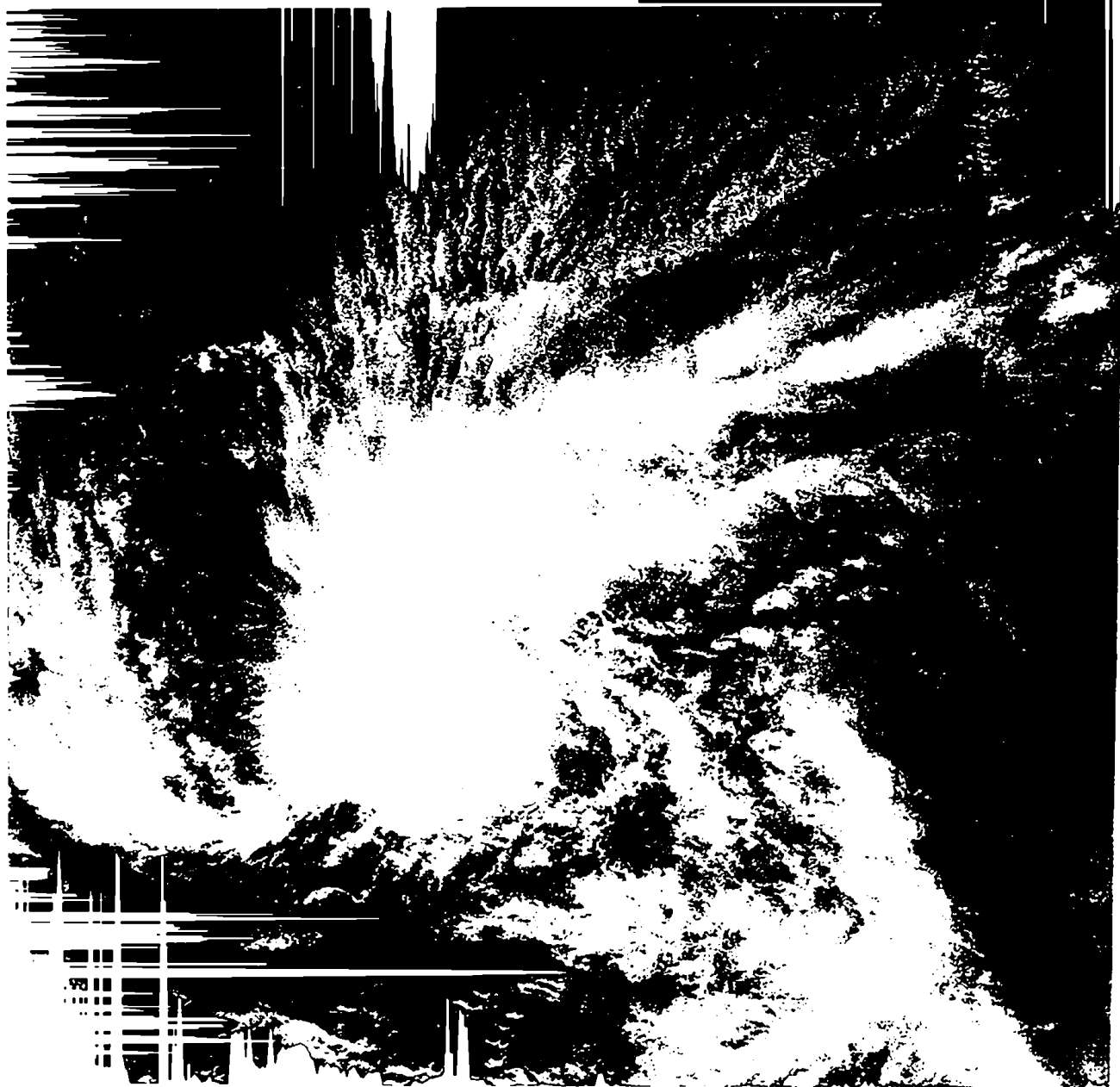


No year passes
without cyclones
wreaking havoc on
the Indian coasts, says
M. J. VARKEY

KILLER STORMS FROM THE SEAS



THE cyclone this year was no less worse than that in the earlier years. The death, destruction and misery it caused on the coasts of Andhra Pradesh and in the Bay of Bengal has almost become a regular feature.

