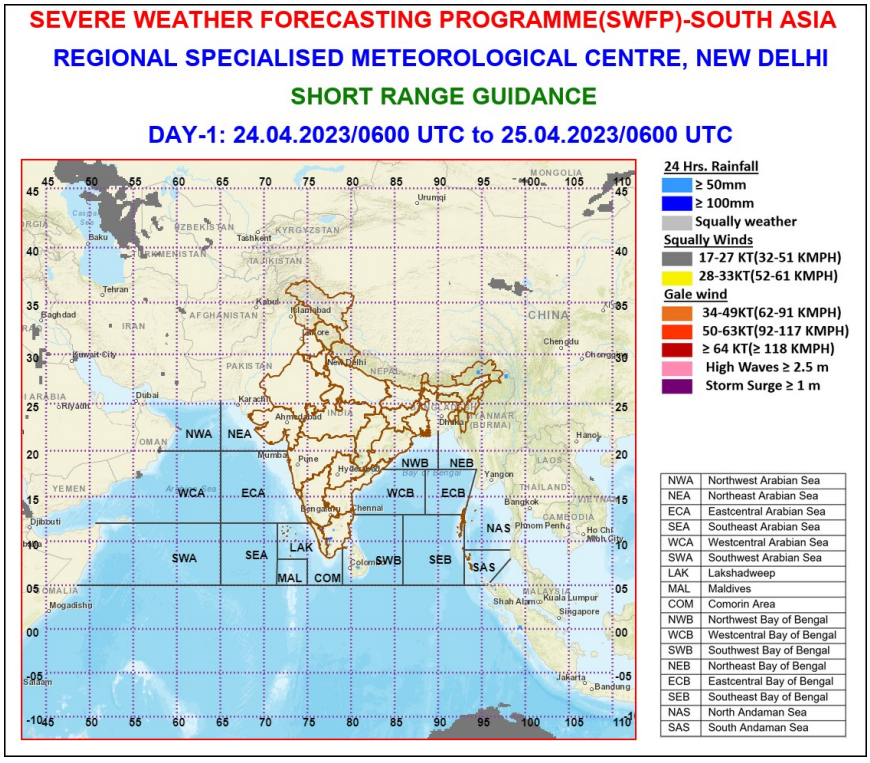


Fig. 19: Typical guidance product under SWFP

Frequency: Once daily

Validity: Next 5 days

Role: IMD is the regional centre to interpret NWP guidance, run models, and provide severe weather guidance to member countries. It provides also training to the forecasters in the region.

28. **What is IVOF ? How many ships are currently registered under IVOF?**

Under the auspices of the World Meteorological Organisation, the India Meteorological Department maintains a Voluntary Observing Fleet (VOF) which collects observations over the sea areas which cover three-fourth, surface of the earth and thus act as floating observatories. IMD is one of the 31 maritime countries which have successfully introduced the scheme of VOF since 1946. IMD has equipped a total of 206 merchant ships on the Indian register to collect and transmit weather observations from the sea areas. For this purpose the VOF ships are categorised as Selected, Supplementary and Auxilliary depending on the frequency of voyages and number of days of navigation done in a year. The Selected ships record and transmit a full set of synoptic observations for which purpose they are supplied with (1) a mercury barometer, (2) a psychrometer, (3) a marine bucket, (4) a sea thermometer for recording sea surface temperature and (5) a microbarograph to record continuously the variation of atmospheric pressure. The Supplementary ships record and transmit a reduced set of synoptic observations for which only (1) a mercury barometer, and (2) a psychrometer are supplied. The Auxiliary ships are only expected to send radio weather messages, in certain oceanic areas where the shipping is sparse or under specified conditions, in abbreviated code or in plain language. Such ships use their own instruments after they have been inspected and approved for the purpose. Besides supplying appropriate instruments, the India Meteorological Department also provides relevant meteorological publications to all the V.O.F. ships for reference at sea.

29. What are meteorological buoys? How many buoys are there currently?

Weather buoys are instruments which collect weather and ocean data within the world's oceans, as well as aid during emergency response to chemical spills, legal proceedings, and engineering design. There are two types of buoys:

- Moored buoys: Moored buoys are connected with the ocean bottom using either chains, nylon, or buoyant polypropylene. Moored weather buoys range from 1.5–12 metres in diameter.
- Drifting buoys: Drifting buoys are smaller, with diameters of 30–40 centimetres.

Total No. of meteorological buoys in North Indian Ocean: 20

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