TROPICAL CYCLONES

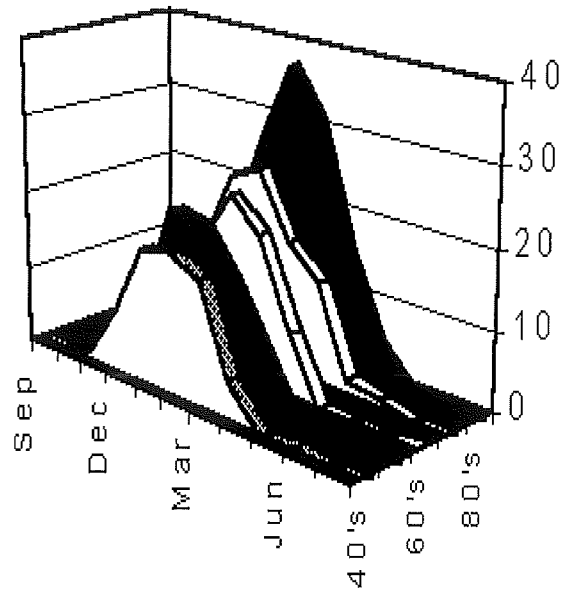
Tropical Cyclones

Cyclones in the tropics are smaller than those in mid-latitudes, but they pack a meaner punch and should be avoided.

Where do the names come from?
A centre of low pressure is called a depression (or a low). It can also be called a cyclone, meaning an area of circulating wind. This term either comes from the Greek *Kuklos* (to rotate) or maybe from *Cyclops*, (a one-eyed monster). A tropical cyclone is a circular area of strongly rotating air in the tropics. To be a tropical cyclone, winds within the rotating core need to be estimated to be "*averaging*" 34 knots (62 km/hr) or more. That's gale force, "*averaged*" over a ten-minute period. The term "tropical depression" is used for tropical areas of low pressure that do not meet this requirement. A "hurricane-force wind" is defined as any wind averaging 64 knots (118 km/hr) or more, and comes from the Caribbean *hurucan* (devil, or big wind). Tropical cyclones with winds of hurricane strength (or force) are classified in most parts of the world as being of hurricane intensity, or are simply called hurricanes. About Asia, such a tropical cyclone is referred to as a typhoon, a term which comes from the Chinese words *tai fung* (wind that strikes), or from the Greek monster *Typheous* (the father of storms).

When winds rotating around a cyclone in the tropics build to gale force, this tropical cyclone is given its own name to help in its identification. This is done by the appropriate Tropical Cyclone Warning Centre. These names are prepared well in advance by the Tropical Cyclone Committee of the World Meteorological Organisation (WMO). There are several Tropical Cyclone Warning Centres around the world, and each keeps its own list of names, usually made up from names typical of that part of the world. The lists are used in alphabetical order, but occasionally letters such as Q are skipped. The two Tropical Cyclone Warning Centres looking after the South Pacific are located at Brisbane, Queensland, and at Nadi, Fiji. This explains why the names of cyclones forming around the South Pacific seem to jump about the alphabet.

How often do they occur?
The cyclone season in the Southern Hemisphere is officially from the start of November to the end of April. There is an average of 8 to 10 tropical cyclones in the South-west Pacific Ocean each season. But the cyclone



seasons are getting longer. This graph shows the number of tropical cyclones detected in the South Pacific (145E to 125W and south of the equator) by month per decade. OK, satellite detection didn't start until the '60s, but even so — look at the numbers for May: two in the '70s and five in the '80s, pointing to a lengthening of the South Pacific Cyclone Season.

South Pacific 145E to 125 W Number of tropical cyclones per month per decade												
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
'40s			1	8	17	18	16	5				
'50s			2	8	21	20	15	7				
'60s			6	13	16	23	19	8				
'70s		1	5	13	23	25	17	13	2	1		
'80s		1	3	12	26	37	31	15	5			

How are tropical cyclones formed?
The quick answer is: *warm seas*. The recipe to brew a tropical cyclone is as follows ...

• Take an area with sea surface temperatures above 26C ...
This occurs only in the tropics, namely between the latitudes of the tropic of Cancer and the tropic of Capricorn. Oceans are usually warmest on their western side, and this is where most tropical cyclones form. Also, oceans are warmest in summer.

• add lots of moist air (clouds) ...
Tropical cyclones form only over the sea, not over the land. They usually form in areas that have plenty of thunderstorm clouds. Such a place is the Convergence Zone, where the trade winds (found in the tropics) bump into the equatorial winds.

Moist air warmed by hot sea expands, becomes lighter than its surroundings, and rises, making clouds. Rising air in the tropics also occurs when something disturbs or obstructs and slows down the normal trade wind flow, causing the arriving air to pile up on itself. A clump of raining cloud releases heat and ends up with lower air pressure than its surroundings, and this causes the heavier air on its outer fringe to move in, trying to correct the pressure imbalance.