No year, perhaps, passes without reports of deaths, destruction and misery caused by severe cyclones over the coastal areas of the Indian subcontinent. Last year, the November cyclone (let us name it as 'Dilly', in India nobody names cyclones!) caused

any damage. The most destructive cyclone which hit the Indian subcontinent (over Calcutta) happened in 1737 killing about 3,00,000 persons. In the near past, another severe cyclone hit Bangladesh in 1970 and took a toll of about 2,00,000 lives.

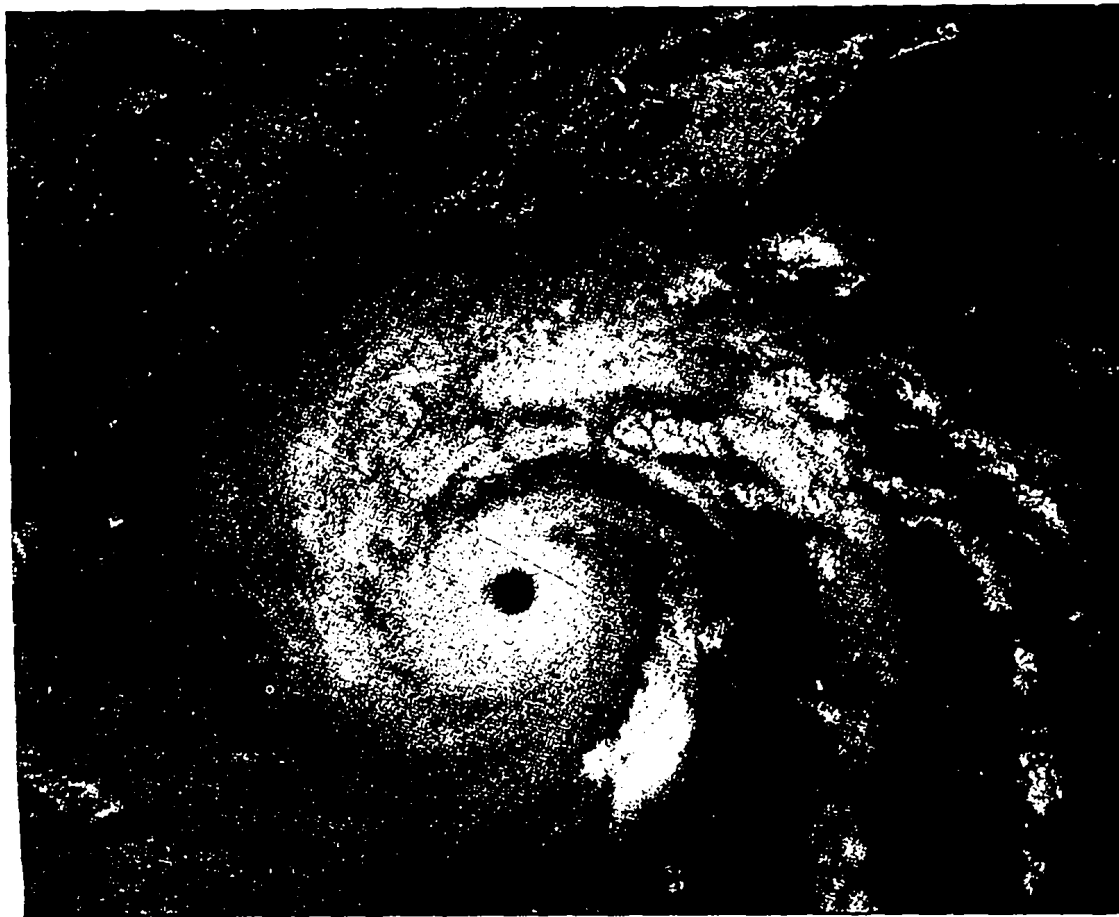
Severe cyclones strike in other parts of the world also like the south west Indian Ocean (moving towards southern Africa), north Australia and surrounding seas, Gulf of Mexico and Carribbean sea and American coasts of North Pacific. In fact, the whole of

form over land areas, for example, in many regions of Europe. But they differ in some ways from tropical cyclones.

