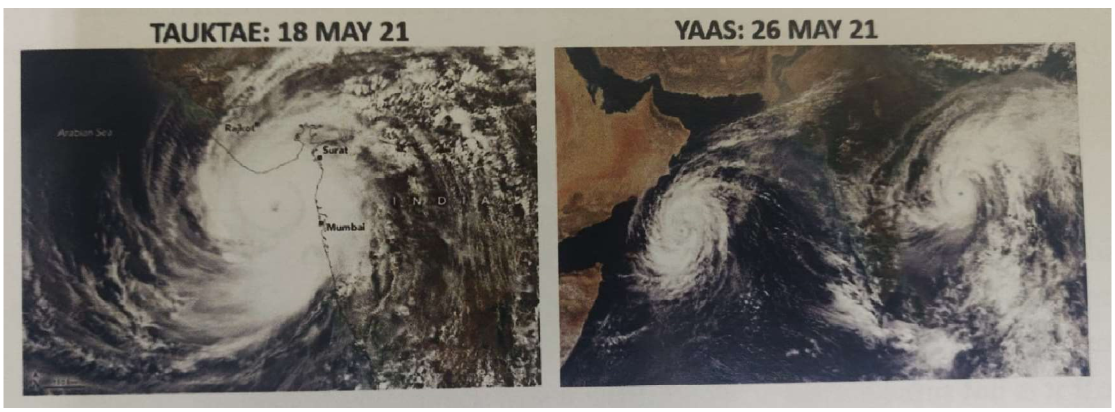
TROPICAL CYCLONE

1. Tropical Cyclone is an intense storm that forms over warm sea surface. It is characterized by low atmospheric pressure, high winds, and heavy rain. It gradually grow from a wave in upper air or a trough or low pressure area over sea surface. Under favourable conditions it intensify into a depression and then into a stream. The storm moves in the direction of the steering wind current (wind at the topmost level up to which the circulation of the storm extends). The storm maintains its energy or grow further as long as it is over the warm sea surface. On making a landfall or en reaching a cooler sea surface the system weakens.

2. Winds generated by a cyclonic storm are very strong and exceeds 119 Kmph and in extreme cases may exceed 320 kmph. The devastating wind is accompanied by very intense rain and thunderstorm and elevation of sea surface up to about 20 Ft above normal level due to storm surge. Such combinations of intense weather elements make a cyclonic storm the most hazardous weather phenomenon in the tropical and sub-tropical regions. Every year during the summer months in both the hemispheres cyclones strike most of the countries which are located in the tropical or sub-tropical regions. India and neighbouring countries adjacent to sea also experience tropical cyclone every year.



3. Tropical Cyclones are known in different local names in different parts of the world. In the North Atlantic Ocean and the eastern North Pacific they are called hurricanes, and in the western North Pacific around the Philippines, Japan, and China the storms are referred to as typhoons. In the western South Pacific and Indian Ocean they are referred to as cyclones and in Australia they are also known as Willy Willy. All these different names refer to the same type of storm.

4. It has been observed that the tropical cyclones origin in certain areas of ocean and follow pre-dominant tracks. The track, no doubt depends on the seasonal wind pattern of the area. Following image shows the normal position of origin of the storms and the paths they usually follow.

5. **Life cycle of Tropical Cyclone.** The life cycle of a tropical cyclone can be broadly divided into Formative Stage Mature Stage and Dissipating or Decaying Stage.

6. **Formative Stage**. The energy for a tropical cyclone is provided by the transfer of beat from the warm sea surface to the overlying ait. Primarily, the transfer of energy takes place by evaporation from the sea surface. As the warm and moist air rises, it expands and cools and then becomes saturated and releases latent heat due to condensation. The air above the disturbance is warmed and moistened by

this process. This results in higher temperature in the column of disturbed ait as compared to the surroundings which makes the rising air more buoyant and enhancement in vertical movement.

7. The above said situation is required to be sustained for the energy supply to continue and the disturbance to grow further and further. The supply chain may stop if the sea surface is not sufficiently warm and depth of warm water is not adequate. This is because, the moderate disturbance may cause convective build up and rain which will cool the sea surface if it is not sufficiently warm and if the warm water layer is shallow.