• ... and spin
At the equator, the spin of the earth is all-horizontal, and wind can blow only in straight lines under its own inertia. So, within the equatorial zone (from latitude 5° north to 5° south), tropical cyclones are very rare and have a hard time; a pressure imbalance is relieved as soon as it forms. But further from the equator, the earth's spin starts to have a vertical component which forces surface winds to blow in curves. This means that wind drawn into low pressure takes a twisted path inwards rather than a direct path, and ends up spinning around the low centre. In the Southern Hemisphere, the spin is clockwise around low pressure.

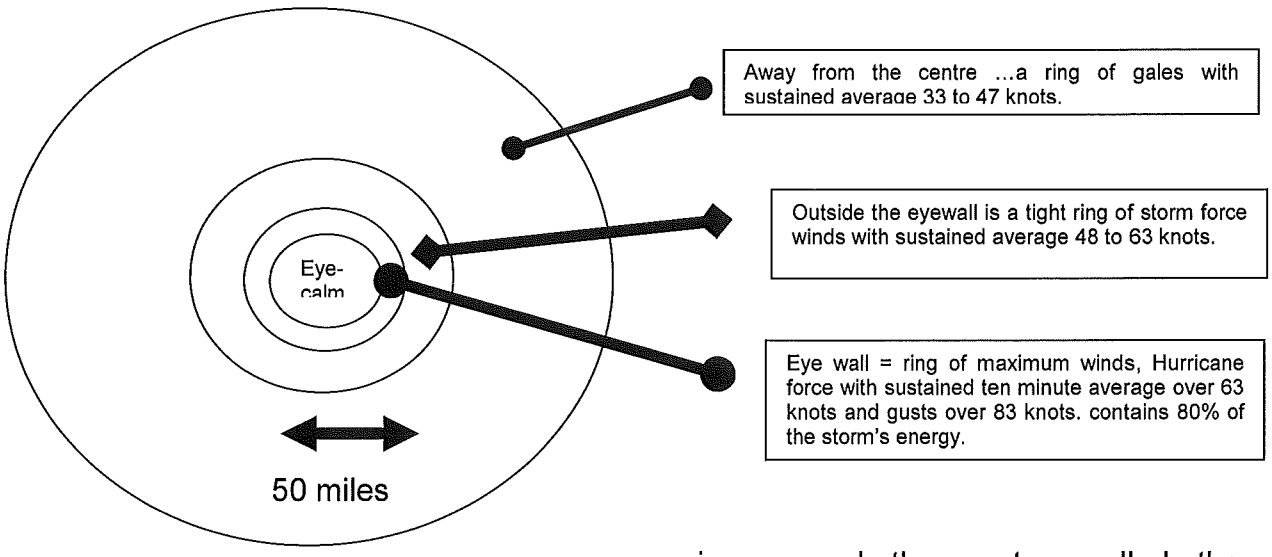
Sometimes the incoming spiral of wind does not fully relieve the pressure imbalance. It feeds in more moisture, making more clouds, more rain, more heat, and leading to a lower central pressure. In these cases, the system of twisting winds gets stronger and becomes a tropical cyclone. It takes about three days for this to happen. During this stage, the tropical cyclone resembles a cylinder of strong winds whirling round a core of light winds. Tropical cyclones remain at full strength so long as they are being fed with an inflow of warm moist air. Once they move onto land, however, or out of tropical waters (above 26C), they start to unravel. Drier or cooler air cannot climb so high, so the cylinder

becomes less tall, expands in area and dissipates.

Once tropical cyclones leave the tropics, they commonly broaden out and lose their distinctive eye, become asymmetrical, and acquire a frontal system typical of temperate (mid-latitude) cyclones. They are no longer tropical cyclones but may still be referred to by their given name — for example, "Cyclone ALPHA". The wind warning classification concerning such a cyclone will no longer be "hurricane warning", even though winds mentioned may still refer to speeds of 64 knots or more. The odd one develops into a deep mid-latitude depression with strong winds. This is done by feeding cold air into its circulation, the strong winds being formed by the changing temperature difference across the cyclone. The WAHINE storm on 10 April 1968 is an example of this, resulting in wind gusts in Wellington up to 132 knots (or 243 km/hr). Cyclone BOLA on 6–10 March 1988 is another example.