During a period of 70 years, 82 cyclones struck in the Arabian Sea region. Out of 370 cyclones (during a period of 80 years) in the Bay of Bengal only 29 formed during January, February, March and April (7.2/month). October and November were the peak months with an average of 66. The probabilities for May, June, July, August, September and

December were almost the same (35/month). This indicates that Bay of Bengal is more prone to cyclones by about 4 times. About 80 tropical cyclones of various intensities form every year all over the world. The energy involved in the formation and growth of cyclones is as high as that of many atomic bombs. Generally, they last for a period of one to two weeks. But, once in the Atlantic a cyclone lasted for 31 days!

Although the exact mechanisms which cause the cyclones are not known, scientists are on the job. Recently an experiment called the Fronts and Atlantic Storm Track Experiment (FASTEX) was planned by about 100 weather researchers from the UK, France and USA. On the European side they have kept ready planes to fly



Satellite photograph of a cyclone that crossed Machalipatnam on 8 May 1990

hundreds of deaths and destruction of property worth hundreds of crores in Andhra Pradesh. Later, the December cyclone (say 'Dally') ferociously moved close to the coast causing fear. Many precautionary actions had to be taken by government agencies. This one, later meandered southwards in the sea and dissipated without causing

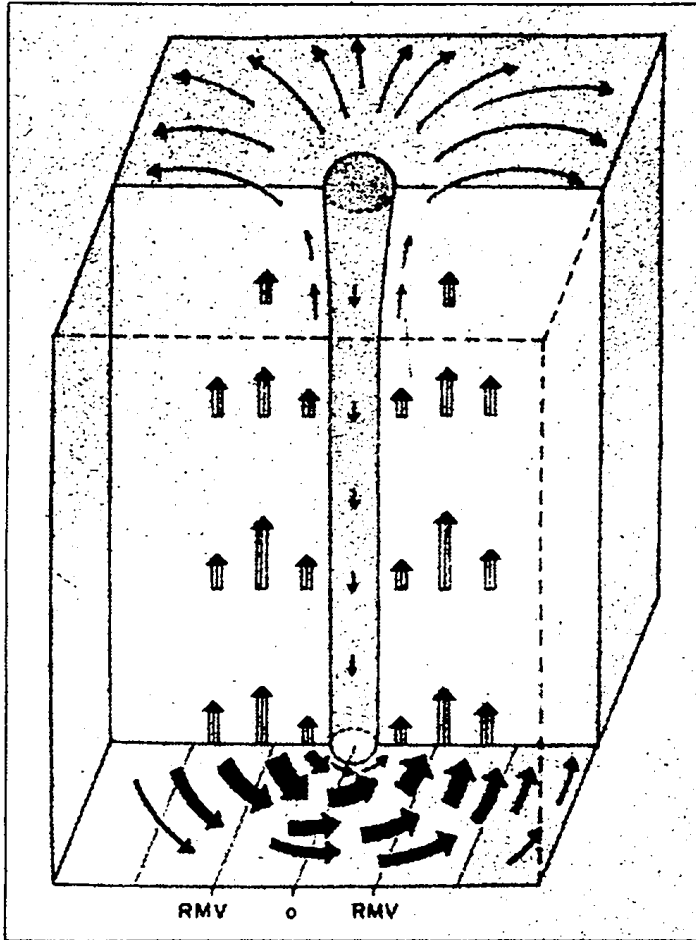
southern Indian Ocean between 5° and 20°S is cyclone prone. All over these areas, cyclones form in the deep seas away from the equator. Then they move towards north (in northern hemisphere) and towards south (in southern hemisphere) dissipating in the seas. These are called tropical cyclones. Many extratropical cyclones

into the storms as they approach the coasts of North Atlantic. On the American side scientists would explore the initial phases of a cyclone using planes, satellites, and ships. These studies would bring in some new ideas and theories about cyclones, possibly leading to better predictions locally and globally.