8. Existence of only the vertical motion of warm air is not adequate to initiate the formation of a tropical system. It is important that there is flow of moist and warm air into a pre-existing disturbance for further development to occur. The rising air increases the temperature at the core of the disturbance through release of latent heat and direct heat transfer from the sea surface. This results in decrease in the atmospheric pressure in the centre of the disturbance. The decreasing pressure causes flow of wind with increased speed around the centre (anti-clock wise over northern hemisphere and clockwise over southern hemisphere). This increases the process of evaporation and heat transfer thereby contributing to further rising of air. The warming of the core and the increased surface winds thus reinforce each other in a positive feedback mechanism.

9. **Anatomy.** The cyclones are circular storms, generally 250-320 km in diameter, whose winds spin around a central region where atmospheric pressure is very low. The winds are driven by this low-pressure centre and the Coriolis force of the earth. As a result, tropical cyclones rotate in a counter-clockwise direction in the Northern Hemisphere and in a clockwise direction in the Southern Hemisphere.

10. A tropical cyclone can be divided into three regions of wind fields

a) A ring-shaped outer region with outer radius of about 160 km and an inner radius of about 30 to 50 km. There is uniform increase in wind spend towards the centre. This region is also known as the **rain band**. This is a band of secondary cells arranged around the centre and spiral into the centre of the storm. Sometimes the band is seen stationary while in other cases they rotate around the centre. In some cases the band is seen shifting side to side unsteadily. In such case, the actual place of land fall on the coast may largely vary from the forecast location.

As a tropical cyclone hit the land man, there is increase in frictional force due to prevalent land topography. Increase in friction causes increase in convergence into the eye wall which subsequently increases the vertical motion of air leading to extreme and rapid convective build up. The situation causes torrential rain. The rainfall is so heavy that it may be close to 300 mm in 24 hours.

b) The second region is the **eye wall** which is about 15 to 30 Km from the centre. In this region wind speed is the maximum. This region is characterised by extremely strong winds and is responsible for all types of destructions and calamitic factors of a cyclone. Maximum wind speed is observed around 1000 Ft above surface. The region is also characterised by heavy to extremely heavy rainfall and very intense convective clouds. Clouds may vertically grow to the height of more than 45,000 Ft. There is upward movement of air in the eye wall with great vertical velocity. The updraft becomes stable when the air reaches tropopause. Here the air flows outward and due to Coriolis force the outward flowing air creates anticyclone circulation aloft.

c) Surrounded by the eye wall is the eye in the centre. Winds in the eye are light or calm and is also characterised by clear sky, warm temperature and very low atmospheric pressure which may be as low as 960 hPa against average surface pressure of 1000 hPa. In case of a super cyclone the pressure may further deep to less than 900 hPa. There is some amount of subsidence of air in the eye. Subsidence results in compression and increase in temperature. Hence, temperature at the eye is about 5° C more than the surrounding areas under cyclone. As the warmer air can hold more water before condensation, this region generally remains free of any significant cloud.

10**. Intensification and Mature Stage**. For a tropical cyclone to continue developing, the surrounding air in the vertical column must be cooler so that the instability is maintained to great height. The vertical movement of air results in deep convective clouds to develop. The rising air at centre, on the other hand, also draws air from the surrounding atmosphere from 1.5 Km to about 5 Km. If this air is sufficiently humid, the circulation and subsequent vertical movement of air will continue. However, if the surrounding air is dry, then evaporation of some amount of moisture in the centre will take place. This will decrease the temperature in the centre. This situation will arrest further intensification of the system.

11. As a tropical system grows, the rapidity of the circulation of air increases of the increase is required to be sustained. For this, it is important that the low-pressure area is located at least about 500 Km away from the equator. If it is too close to the equator, then the effect of the Coriolis force will be too small to provide the necessary spin. The air that is drawn towards the centre is deflected by the Coriolis force. As mentioned earlier, the direction of the resulting circulation around the low in the northern hemisphere is anti-clock wise and is the southern hemisphere it a clockwise.

12. Another important requirement for intensification is that, there mart be a little change (increase) in the wind speed with bright. Too much increase in wind speed with height disturbs the vertical alignment of the system over the warm surface which is providing the energy. When verticality is not maintained, the energy feeding mechanism gets disturbed. The ideal condition for vertical orientation of tropical cyclone is minor north to south.

13. **Dissipating stage**. The conditions required to weaken a storm are as follows:

4) Decrease in moisture feed from warm sea surface.

b) Mechanism to counter the prevailing wind speed.