Why do they form?
A ray of sunlight striking the earth at the equator only lights up a small area. The same-sized ray near the poles spreads its light over a larger area. Hence sunlight is stronger at the equator than near the poles. The equator is heated every day, but each pole spends half the year in darkness, cooling down. It is this varying temperature difference between the equator and the poles that drives all the weather. Air from the tropics does not directly mix with air from the poles. Instead, these air masses twist around each other, causing warm and cold fronts and areas of low pressure in the mid-latitudes. If this mixing process does not work properly, then heat will build up in the tropical seas as hot water. In response to this extra energy tropical cyclones form, taking away the energy and sharing it around the world. So, in fact, tropical cyclones are safety valves of the earth's heating system — they prevent the oceans from overheating.

The insides of a tropical cyclone
Winds spiral in at the bottom, bringing in moist air (clouds). This creates a series of rainbands spiralling inwards. These rainbands bunch together in a ring around the centre, called the EYEWALL. This is the most dangerous part of the cyclone, where the strongest winds are found circling the centre (maybe gusting to 100 knots, 185 km/hr) and where a lot of the air



rises rapidly (up to maybe 20 km, which is higher than normal thunderstorms) and cools quickly, forming torrential rain. Inside the eyewall is the EYE of the cyclone, an area of descending warm air with light winds and few clouds. The temperature can be up to 10° warmer than the surrounding air. The eye extends down from the top through the cyclone like a tunnel and has a diameter of about 10 to 30 kilometres (but this tunnel can sometimes be as large as 100 kilometres across at the top). After the incoming air rises up through the eyewall and reaches the top of the cyclone, some of it sinks into the eye, but most of it is blown outwards by strong winds spiralling outwards.

When the eye passes over a place, the wind drops suddenly and clouds mostly clear. This lull may last a few minutes or perhaps half an hour, but then the wind will resume its full strength again quite suddenly and from a completely different direction. The track of a tropical cyclone may be erratic, with unforeseen changes in speed and direction. The eye wobbles about the track.

Dangers of a Tropical Cyclone

• Damaging winds, especially at sea, through narrow straits and around headlands. Flying debris. No food crops can survive hurricane force winds. Leaves are ripped off trees.

• Heavy and persistent rain. Flooding of low-lying areas, washing away bridges. Landslides about the hills.

• Heavy swell, smashing coral reefs and coastal defences.

• A "STORM SURGE" — a rise of the mean sea level caused partly by low air pressure and partly by piling up of seawater by onshore winds. A storm surge may lift the sea level by as much as a couple of metres. If this coincides with a high tide, then low-lying islands (such as atolls in the South Pacific) may be completely covered in water, and battered by huge waves. Boats in marinas may float off their pile-moorings.

Precaution Checklist

When a tropical cyclone is expected follow this checklist ...

• Put away, secure or tie down any objects that may fly in the wind.