Meanwhile with the current knowledge one can say that thermal fronts in the atmosphere and sea, interaction of different air masses and water masses (in sea) and relative humidity of tropospheric atmosphere play their roles in causing cyclones. Different types of winds (as far as velocity and direction are concerned) at different levels of atmosphere and the resulting shears also have important roles in cyclone formation and growth. Only warm tropical seas with surface temperatures over 26.5°C can cause and nourish cyclones. It is difficult to say which agency in what proportion causes a storm but certain combinations, at the right time trigger the storms. Anybody who observes open places between tall buildings, open harvested fields or dusty and hot roads can sometimes see small

vortices in the air very near to the ground moving hither and thither sucking up dust. They last for seconds only. These are formed due to sun's heating, wind and boundary effects. The initial phase of a cyclone in sea also can be something similar to these small land vortices. What meteorologists observe as the starting point of a cyclone is a small low pressure spot or area caused by some of these factors.

The initial low pressure spots form far away from the equator (by about 5° latitude) and while some grow into depressions others become grow further into cyclones. The fact that no cyclones form around the equator reveals that the Coriolis force (arising out of Earth's rotation) plays an important role in the formation of cyclones or cyclogenesis. Over a period of 20 years (1958-1977) out of a total of



Schematic of horizontal and vertical flows of air in a cyclone in the northern hemisphere

about 1500 cyclones none started in the equatorial belt of 4°N to 4°S , over the whole world. (Cyclone Kate which started at 4.4°N in 1970 in the western north Pacific was closest to the equator.) The number of cyclones which form in high latitudes (less than 22°N) are very few (about 13% only). Majority (65%) of tropical cyclones are limited to a latitude belt of 10° - 29° around the equator.

A cyclone proceeds through different phases: lows, depressions, deep depressions, young cyclones (winds less than 62 kmph), severe cyclones (winds less than 89 kmph) and very severe cyclones with hurricane cores (winds less than 118 kmph). During their growth some of them wander in the sea and die out while some move towards land, cross the coast and cause destruction. They can move in any direction but always

away from the equator, with different speeds (around 15 kmph). Cyclones, generally, after entering land diffuse and die out due to absence of nourishing energy source (warm sea surface) and land surface friction. Very rarely, cyclones which enter the southern peninsular India from the Bay of Bengal dissipate while on land, but later they move into the Arabian Sea and intensify into cyclones and move roughly northwards. The paths and processes of growth or dissipation depend on surface friction (land or sea), sea surface properties and atmospheric conditions at high levels. Recently in the Arabian Sea one severe cyclone was dissipated by a 'counter-cyclone' in the upper atmosphere.