14. Both of the above requirements are met when a cyclone makes landfall. Hence, there is rapid weakening of the storm after it arrives over land. In fact, the frictional force caused by the land topography starts acting soon after the eye wall enters land. The dissipation is so rapid that the system becomes a depression or a low-pressure area within a day or so.

15. It is seen that a tropical storm weakens over the sea itself. This happens when the system remains over the sea for a long time and travels across a great distance. When the cyclone crosses the latitudes northward, it encounters decrease in sea surface temperature. As the system moves to higher latitude, it becomes an extra tropical system and the loses its original characteristics of tropical cyclone. The core temperature decreases, the central pressure increases and subsequently, the speed of spinning winds and vertical movement also decreases. As a result, the diameter of the storm increases and it gradually defuses in a few days after moving with the zonal winds.

16. Classification of Cyclonic Disturbances over North Indian Ocean. Based on the associated maximum sustained wind speed, the tropical disturbances over north Indian Ocean region are classified as follows:-

Type of Disturbance	***Associated Maximum Sustained Wind Speed***
Low Pressure Area	Not exceeding 17 Kt (<31 Kr)
Depression	17 to 27 Kt (31 to 49 Kmph)
Deep Depression	28 to 33 Kt (50 to 61 Kmph)
Cyclonic Storm	34 to 47 Kt (62 to 88 Kmph)
Severe Cyclonic Storm	48 to 63 Kt (89 to 117 Kmph)
Very Severe Cyclonic Storm	64 to 90 Kt (118 to 167 Kmph)
Extremely Severe Cyclonic Storm	91 to 119 Kr (168 to 221 Kmph)
Super Cyclonic Storm	120 Kt and above (>=222 Kmph)

17. Life Period. The average life period of cyclonic disturbances over North Indian Ocean region are as follows; -

Disturbance	**Average Life**
Depression (D)	2 days
Deep Depression (DD)	3 days
Cyclonic Storm (CS)	3.5 days
Severe Cyclonic Storm (SCS)	4 days
Very Severe Cyclonic Storm (VSCS)	5 days
Extremely Severe Cyclonic Storm (ESCS)	5.75 days
Super Cyclonic Storm (SuSc)	5.75 days

18. VSCS have higher mean life period over both the Arabian Sea and the Bay of Bengal in pre-monsoon, post-monsoon and year as a whole. While the VSCS stage has significantly higher duration over the Arabian Sea that over the Bay of Bengal in pre-monsoon and the year as a whole, it is significantly higher over the Bay of Bengal than over the Arabian Sea during post-monsoon season. During the monsoon season, the duration D, DD and CS stages are significantly higher over BOB than they are over the ARB.

19. The track of longest ever recorded cyclone over the North Indian Ocean is shown in below. It originated over the South China Sea, moved west-north westwards across Vietnam, Bay of Bengal, South India and Arabian Sea to Oman during Oct. 1924.

20. **Vertical Structure.** The vertical structure of tropical cyclones is divided into **three sections.**

a) The lowest layer, known as the inflow layer, extends up to 3 km and is crucial for generating the storm. The wind flow is towards the centre of the storm. Most of this inflow layer occurs in the planetary boundary layer where friction plays a great role.

b) The primary cyclonic storm occurs in the middle layer, which extends from 3 km to 7 km.

The outflow layer is located above 7 kilometres and extends up to the top of the storm. The wind is anticyclonic (clockwise). Outflow is most pronounced around 12 Km level.

21. **Size of Cyclone**. Tropical cyclones are about 300 miles (483 km) wide although they can vary considerably. Size is not necessarily an indication of cyclone intensity. Hurricane Andrew (1992), the second most devastating hurricane to hit the United States, next to Katrina in 2005, was a relatively small hurricane. On record, Typhoon Tip (19) was the largest storms with gale force winds (39 mph/63 km/h) that extended out for 675 miles (1087 km) in radius in the Northwest Pacific on 12 October,1979. The smallest storm Macro with gale force winds that only extended 11.5 miles (18.5 km) radius when it struck Misantla, Mexico, on October 7, 2008.

22. **Movement.** Tropical cyclones initially move west to east in the direction of the trade winds. However, due to the prevailing Coriolis force cyclones turn to right in the northern hemisphere and to left in the southern hemisphere as shown in a picture above while discussing the origins of the tropical cyclones.