• Store drinking water

• Check batteries in torch and radio

• Top up on fuel and tinned food

• Move animals to safety

• Move small boats to shelter

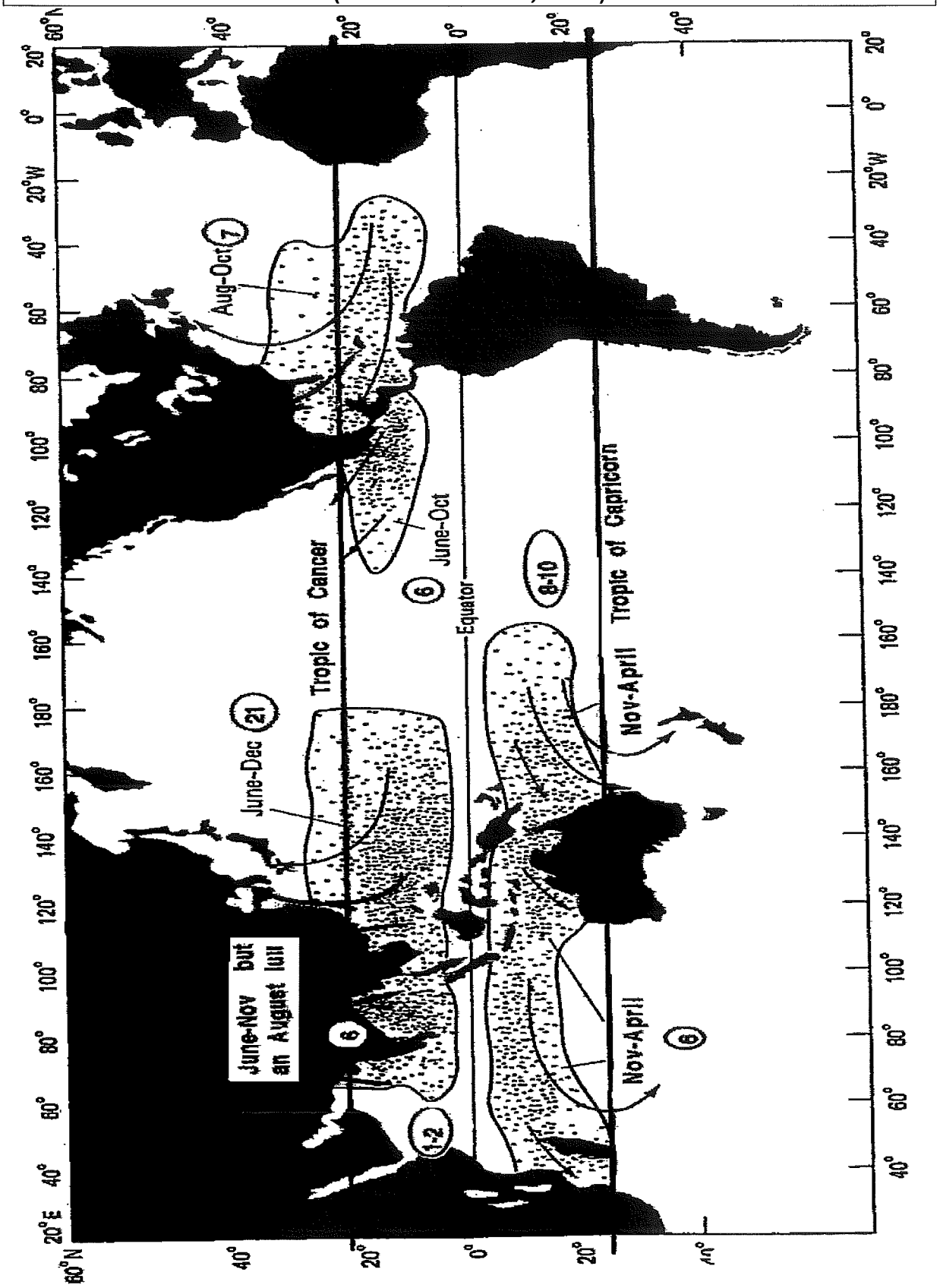
• Board up or protect windows

• Avoid coastal areas that may be swept by storm surge

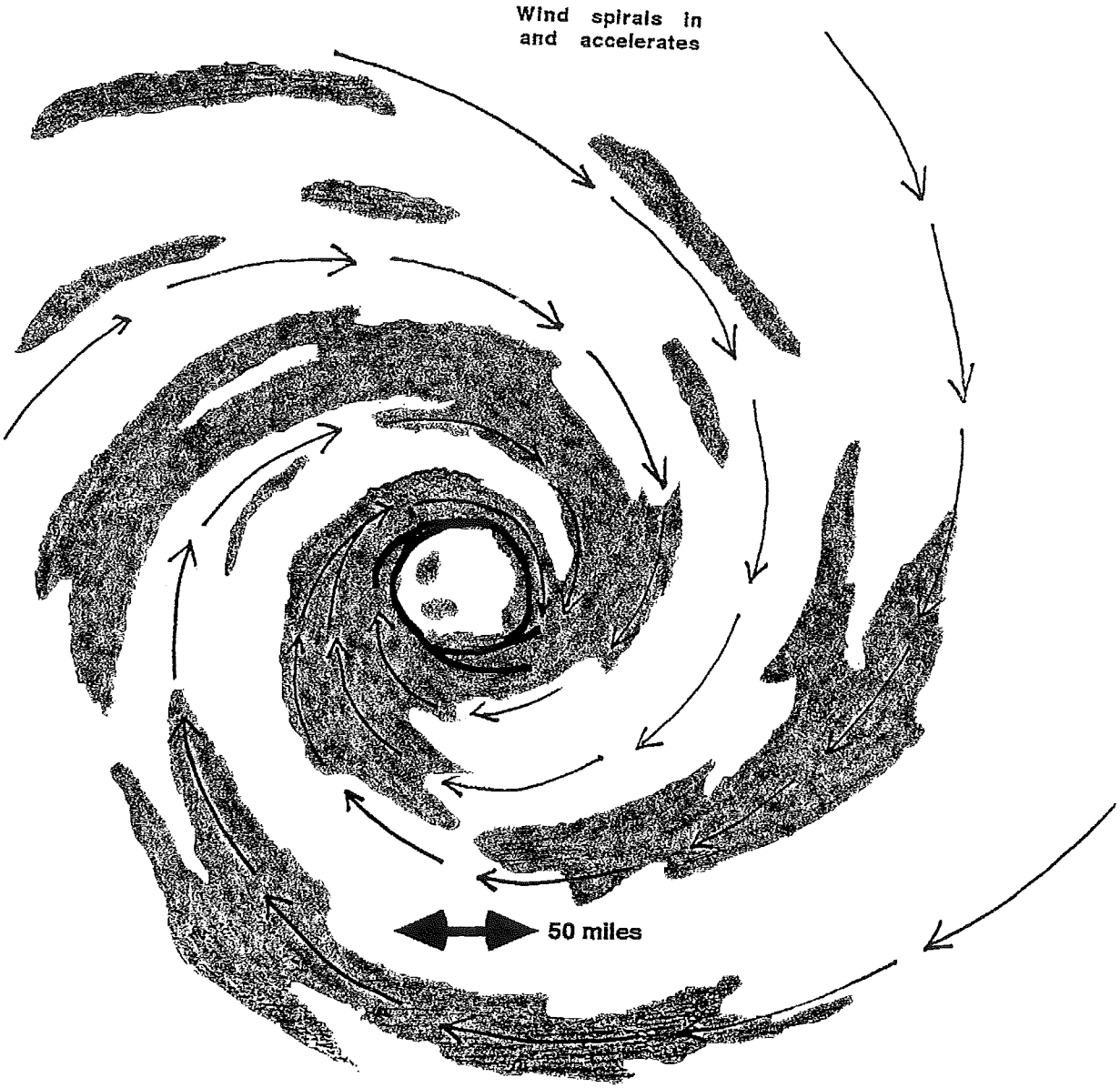
• Stay indoors during the height of the storm — usually a day or so