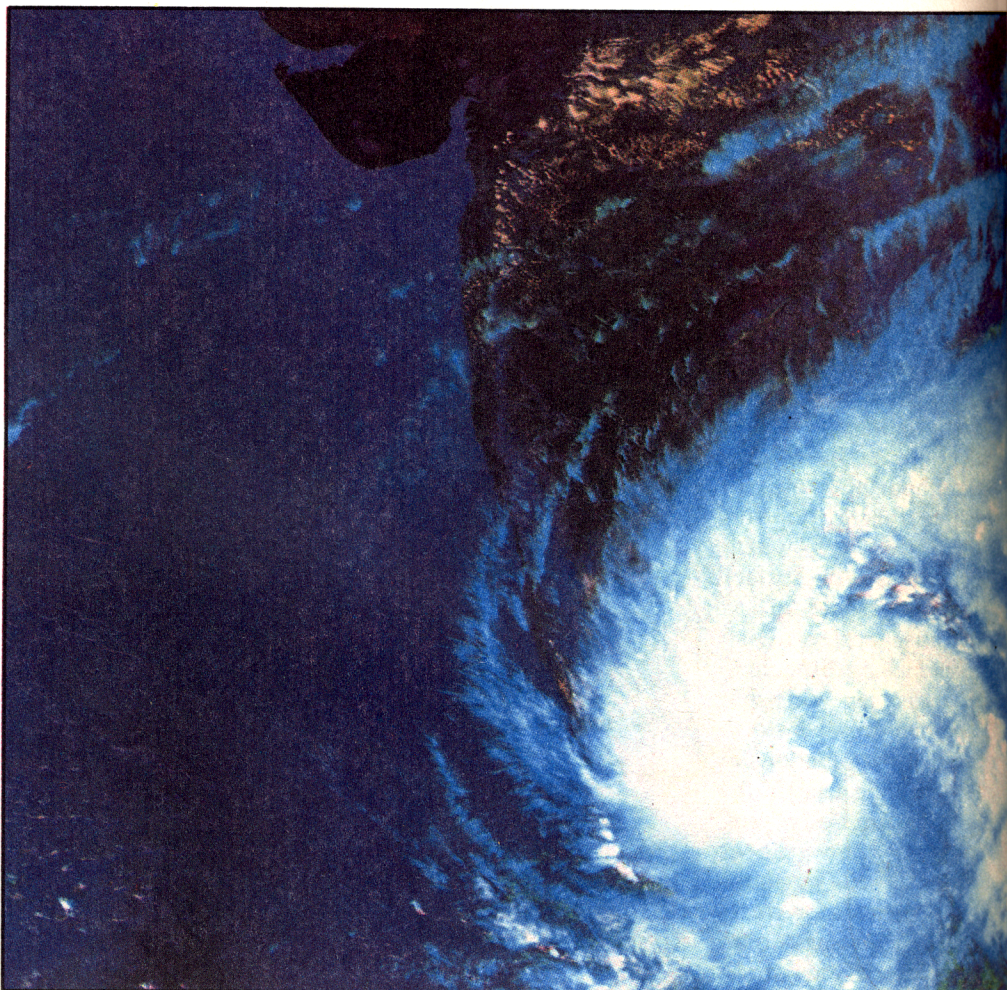
Cyclones are of various types in winds, rains, clouds and land coverage. A cyclone from start to end involves very large amounts

of heat and kinetic energy. It intensifies with the enormous availability of latent heat released by rising air (around the eye) leading to condensation, clouds and heavy rains. During a storm it would rain for many days with varying intensities. Over the eye (central area of about 20 km diameter) calm and clear skies exist. From the eye outwards to the periphery, bands of heavy, tall clouds prevail. Satellite photographs show them as spiraling bands of upper air clouds starting from the core and diverging outwards. The most important variables which control a cyclone's intensity are central pressure drop (CPD) and radius of maximum velocity (RMV). At the early (young) stages, the CPD would be low (about 40 millibars) and RMV would be high (about 55 km) with a maximum surface velocity (MSV) of about 75 kmph. As the cyclone matures the

CPD and MSV would increase gradually with decrease in RMV. In the case of a mature very severe cyclone (with hurricane core), the CPD can be very large (about 95 millibars), RMV about 40 kmph and MSV about 160 kmph.