23. 23. In general, the average direction of the winds at various layers in portion of the atmosphere where the system prevails, determine the direction of the movement of the cyclones. The week systems like depressions or deep depression, the lower and middle level winds tend to move the storm. However, the stronger system extends up to upper tropospheric levels. In such case the middle and upper level winds play greater role. In general, it has been found that the direction of the winds just above the layer up to which the associated circulation extends, give a good indication of the movement of the tropical cyclones.

24. **Hazards Caused by Cyclone.** Cyclones are the low pressure systems. The severity of weather increases with the intensity of the low pressure. Intense low pressure systems like depressions and cyclones originate in the equatorial trough zone over warm ocean surface under certain favourable atmospheric conditions. The cyclonic storms cause heavy rains, strong winds and also high seas and devastate coastal areas at the time of landfall, leading to loss of life and property.

25. The expected damage associated with the cyclonic disturbances of different intensities along with action suggested by IMD to disaster managers is given in the following table.

Intensity	Damage Expected	Action Suggested
Deep Depression (DD)	Minor damage to unsecured structures	Fishermen advised not to venture into the open seas.
Cyclonic Storm (CS)	Damage to thatched huts. Breaking of tree branches. Minor damage to power and communication.	Total suspension of fishing.
Severe Cyclonic Storm (SCS)	Extensive damage to thatched roofs and huts. Minor damage to power and communication. Flooding.	Total suspension of fishing. Coastal hutment dwellers to be moved to safer places. People to remain indoors.
Very Severe Cyclonic Storm (VSCS)	Extensive damage to kutcha houses. Partial disruption of power and communication line. Minor disruption of rail and road traffic. Threat from flying debris. Flood.	Total suspension of fishing. Mobilise evacuation. Regulation of rail and road traffic. People to remain indoors.
Extremely Severe Cyclonic Storm (ESCS)	Extensive damage to kutcha houses. Damage to old	Total suspension of fishing. Extensive evacuation.

168-221 kmph (91-119 Kt))	buildings. Large-scale disruption of power and communication. Disruption of rail and road traffic due to flood. Threat from flying debris.	Diversion or suspension of rail and road traffic. People to remain indoors
Super Cyclonic Storm (SuSc)	Extensive structural damage. Total disruption of communication and power supply. Extensive damage to bridges. Large-scale disruption of rail and road traffic. Large-scale flooding and inundation of sea water. Air full of flying debris	Total suspension of fishing. Large-scale evacuation. Total suspension of rail and road traffic. People to remain indoors inside strong structures.

26. **Strong Winds.** Strong winds cause extensive damage in the cyclone affected areas. Sometime the damages produced by strong wind are very extensive and cover areas greater than the areas of heavy rains and storm surges. The impact on the areas through which the eye passes, is further more. While the areas away from the eye are generally affected by unidirectional winds, an eye passage brings with it rapid changes in wind direction, which imposes torques and can twist the vegetation or even structures. Parts of structures that were loosened or weakened by the winds from one direction are subsequently severely damaged or blown down when hit upon by the strong winds from the opposite direction.

27. Many of the overhead communication networks are susceptible to damage when the winds reach 85 kts (158 kmph), This is especially the case for secondary telephone lines. Microwave towers are susceptible to misalignment when winds reach 85 krs (158 kmph). This affects local telephone, cellular service and long distance service. Microwave and radio towers are susceptible to destruction when winds reach 100 kts (186 kmph). At higher wind speed even larger antennas are also vulnerable and are blown off. Even large satellite communication dishes can be damaged in cyclones with sustained wind speeds of 135 kts (251 kmph). Coastal roads/locations are vulnerable to damage from inundation/waves run up. The most detrimental hazards to roadways are uprooted trees, power poles and lines, and debris falling on roads and blocking them. This becomes a serious problem when winds reach 80 kts (149 kmph) or more.

28. **Rainfall.** Generally heavy to extremely heavy intensity takes place over the affected area thus leading to excessive amount of water. The amount of fall in 24 hours may be more than 30 Cm. Persistent rains give rise to unprecedented floods. Rainwater on the top of storm surge worsens the situation. Rain is an annoying problem for the people who become shelter less due to a cyclone. It creates problems in post cyclone relief operations also.