• Do not be deceived by a temporary lull if the eye passes by

Tropical Cyclones
Each dot is a point of origin. Average number per year is circled.
(After *Gedzelman, 1980*)

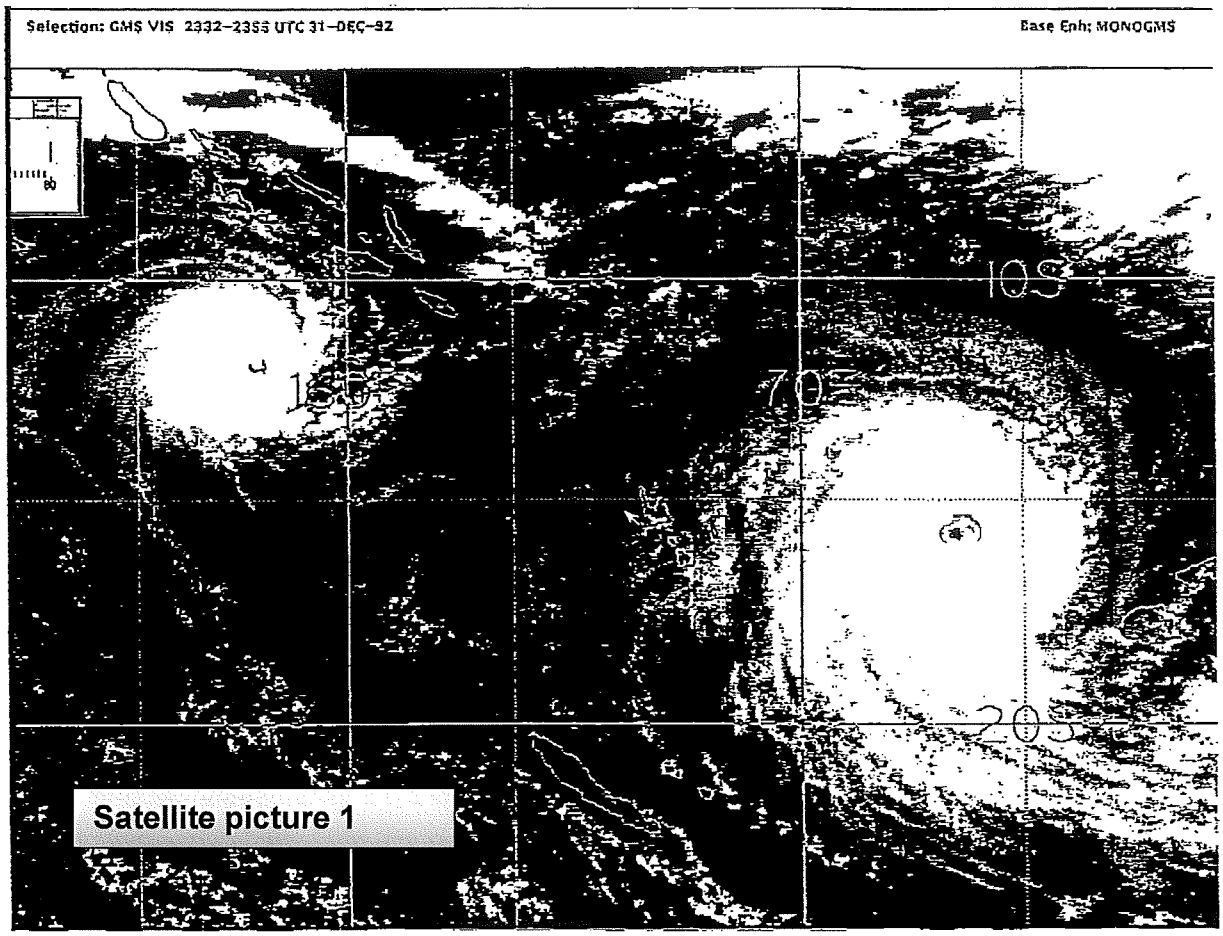


Weather radar image showing rain pattern of a tropical cyclone (stylised for simplicity)



Wind direction lines (streamlines) curve more and more as they approach the centre, eventually wrapping around the eye.

