



How Hurricanes Happen

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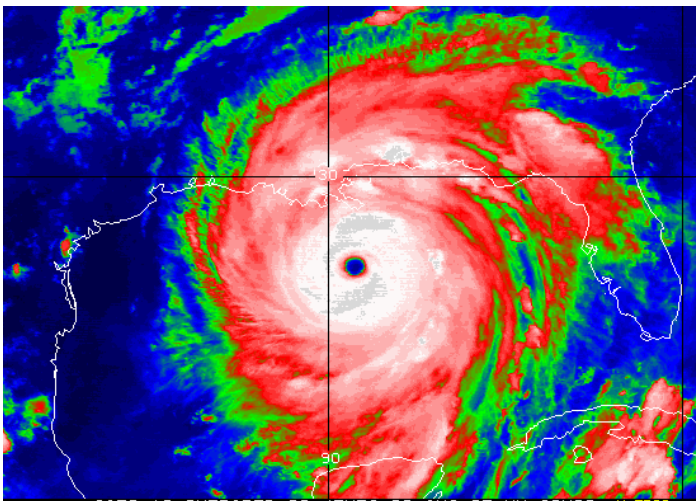
Between 1968 and 2003 an average of 8 hurricanes battered the Caribbean and southern American states with 2 being extreme, category 3 or above. Eight times as many hurricanes arise regularly in the India Ocean, in South East Asia and the Pacific, yet none has captured the attention of the world like Hurricane Katrina. In a few hours of Monday 29th August 2005 Katrina almost wiped the major and historic city of New Orleans off the map. Over 1100 died, a million people were displaced and 5 million left without power. It is estimated over \$200bn damage was caused in New Orleans and across an area the size of the UK.

Could a similar event happen here? No.

Is global warming to blame? Marginally, but see below.

So, how do hurricanes happen?

Hurricanes only arise within a certain set of favourable meteorological conditions. They originate in air over warm ocean water where the temperature is 26.5 °C or more to a depth approaching 50 metres. This is basically water in tropical latitudes. The sun evaporates water from the surface and the warm moist air rises. Air becomes cooler with altitude (about 1°C for every 200 metres altitude) and the quantity of water vapour it can hold reduces, so the moist air cools, condenses into tiny water droplets and forms clouds. UK weather forecasters talk of clouds 'bubbling up' during a summer day, and the cause is exactly the same. Frequently we enjoy more sunshine in our mornings than afternoons.



Infra red picture of hurricane Katrina taken from the internet site Wikipedia. Note relative heat (red + white) in centre

Were there to be absolutely no wind the moist air rising would eventually be balanced by cool air descending and

the system would stagnate. Were a strong wind to blow, the water droplets would be dispersed. So the second condition which must apply is for the winds to be light at all altitudes. These blow the clouds and cooled air to leeward allowing more and more moist air to rise.

Name	Pressure mbars	Storm surge (m)	Wind speed (mph)
Tropical depression			23-39
Tropical storm			39-73
Hurricane Cat 1	> 980	1.5	74-95
Hurricane Cat 2	965-979	2-2.5	96-110
Hurricane Cat 3	945-964	2.5-4.0	111-130
Hurricane Cat 4	920-944	4.0-5.5	131-155
Hurricane Cat 5	<920	>5.5	>155

The outcome is to create a large volume of cloud and turbulent air with warm air moving up and cooler air down. The moving clouds collect static electricity which is eventually discharged as lightning and heard as thunder.

Again in relatively quiet winds a group of thunder storm clouds can coalesce. If conditions so conspire the next stage begins. It is not quite as simple as this but the mechanism can be best understood by assuming that warm moist air is being drawn upwards mostly from the fringes of the storm whilst the colder (and heavier) air is tending to sink from the centre of the cloud mass. Once a complete circle has been formed the cloud mass becomes a tropical depression and its movement is affected by what is known as the Coriolis effect. This, in the Northern Hemisphere, causes the cold air moving towards and down from the centre of the cloud mass to veer slightly to the right. The outcome is that the descending air goes into an anti-clockwise spiral (looking downwards from the top). A noticeable 'eye' develops with the winds nearest the eye being the strongest and the cloud mass being dragged anti-clockwise round after it.