29. Storm Surge. Though, the deaths and destruction are caused directly by the winds in a tropical cyclone, storm surge is the major cause of devastation from tropical storms. The winds lead to massive piling of sea water in the form storm surge that leads to sudden flooding of coastal regions due to rise of sea level. In India such rise in sea level is maximum over West Bengal and Odisha coast where the storm surges get amplified due to the prevailing topography and depth of sea. The northward converging shape of the Bay of Bengal provides another reason for the enhanced storm surge in these

areas. The other cause of enhanced surge is the astronomical tide. The rise due to high tide may be as high as 4.5 m above the mean sea level at some parts of Indian coast. The worst devastation is caused when the peak surge occurs at the time of high tide. The sand and gravel carried by the moving currents at the bottom of the surge can cause sand papering action of the foundations of the structures. The huge volume of water can cause such pressure difference that the house "floats" and once the house is lifted from the foundations, water enters the structure that eventually collapses.

30. **Marine Impact ('T' Number of Tropical Disturbance).** This is another method for estimating intensity of tropical cyclones over North Indian Ocean Region. In this method, maximum wind speeds associated with tropical cyclones are estimated operationally by a very widely used tool, the Satellite-based Dvorak technique (SDT) of cloud pattern. Satellite-based Dvorak Technique (SDT). A statistical method for estimating the intensity of tropical cyclones from interpretation of satellite imagery. It uses regular Infrared and Visible imageries. It is based on a "measurement" of the cyclone's convective cloud pattern and a set of rules.

31. In this technique, the current intensity in terms of T numbers of TCs is estimated by analysing satellite image patterns (e.g. eye, shear, banded, central dense overcast). It is used to estimate intensity by assigning a T number which ranges from 1 to 8 with increments of 0.5. A unit T number corresponds to the climatological rate of TC intensity. The T number is mainly used to issue advisory to those operating in the Sea. The wind speed, condition of Sea and wave height associated with "T" numbers of various categories of cyclonic disturbances, are given in the following table.

Intensity	Strength of wind in k t/Kmph	Satellite 'T' No.	Condition of sea	Wave height (m)	Action suggested
Depression	17-21/31-40 22-27/41-49	1.5	Moderate Rough	1.25-2.5 2.5-4.0	
Deep Depression	28-33/50-61	2.0	Very Rough	4.0- 6.0	Fishermen advised not to venture into the open seas.
Cyclone	34-47/62-87	2.5-3.0	High	6.0 -9.0	Total suspension of fishing operations
Severe Cyclone	48-63/88-117	3.5	Very High	9.0 -14.0	
Very Severe Cyclone	64-90/118-167	4.0-4.5	Phenomenal	>14.0	
Extremely Severe Cyclone	91-119/168-221	5.0-6.0		>14.0	
Super Cyclonic Storm	120 or more/and more	>6.0		>14.0	

32. Cyclone hazard prone districts of India. Based on frequency of cyclones, total number of severe cyclones, maximum wind speed, probable maximum surge, and precipitation for all districts is

proneness to cyclones has been worked out by IMD. Ninety-six districts including 72 districts touching the coast and 24 districts not touching the coast, but lying within 100 km from the coast have been classified based on their proneness. Out of 96 districts, 12 are very highly prone, 41 are highly prone, 30 are moderately prone, and the remaining 13 are less prone. Twelve very highly prone districts include South and North 24 Parganas, Medinipur, and Kolkata of West Bengal, Balasore, Bhadrak, Kendrapara, and Jagatsinghpur districts of Odisha, Nellore, Krishna, and east Godavari districts of Andhra Pradesh and Yanam of Puducherry. The remaining districts of Odisha and Andhra Pradesh, which touch the coast are highly prone districts. The north Tamil Nadu coastal districts are more prone than the south Tamil Nadu districts (south of about 10°N latitude). Most of the coastal districts of Gujarat and north Konkan are also highly prone districts. The remaining districts in the west coast and south Tamil Nadu are either moderately prone or less prone districts.

33. **Records of Tropical Cyclone of North Indian Ocean.** Some of the data pertaining to cyclones that originated over North Indian Ocean region since 1890 are given below.