The pattern of squally shower bands interspersed with avenues of quieter air spiralling into the eye is typical.



Satellite picture 1

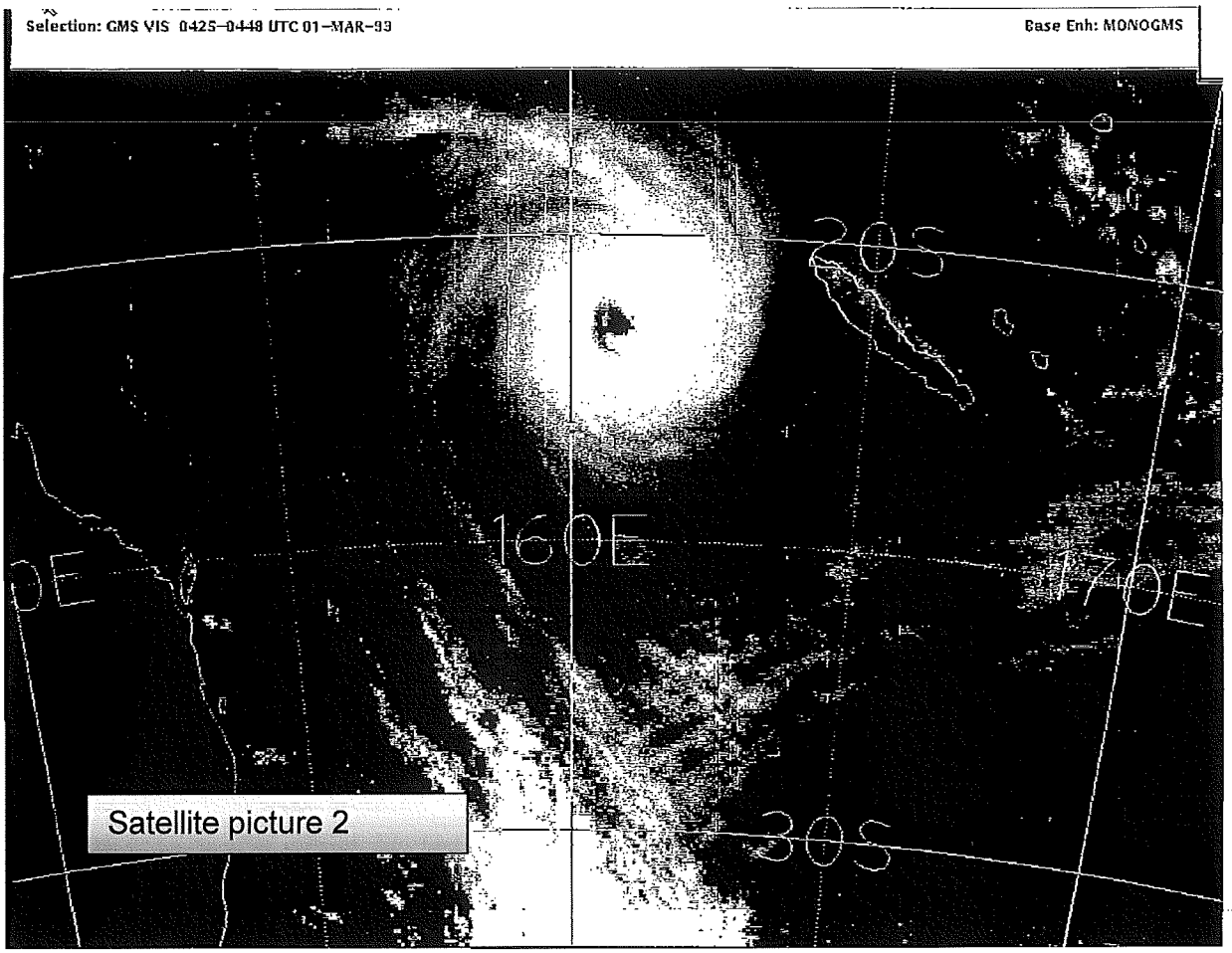
0000 UTC 1 January 1993

Tropical Cyclone NINA, on the left (near the Solomons), was named by Brisbane Tropical Cyclone Warning Centre. Intensity (estimated maximum sustained wind speed) 75 knots. Estimated central sea level pressure 960 hPa.