Winds in a cyclone in the northern hemisphere rotate around the eye in an anticlockwise direction. In the southern hemisphere winds rotate in clockwise direction. Hence, looking in the direction of forward movement of storm, southerlies would prevail on right hand side and northerlies on left hand side in both hemispheres. As the cyclone moves forwards over an area, first easterlies blow, then calms of the eye and lastly westerlies of the rear hemisphere. In case of stationary cyclones the winds are symmetrical in pattern in all four quadrants. Winds

strengthen fast from the eye to RMV to a maximum. Then decrease slowly to the outskirts. Correspondingly, pressure gradients are maximum around RMV. For moving storms, the wind field is asymmetrical between the right hand side and left hand side hemispheres with a maximum velocity difference equal to the forward speed of the storm as a whole (looking forward in the direction of movement). These types of horizontal wind fields prevail upto about 10 km above the Earth's surface. Winds at surface are not exactly tangential to the circular isobars as can be seen in the schematic diagrams. Due to effects of surface friction winds blow slightly inwards from the exact-tangent towards the eye by about 25° in the outer regions and by about 12° near RMV. These



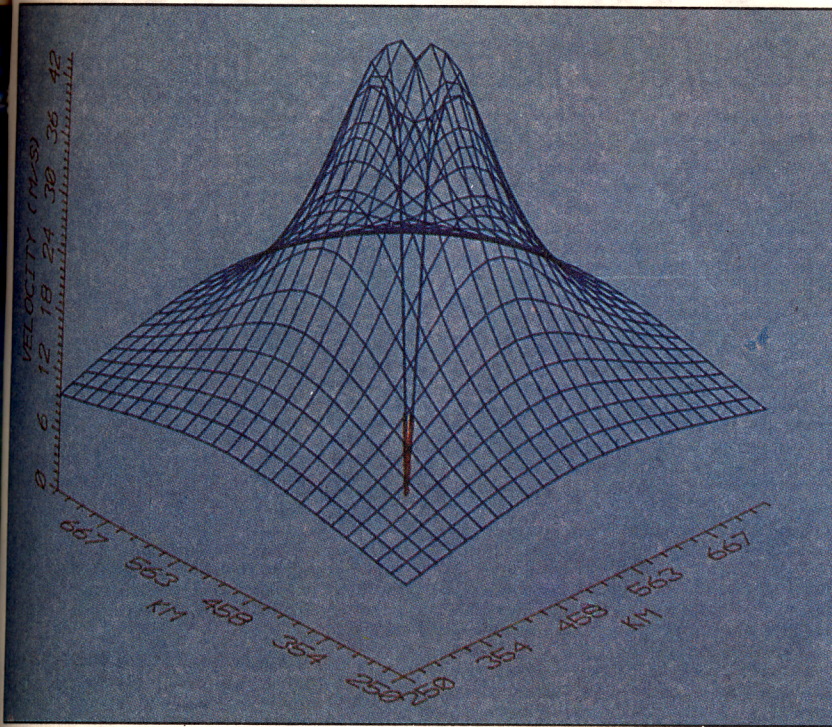
Satellite photograph of a cyclone that crossed the coast on 14 November 1991

inward blowing winds accumulate lot of air masses around the eye of the storm wherein low subsidence of air prevails. Hence around RMV, upward air flows exist upto about 12 km and at this height the flow is outwards to the peripheries flushing out the sucked up surface air.

Sometimes cyclones cause severe damages to ships and marine installations when caught up in the high winds and waves. With the use of satellites, advance information on cyclone movements are possible and hence less chances of damages at sea. But destruction caused on land during and after landfall (crossing of coastline) is very large in many cases. Compared to other areas, cyclones cause heavy loss of lives in the Indian Ocean and west Pacific regions due to high