Year	**D**	**Cs**	**Scs**
1890-1899	112	60	28
1900-1909	105	69	29
1910-1919	95	54	21
1920-1929	140	62	18
1930-1939	151	63	21
1940-1949	162	55	23
1950-1959	134	39	10
1960-1969	153	61	38
1970-1979	153	66	44

YEAR	**D**	**DD**	**SC**	**SCS**	**VSCS**	**ESCS**	**SuSC**
1980-1989	110	84	44	21	15	9	1
1990-1999	93	69	41	25	18	9	3

at it took a west-northwest ward path, reaching cyclonic storm strength the nest day. Aided by highly favourable conditions, the storm rapidly intensified, attaining super cyclonic storm intensity on 28 October, before peaking on the next day with winds of 260 km/h (160 mph) and a record-low pressure of 912 hpa. The storm devastated Odisha in which population of 1,25,71,000 were affected, 18.28,532 buses were damaged and 9,887 people were killed.

YEAR	**D**	**DD**	**SC**	**SCS**	**VSCS**	**ESCS**	**SUSC**	**STRONGEST CYCLONE**
2000-2009	110	84	44	21	15	9	1	SuSC Gonu,ESCS Nargis

Super Cyclonic Storm Gonu was an extremely powerful tropical cyclone that became the strongest cyclone on record in the Arabian Sea Gora developed from a persistent area of convection in the eastern Arabian Sea on June 1, 2007. It rapidly intensified to attain peak winds of 240 km/h on Jane 4.

Gonu made landfall on the easternmost tip of Oman, becoming the strongest tropical cyclone to hit the Arabian Peninsula. It then turned northward into the Gulf of Oman, and dissipated on June 7, after making landfall in southern Iran, the first landfall in the country since 1898. The cyclone caused

50 deaths in Oman, where the cyclone was considered the nation's worst natural disaster. Gonu dropped heavy rainfall near the eastern coastline, reaching sup to 610 mm, which caused flooding and heavy damage. In Iran, the cyclone card 28 deaths.

Extremely Severe Cyclonic Storm Nargis was an extremely destructive and deadly tropical cyclone that caused the worst natural disaster in the recorded history of Myanmar during early May 2008. The cyclone made landfall in myanmar on Friday, 2 May 2008, sending a storm surge 40 kilometres up the densely populated Irrawaddy delta, causing catastrophic destruction and at least 1,38,373 fatalities. The Labutta Towniship alone was reported to have 80,000 dead, with about 10,000 more deaths in Bogale. Nargis is the costliest tropical cyclone un record in the North Indian Com at the time, before that record was broken by Cyclone Amphan in 2020.

YEAR	**D**	**DD**	**SC**	**SCS**	**VSCS**	**ESCS**	**SUSC**	**STRONGEST CYCLONE**
2010-2019	99	68	43	27	21	10	1	kyarr

Super Cyclonic Storm Kyarr was an extremely powerful tropical cyclone that became the first super cyclonic storm in the North Indian Ocean since Gonu in 2007. It was also the second strongest tropical cyclone in the Arabian Sea. Kyarr developed the Equator. The system organized itself and intensified to a tropical storm on October 24 as it moved eastwards. It became Super Cyclonic Storm on October 27, as it turned westward. On that same day, Kyarr peaked as a Super Cyclonic Storm, with maximum winds of 240 km/h. Afterward, Kyarr gradually began to weaken, while curving westward, and then turning to the southwest. On October 31, Kyarr weakened into a Deep Depression, before turning southward on November 2, passing just to the west of Socotra. Kyarr degenerated into a remnant low later that day, before dissipating on November 3, just off the coast of Somalia. Despite the immense strength of the storm, and many countries being affected by high tides and storm surges, there were no reported fatalities.

YEAR	**D**	**DD**	**SC**	**SCS**	**VSCS**	**ESCS**	**SUSC**	**STRONGEST CYCLONE**	**NO OF DEATH**	**REMARKS**
2020	9	6	5	4	3	1	1	SuSC amphan	269	First SuSC in the Bay of Bengal since 1999, Featured the costliest cyclone ever recorded in North Indian Ocean.
2021	10	6	5	3	2	1	0	ESCS Tauktae	230	
2022	15	7	3	2	0	0	0	SCS Ami	79	

2023(Till May 2023)	2	1	1	1	1	1	0	ESCS Mocha		
TOTAL	**36**	**20**	**14**	**10**	**6**	**3**	**1**	**AMPHAN**		

