Global warming and storms

The strongest storms driven by latent heat will become more powerful and the greater wind speeds will make them more destructive as a result of Global Warming. The destructive power of wind increases with the cube (power 3) of its speed. The increase in destructive potential (ΔDP) when a cyclone increases its wind speed from v_1 to v_2 is given by:

$$\Delta\text{DP} = \frac{(v_2)^3 - (v_1)^3}{(v_1)^3}$$

For example, let's calculate the increase in destructive potential if a cyclone increases its wind speed from 200 km/h to 240 km/h:

$$\Delta\text{DP} = \frac{(240)^3 - (200)^3}{(200)^3}\ X\ \frac{100}{1} = 73\%$$

Therefore***, a 20% increase in wind speed increases its destructive potential by 73%.*** Latent heat of condensation is energy released when water vapour condenses to form water droplets. Storm types driven by latent heat include thunderstorms, tornadoes and storms referred to as cyclones in the Indian Ocean and South Pacific, typhoons in the Western Pacific and hurricanes in the Western Atlantic and Eastern Pacific Oceans.

Storms are formed as follows:

1. As warm, moist air moves over the ocean, water vapour carrying latent heat (the fuel of storms) rises and expands creating relatively lower pressure at the surface.

2. It cools as it rises and condenses into water droplets.

3. Condensation releases the latent heat (2256 kJ or 539,000 calories per kilogram of water) into the surrounding atmosphere creating a vigorous updraft.

4. Moist air from the ocean takes the place of the displaced parcel of air. Consequently, surface winds begin to increase in speed and move towards the centre of the lower pressure importing more moist air.

5. The higher pressure aloft in response to the warming from the latent heat allow the outward flow of air venting the storm and the cycle of latent heat release, surface pressure fall and increase in surface wind speed continue importing more moist air and so on.

Sometimes an intense cluster of thunderstorms combine their latent heat into a warm centre of air. If the thunderstorms increase in intensity, more latent heat is released, surface pressure falls further increasing the speed of the converging surface winds.

When the wind speed becomes sustained at 62 km/hr (39 mph) or greater, we have a Tropical Storm.

More moisture from Global Warming allows for more condensation and more latent heat release. The strongest storms can use all the extra latent heat released creating a more vigorous updraft and for the strongest storms the wind speed is increased further.

Warmer surface water dissipates more readily into water vapour, facilitating the growth of smaller storms into larger, more powerful systems. *The global sea surface temperature as a result of Global Warming is approximately 1 degree Celsius higher now than 140 years ago. According to the Clausius-Clapeyron equation, a rise of 1 degree Celsius in the global sea surface temperature will cause 7% more water vapour to be held in the surface air at saturation. On condensation, extra latent heat of 157.9 kJ (or 37,730 calories) per kilogram of water will potentially be released into the surrounding atmosphere and fuel the strongest storms.*

The *intensity* of tropical cyclones is primarily a function of *sea surface temperature* (SST). The observed Atlantic hurricane data[1] show a strong correlation between Atlantic sea surface temperatures and the Power Dissipation Index (PDI). The PDI combines frequency, *intensity*, and duration of hurricanes into a single index. We define Maximum Potential Intensity (MPI) by the central pressure of a cyclone. A rapid increase in MPI of about ***30*** *hPa / degree Celsius* is found[2] for 26°C < SST < 29°C. The minimum sea surface temperature required for cyclone development, for example, is 26.5 °C. The other factor being relative humidity will be close to 90%. *An increase in Maximum Potential Intensity for storms of 20% is predicted for a doubling of carbon dioxide content in the atmosphere.*

The maximum wind speed (V) of a cyclone in m/s is given by Takahashi's formula[1]:

$$\mathrm{V} = 5.95\sqrt{(1010 - \mathrm{P_c})}$$

where P_c is the central pressure in hPa**.**

The formula shows that lower central pressure corresponds to higher wind speed. For example, a hurricane with a central pressure of 925hPa (or mbar) will be a (Category 3) major hurricane (or severe tropical cyclone) with a maximum wind speed of 198 km/h and one with central pressure of 895hPa will be a (Category 4) major hurricane (or severe tropical cyclone) with a maximum wind speed of 230 km/h. Consider a major hurricane that has developed on the ocean with a sea surface temperature greater than 26.5 °C and a maximum wind speed of 198 km/h. Let's calculate the increase the maximum wind speed for an increase in sea surface temperature (due to *Global Warming*) of 1 degree Celsius (i.e. 30 hPa fall in central pressure). *Using the formula (and converting wind speed to km/h) a central pressure fall of 30 hPa (e.g. from 925 hPa to 895 hPa) will increase the maximum wind speed of the hurricane by 32 km/h as follows:*

$$\Delta V = 3.6X5.95\left(\sqrt{1010 - P_2} - \sqrt{1010 - P_1}\right) = 3.6X5.95\left(\sqrt{115} - \sqrt{85}\right) = 32\ km/h$$

The major hurricane or severe tropical cyclone has increased in strength from Category 3 to Category 4 as a result of Global Warming. *Using the formula again, a central pressure fall of 30 hPa (e.g. from 943 hPa to 913 hPa) will increase the maximum wind speed of the hurricane by 36 km/h (i.e.175 km/h to 211 km/h).* ***The hurricane has increased in strength from Category 2 (extensive damage) to Category 4 (catastrophic damage) as a result of Global Warming. Therefore, a cyclone or hurricane that would have developed prior to Global Warming will now be much stronger and potentially more destructive.***

The region in which tropical storms can form almost surely will expand as sea surface temperatures rise[3]*. Cyclone Catarina in March 2004 was the first recorded tropical storm in the South Atlantic Ocean. The extra water vapour content in the strongest storms due to Global Warming will increase the amount of rainfall and the size of floods.*

A weather front is a boundary separating two masses of air of different temperature and humidity. The colder and denser air of a cold front wedges under the less dense and warmer air mass. The warmer air mass, in turn, is lifted along a frontal boundary producing thunderstorms and stronger winds at ground level. A warm front occurs at the edge of a uniform warm air mass. Thunderstorms may occur if the warm air mass is unstable. There will be conditions with weather fronts where the warm air mass will be carrying more moisture than would be the case without Global Warming. The power of the frontal storms in this case will increase as the temperature difference between the air masses increase.

References

1. Emanuel, K., (2007), *Environmental Factors Affecting Tropical Cyclone Power Dissipation*, Journal of Climate, Vol. 20, p5507.

2. Holland, Greg J., (1997*), The Maximum Potential Intensity of Tropical Cyclones*. J. Atmos. Sci., Vol. 54, pp2519–2541.

3. Hansen, James, (2009). *Storms of My Grandchildren*, Bloomsbury Publishing, London, p254.

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