Tropical Cyclone KINA, on the right (near Fiji), was named by Fijian Tropical Cyclone Warning Centre. Intensity (estimated maximum sustained wind speed) 75 knots. Estimated central sea level pressure 960 hPa.

Here, NINA is almost half the size of KINA and has a smaller ring of gales around it, yet they both pack the same punch near their centre.

Names may move around the alphabet, even for neighbouring cyclones.
There is no direct relationship between size and intensity.



Satellite picture 2

0500 UTC 1 March 1993

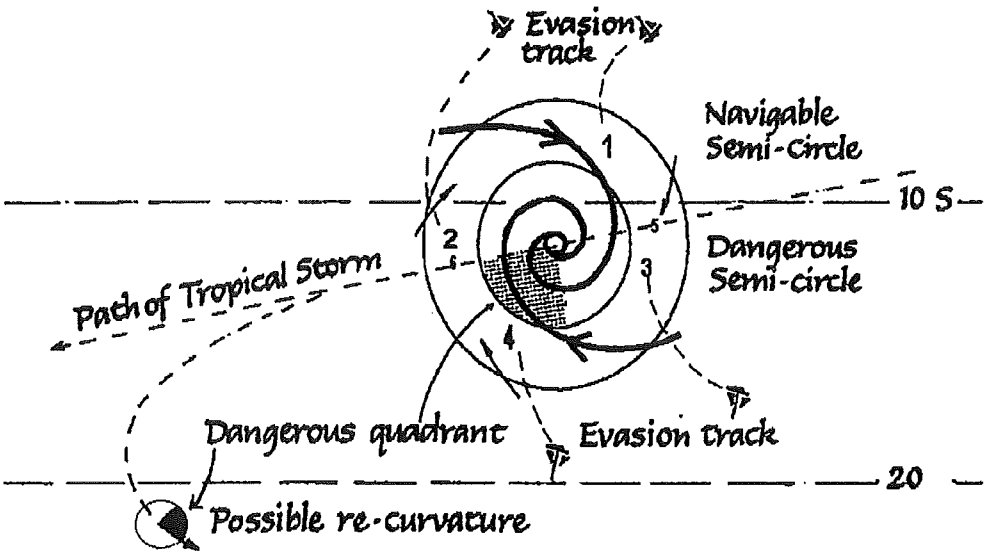
Tropical Cyclone POLLY (just west of New Caledonia) is viewed with intensity (estimated maximum sustained wind speed) 85 knots and estimated central sea level pressure 955 hPa.

POLLY is very small — about the same size as the main island of New Caledonia. The system has very tightly coiled cloud bands, a sign of its extreme intensity. It also has a large eye, with its upper part something like 100 miles across.

Soon after this image was taken, POLLY moved out of the tropics and into a regime of strong upper winds. These winds toppled the system, and sheared it apart. POLLY was too small to maintain its structure outside the tropics.

South Pacific tropical cyclones may be small and compact, but they still pack a mean punch near their centre.

EVASION PATHS in the SOUTHERN HEMISPHERE



Face the wind

EYE is between 90 and 135 degrees to your left depending on indraft angle (which lessens as the system approaches).

Is wind direction veering? — YES → Is baro rising? — YES → 1. The eye is moving away. Fine Reach, with wind to port. Head for path at right angles to cyclone track.

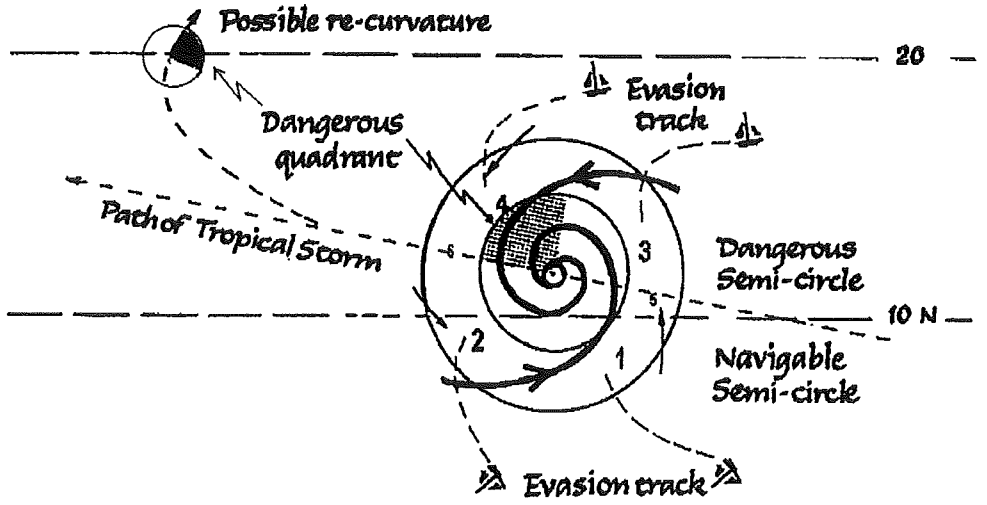
Is baro rising? — NO → 2. Run or reach with the wind on your port quarter. If no room, heave-to.