The Super Cyclonic Storm Amphan was the first SuCS over the Ball, after the Odisha SuCS of 1999, south Andaman Sea and adjoining southeast Bay of Bengal (BoB) on 13th May. It concentrated into a cyclonic storm 16 May. Moving nearly northwards, it further intensified into a Severe Cyclonic Sturm over southeast Bolt on 17th May. Further, it intensified into a Very Severe Cyclonic Storm on the same day,, Extremely Severe Cyclonic Storm on 18th and into a Super Cyclonic Storm around moon of 18th May. It maintained the intensity of Super Cyclonic Sturm ever west-central BoB for nearly 24 hours, before weakening into an Extremely Severe Cyclonic Storm over west-central Ball around noon of 19th May. Thereafter it weakened slightly and crossed West Bengal Bangladesh coasts as a Very Severe Cyclonic Storm, across Sundarbans on 20th May with maximum sustained wind speed of 155-165 kmph gusting to 185 kmph. Then it gradually moved north northeast sward. It moved very close to Kolkata during this period. Moving further north-north-eastward, it weakened into an SCS over Bangladesh & adjoining West Bengal. Later it rapidly weakened over Bangladesh on 21 May.

34. Forecasting. With development in various infrastructures like weather satellite, weather radar and advancement in Numerical Weather Prediction (NWP) models, forecasting on the track and intensity of tropical cyclones has been quite accurate these days. Most of the countries located in the tropical regions have established separate Met Station for monitoring the tropical systems. However, the conventional method of analysing various charts like surface chart, upper air chart, prognostic charts, study of prevailing thermodynamic situation, etc are still regarded as important tools for forecasting tropical cyclones.

35. In India, the responsibility of issue of forecast and warning in respect of tropical storm is carried out by India Met Department (IMD) which is an organization under Ministry of Earth Science. Land-based surface and upper-air stations, Doppler Weather Radars (DWRs), satellites, ships and buoys (Buoys are the anchored floating observation stations installed over sea) are the observational networks that functions under IMD. The cyclone warning organisation of IMD has a three-tier system to cater to the needs of states adjacent to sea at national, regional and local levels. The agencies carry out international responsibility also. The three Area Cyclone Warning Centres (ACWCs) are located at Chennai, Mumbai and Kolkata and four Cyclone Warning Centres (CWCs) functioning under ACWCs are located at Visakhapatnam, Ahmedabad, Bhubaneswar and Thiruvananthapuram. The ultimate responsibility for operational storm warning work for the respective areas rests with the ACWCs and CWCs.

36.Area of Responsibility of ACWC/CWC is shown below:-

ACWC/CWC	Sea area	Coastal Area (75 Km from Coast Line)	Maritime State
Kolkata ACWC	Bay of Bengal	West Bengal, Andaman & Nicobar Islands	West Bengal, Andaman & Nicobar Islands
Chennai ACWC		Tamil Nadu and Pondicherry	TamilNadu, Pondicherry and Karaikal

Thiruvananthapuram CWC		Kerala and Karnataka	Kerala, Mahe, Karnataka and Lakshadweep
Mumbai ACWC	Arabian Sea	Maharashtra and Goa	Maharashtra and Goa
Bhubaneshwar CWC		Odisha	Odisha
Visakhapemam CWC		Andhra Pradesh	Andhra Pradesh and Yanam
Ahmedabad CWC		Gujarat, Diu, Danman, Dadra & Nagar Haveli	Gujarat, Diu, Danman, Dadra & Nagar Haveli

37. The World Meteorological Organization (WMO) serves as a platform for the information sources for tropical cyclone forecasters to obtain data and tools which are useful for monitoring and forecasting of tropical cyclones. Regional specialised Meteorological Centres (RSMC) have been established in different parts of the tropical regions from which WMO collects input and utilizes for bringing improvements in the forecasting techniques.

38. The above is a picture available in the WMO (RSMC) site where a link is given to the location of any prevailing tropical cyclone. The image is of 12 May 23 when a tropical cyclone was located over Bay of Bengal. On clicking on the symbol of tropical cyclone all information in respect of intensity, movement, landfall, etc, are shown.