The Coriolis effect arises from the rotation of the Earth. It is greatest at the poles and zero at the Equator. Hurricanes thus emerge from a relatively narrow band. They do not form in higher latitudes because ocean temperature are too low or in latitudes near the Equator because the Coriolis effect is too weak.

A tropical depression will have a measurably lower pressure

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This note has been written for ALDES by Richard Balmer. It should be factually accurate but any opinions expressed are the author's alone. If you see errors or have comments please contact Richard Balmer at 79, Links Drive, Solihull, B91 2DJ, email richard_balmer@blueyonder.co.uk

at its centre but the winds at the centre will be brisk, no more.

What happens thereafter is still not inevitable. If a tropical depression is to develop into a hurricane it must continue to track slowly over warm ocean water which is being evaporated into the atmosphere by the sun and it still needs weak high altitude winds to prevent the system breaking up. Thus a hurricane's energy dissipates rapidly if the prevailing winds take it over land (because it loses its source of water) or if it veers towards a Pole (because the water becomes too cool) or if its action whips up the ocean bringing cold water to the surface.

Unhappily the prevailing wind in the Atlantic above the Equator is WNW. Thus many thunderstorms which originate off the north coast of Brazil track over warm ocean water all the way to the Caribbean and Gulf of Mexico. If the high altitude winds are weak, as they have been in recent years independently of global warming, hurricanes are inevitable. The cloud mass grows and grows and the energy released as the water vapour condenses drives the spiral of descending cold air faster and faster. It has been calculated that an 'average' hurricane has a radius of 665 km and is operating at a power of over half a billion megawatts, 400 times the total installed electrical power on Earth!

Hurricane Katrina was first identified as a tropical depression on Tuesday 23rd August over the SE Bahamas. Two days later it hit Florida and decreased in violence but the wind direction then took it over the Gulf of Mexico where it was re-invigorated. On the Sunday it reached Category 5 with wind speeds of 175 mph gusting to 216 mph. By the following day, when it hit New Orleans, it was back to Category 4.

While high winds cause damage directly, they also 'drag' and push the ocean water along with them. This raises the sea level by several metres (see table) in so called 'storm surges' causing flooding which is commonly more devastating than the winds. In addition heavy rain can fall, often many centimetres in a few hours, raising river levels and overwhelming banks and drainage systems. New Orleans half expected the levees (banks) which protect it to be overtopped, but not that lengths of the levees would fail altogether. It was this failure that hugely increased the quantity of flood water which poured into the city and did so much damage.

Storm force winds reaching hurricane strength can be generated in other circumstances which create turbulence, in particular where warm and cold fronts collide but, lacking the mechanism to grow, they tend to be more transitory and much smaller. Michael Fish will for ever be remembered for dismissing the threat of the October 1987 hurricane which devastated woodland in SE England on the night of Friday 16th of that month. It was modest in comparison to Katrina. Though 18 people are thought to have lost their lives and 15 million trees blown down, it only reached hurricane force locally, for short periods, in a few areas along the South Coast. Even now it is not certain

why it occurred. One theory is that the left over warm moist air from Hurricane Floyd which had been tracking up the east coast of the USA was pushed by the jet stream over the Bay of Biscay and then northwards into a mass of cold Arctic air. This set up turbulence, then a spiral of accelerating, descending winds.

But, before we blame global warming for this or hurricanes elsewhere, we should note that Katrina hit land at Category 4 not 5 and that, of the 2 recorded Category 5's that have made landfall in the USA, one, at Camille, was 36 years ago in 1969 and the other 70 years ago, in 1935 at Florida Keys. In the UK the storm of 1987 was the greatest since - wait for it - 1703, over 300 years back and well before the industrial revolution.

It is the case, however, that warmer seas and air mean the weather systems have more energy to work with. Furthermore, as global warming increases ocean temperatures the area of warm ocean will increase and extend towards the poles. Hurricanes must be expected to slowly become both more frequent and more severe. The world must, over coming decades, expect more violent weather events. Katrina shows just how devastating some can be.