NO → Is wind direction backing? → Is baro rising — YES → 3. Reach or fine reach Keeping wind to port

Is baro rising — NO → **4. The DANGEROUS QUADRANT.**
Keep away from any coastline (lee shore).
If you can face into the wind then <u>sail close-hauled on port tack</u> so as to move away from the eye. Try to balance the wind on the left side of the bow and the sea (hopefully) on the right. If this is not possible, <u>heave-to on a port tack.</u> Try out the Sea-anchor.
Be aware that if the cyclone starts to "re-curve" then its eye will be chasing your evasion path.

Is wind direction backing? — NO → If the wind direction <u>remains steady</u> several hours,
If the barometer is <u>rising</u>, eye is moving away and you can safely go with path 1 or 3.
If barometer is <u>falling</u>, eye is moving towards you (but changing indraft angle will cause slight backing in the wind). Try to run with the wind just abaft of your port beam, keep monitoring the wind....if it backs consider path 4.

EVASION PATHS in the NORTHERN HEMISPHERE



Face the wind

EYE is between 90 and 135 degrees to your right depending on indraft angle (which lessens as system approaches).

Is wind direction Backing? — YES → Is baro rising? — YES → 1.Eye is moving away. Fine Reach, with wind to starboard. Take path right angles to cyclone track.

Is baro rising? — NO → 2. Run or reach with wind on your starboard quarter. If there is no room, heave-to.

NO → Is wind direction veering? — YES → Is baro rising? — YES → 3. Reach or Fine reach, Keeping wind to starboard

Is wind direction veering? — NO → Is baro rising? — NO → 4. The DANGEROUS QUADRANT.
Keep away from any coastline (lee shore). If you can face into the wind then sail close-hauled on starboard tack so as to move away from the eye. Try to balance with the wind on the right side of the bow and the sea (hopefully) on the left. If this is not possible, heave-to on starboard tack. Try out the Sea-anchor.
Be aware that if the cyclone starts to "re-curve" then its eye will be chasing your evasion path.

NO → If the wind direction remains steady over several hours,
If the barometer is rising, then the eye is moving away and you can safely go with path 1 or 3.
If the barometer is falling, the eye is moving towards you (but changing indraft angle will cause a slight veering in the wind). Try to run with the wind just abaft of your starboard beam, but keep monitoring the wind....if it veers consider path 4.

Tropical cyclones are compact, but their central core is dangerous and is worth avoiding. They have enough patterns in their behaviour for us to be able to work out some basic evasion rules. They also can behave erratically, so these rules may not always work.

The speed of movement of the system adds to the wind in one semicircle. This is called the dangerous semi-circle, of which the leading half is called the dangerous quadrant. This is also the quadrant with the most difficult evasion track. If you find yourself in the dangerous quadrant and decide to run with the wind, you are likely to be drawn into a position where the eye will cross your track. Ouch!

Features of the dangerous quadrant

- Speed of movement of the cyclone is added to the wind
- Hardest evasion track
- Anything adrift will tend to be blown into the path of the eye
- If the cyclone makes landfall, wind and waves are onshore only in the dangerous quadrant

The cyclone in the sub-tropics

Once the cyclone travels on land or over sea with a temperature less than 26° C (usually this is found at around 21° latitude, the latitude of the tropic of Capricorn and Cancer), it will run out of fuel and change into something else. There are three possibilities:

- If there is a sub-tropical high situated in its path at around 30–40° latitude, a Squash Zone of type two will form. A belt of easterly gales (or stronger) will form halfway between the cyclone and the high. This belt will take over from the dangerous quadrant as being the worst part of the storm as the system unravels.

- If a zone of colder air is drawn into the cyclone, the temperature difference across the system can refuel the whole system, turning it into a mid-latitude cyclone. Its wind and rain will spread out and cover wider areas (with less intensity). If such a cyclone also manages to survive the trip to the polar side of a jet stream, it may find that air is drafted out of the central region faster than it can replaced, leading to a period of explosive deepening in the mid-latitudes — namely a bomb.

- If the cyclone is too small or encounters a regime of winds aloft which are strong enough to topple it or shear it apart, then all that will be left as it tracks into the mid-latitudes will be a slowly unravelling system of rotating low clouds and an area of moister than normal air. These systems may live longer than they can be tracked on weather maps, but usually mix with their surroundings in a few days.