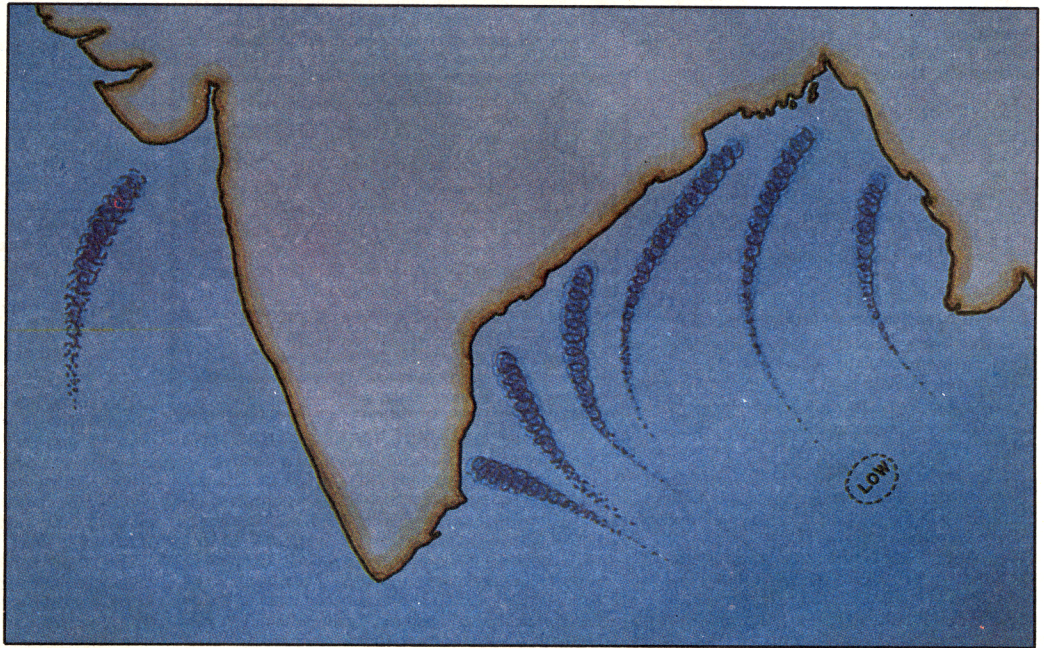
population densities. Out of a total of about 653,800 deaths due to natural disasters like cyclones, floods, volcanic eruptions, earthquakes etc., during 1964-78, about 416,970 were due to tropical cyclones only.

High casualties during cyclones are not due to high winds alone but due to the accompanying landfall, high tide and storm surges causing severe flooding (in addition to that caused by rains and rivers) in low lying coastal areas. Along the east coasts of India, destruction happens in many ways through deaths, losses of crops, houses, public utilities like roads, railways, electrical and communications equipments etc. It is calculated that the ratio of loss of lives to loss of properties (in units of 10 millions of dollars) has reduced much from 161 to



Computer simulation of velocity fields of a mature cyclone. Calm at the centre is marked in red

Over the period 1926 to 1945 in the western hemisphere. Taking the United States of America alone, for the period 1900 to 1980, deaths reduced on an average from 1200/year to about 150/year whereas property losses (in dollars) increased from 0.28 billion/year (1915-20) to 0.8 billion/year (1975-80). This reduction in loss of lives could happen only due to good forecasts using satellites, radars and other observations resulting in timely precautionary measures. Studies have shown that even if sufficient warnings are given well in advance many are unwilling to shift even temporarily due to reluctance to leave behind property and houses, false confidence from previous somehow-survivals and resignation to 'acts of God'.



Some probable tracks of cyclones in the northern Indian Ocean

Even though the heavy rainfalls cause floods and calamities they can also replenish ground water resources. Over the north west coasts of Australia good upwelling is induced by cyclones. This brings to the sea surface water from subsurface levels rich in nutrients. This is good for the fishes. Another

good act of cyclones is the unexpected abundant supply of rain water for crops. In the United States of America, hurricane Connie in 1955 ended a long period of drought (19 months) over an area of about 171,000 square kms.

However, the death and destruction caused by cyclones are too disturbing. As things are the only effective solutions are accurate predictions of movements and landfalls and storm resistant constructions. This would give sufficient time for taking precautionary actions like advance warning, shifting people to temporary safe places and securing properties and installations. The FASTEX experiments could possibly lead to better predictions locally and globally.

Along the coasts of India there are 10 cyclone tracking radar stations. These stations along with the satellites continuously monitor the seas for any disturbing developments. They

provide advance information on intensity and movements of storms. This helps to reduce loss and sufferings to lakhs of people especially along low lying coastal areas.

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