39. Various RSMCs are listed below:-

Area of Responsibility	**RSMC**
Caribbean Sea, Gulf of Mexico, North Atlantic and eastern North Pacific Oceans	Miami, South Florida
Western North Pacific Ocean and South China Sea	Tokyo, Japan
Bay of Bengal and the Arabian Sea	New Delhi, India
South-West Indian Ocean	La Reunion, Mascarene
South-West Pacific Ocean	Nadi, Fiji
Central North Pacific Ocean	honolulu

40.The area of responsibility of RSMC-New Delhi covers Sea areas of north Indian Ocean north of equate 450 E and 1000 E and includes the member countries of WMO/ESCAP Panel on Tropical Cyclones viz, Bangladesh, Maldives, Myanmar, Pakistan, Sri Lanka, Oman, Yemen, Thailand, Iran, Saudi Arabia, Qatar and UAE.

41. **Nomenclature.** Tropical cyclones can last for a week of more. Therefore, there can be more than one cyclone at a time. Weather forecasters give each tropical cyclone a name to avoid confusion. In general, tropical cyclone are named according to the rules at regional level. In the Atlantic and in the Southern hemisphere (Indian ocean and South Pacific), tropical cyclones receive names in alphabetical order, and women and men's names are alternated, Nations in the NorthernIndian ocean began using a new system for naming tropical cyclones in 2000. The names are listed alphabetically country wise, and are neutral gender wise.

The common nude is that the name list is proposed by the National Meteorological and Hydrological Services(NMHS) of WMO Members of a specific region, and approved by the respective tropical cyclone regional bodies at their annual/biannual sessions.

42. **Nomenclature over North Indian Ocean Region.** Within the North Indian Ocean between 45degree E-100 degreeE, tropical cyclones are named by the India Meteorological Department (RSMC New Delhi) when they are judged to have intensified into cyclonic storms. If a cyclonic storm moves into the basin from the Western Pacific, then it will keep its original name. However, if the system weakens into a deep depression and subsequently re-intensifies after moving into the region, then it will be assigned a new name. In May 2020, the naming of cyclone Amphan exhausted the original list of names established in 2004. A new list of names has been prepared and is being used in alphabetical order for storms after Amphan.

List	**Contributing Nation**						
	Bangladesh	India	Iran	Maldives	Myanmar	Oman	Pakistan
1	Nisarga	Gati	Nivar	Burevi	Tauktea	Yaas	Gulab
2	Biparjoy	Tej	Hamoon	Midhili	Michaung	Remal	Asana
3	Arnab	Murasu	Akvan	Kaani	Ngamann	Sail	Sahab
4	Upakul	Aag	Sepand	Odi	Kyarthit	Naseem	Afshan
5	Barshon	Vtom	Booran	Kenau	Sapakyee	Muzn	Manahil
6	Rajani	Jhar	Anahita	Endheri	Wetwun	Sadeem	Shujana
7	Nishith	Probaho	Azar	Riyau	Mwaihout	Dima	Parwaz
8	Urmi	Neer	Pooyan	Guruva	Kywe	Manjour	Zannat
9	Meghala	Prabhanjan	Arsham	Kurangi	Pinku	Rukam	Sasar
10	Samiron	Ghurni	Hengame	Kuredehi	Yinkaung	Watad	Badban
11	Pratikul	Ambud	Savas	Horangu	Linyone	Al-jarz	Sarrab
12	Sarobor	Jaladhi	Tahamtan	Thundi	Kyeekan	Rabab	Gulnar
13	Mahanisha	Vega	Toofan	Faana	Bautphat	Raad	Waseq

list	Contributing nation					
	Qatar	Saudi Arabia	Srilanka	Thiland	U.A.E	Yemen
1	Shaheen	Jawad	Asani	Sitrang	Mandous	Mocha
2	Dana	Fengal	Shakti	Montha	Senyar	Ditwah
3	Lulu	Ghazeer	Gigum	Thianyot	Afoor	Diksam
4	Mouj	Asif	Gagana	Bulan	Nahhaam	Sira
5	Suhail	Sidrah	Verambha	Phutala	Quffal	Bakhur
6	Sadaf	Hared	Garjana	Aiyara	Daaman	Ghwyzi
7	Reem	Faid	Neeba	Saming	Deem	Hawf
8	Rayhan	Kaseer	Ninnada	Kraison	Khubb	Balhaf
9	Anbar	Nakeel	Viduli	Matcha	Khubb	Brom
10	Oud	Haboob	Ogha	Mahingsa	Degl	Shuqra
11	Bahar	Bareq	Salitha	Phraewa	Athmad	Fartak
12	Seef	Alreem	Rivi	Asuri	Boom	Darsah
13	Fanar	Wabil	Rudu	Thara	Saffar	samhah