

# Basic aspects of hurricanes for technology faculty in the United States

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**Abstract-** As predicted by Svante Arrhenius in 1896, global warming is taking place as evidenced by documented rises in average sea level of about 1.7 millimeters per year during the 20th Century. There have been naturally occurring cycles of global warming and cooling throughout the history of the world. Much has been written about the catastrophe that global warming would present to humankind such as an increase in the frequency and severity of hurricanes. This paper presents a discussion of the formation of hurricanes, hurricane season, hurricane ratings, and hurricane prediction and tracking for engineering technology and construction management faculty to use to supplement instruction in courses taught which are not in the environmental or energy related subjects.

*Keywords: global warming, hurricane aspects, hurricane characteristics, hurricane formations*

## INTRODUCTION

Global warming due to human activity was first predicted by Svante Arrhenius in 1896 (NASA, 2007). The primary gases in the atmosphere, nitrogen and oxygen, will not reflect solar radiation, but many gases such as carbon dioxide, methane, nitrous oxide and halogens will trap infrared radiation emitted by the Earth's surface into the atmosphere causing global warming and climatic change. Atmospheric concentrations of carbon dioxide have been measured accurately since the late 1970s (Tans, 2007). Historical levels of atmospheric carbon dioxide and climatic change over the last 400,000 years have been estimated from Antarctica ice core records. Antarctic temperatures have varied from about -18 to 7.2 degrees Fahrenheit relative to present day levels (Thorpe, 2005).

Global records have shown about 0.9 to 1.44 degrees Fahrenheit increase in mean surface temperature of the earth over the last one hundred years (NASA, 2007; and Thorpe, 2005). Over the same period, atmospheric carbon dioxide concentrations have risen from about 290 parts per million (ppm) to about 383 ppm today (Tans, 2007). The basic theory behind global warming is that as greenhouse gas concentrations (primarily carbon dioxide) in the atmosphere increase, global temperatures will increase due to the entrapment of infrared radiation. Kaufman, et al have written about the link between global surface temperature and atmospheric greenhouse gas concentrations (2006). An increase in the mean global temperature is amplified at the poles. In the Arctic, winter temperatures have risen nine degrees Fahrenheit (Appenzeller, 2007) causing ice sheets to melt with the potential of increasing sea level worldwide. In addition, this rise in temperature could cause desalination of the Arctic oceans, thereby interrupting currents that affect weather and climate, including the formation of hurricanes.

## FORMATION OF TROPICAL HURRICANES

Atlantic Basin cyclones or hurricanes form because of massive thermal energies that are caused by the evaporative affects of the warm tropical waters of the Atlantic Ocean. The formation of a tropical cyclone requires a water temperature of at least eighty-one degrees Fahrenheit (26.5 degrees Celsius) or warmer (Brindze, 1973; ATMOS, 2003). There is a direct relationship between the water temperature and the rapid growth of a hurricane; as the water temperature increases, the probable intensity of the hurricane increases. An accumulation of disorganised thunderstorms collects to create a topical wave showing the

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first signs of preliminary organization. Drifting westward, through the tropics, the low-pressure storm gathers strength and organization to form a tropical depression (TD). The TD has a defined circulation and wind speeds of less than 38 mph. It is at this point that the storm is assigned a reference number by the US National Hurricane Center (NHC). As barometric pressure falls and thunderstorms increase in intensity, the storm moves from a TD and develops into a tropical storm (TS) with gale force winds. The TS has a well-defined circulation with wind speeds of 39 to 73 mph.

On reaching Tropical Storm status, the reference number is dropped in favour of a man or woman's first name. Lists of names are designated for several years in advance and are presented in alphabetical order. Names of major storms that cause a high degree of deaths or damage are retired. If the storm develops into a hurricane, or degrades to a TD, the name remains with the storm for its duration of existence (Landsea, 1998). When the practice of naming storms was initiated during World War II, hurricanes were only assigned female first names. This practice was used until 1991 when first names from both genders were added to the pool in alternating sequences (Simpson, 1981; Barnes, 1998).

As atmospheric conditions deteriorate, gale force winds of the TS develop into the hurricane. At this point the storm has developed 74 mph winds and barometric pressure has dropped to at least 980mb, and it is then considered a hurricane. The normal state of atmospheric barometric pressure is 1013mb. In a hurricane, the barometric pressure can drop as low as 954mb. The lowest ever recorded barometric pressure induced by a hurricane was in 1935 during an unnamed storm in the Florida Keys, which had a barometric pressure of just 892mb (Jarrell, 2003).

Once fully formed as a hurricane the storm is rated by a Category number ranging from one to five, in relation to the intensity and sustained wind speed. The Category number describes the intensity of the named storm for example a Category One storm would be a weaker storm and where a Category Five hurricane would be a catastrophic storm. The hurricane rating system is explained in detail in the following pages. A well-developed hurricane can last for as long as two to three weeks. Maximum winds range from 6 to 63 miles out from the center or the eye of the storm. Beyond this range, gale force winds can extend 300 miles out. The storm can develop a cyclonic rotation with a diameter of between 50 and 500 miles. The rotation of the cyclone creates an area at the centre of the hurricane known as the "eye-wall" that averages 20 to 40 miles in diameter (Landsea, 1998), with calm conditions in the centre.

## HURRICANE SEASON

The formation of hurricanes in the Atlantic Basin can happen in any part of the tropical region during the hurricane season. The hurricane season for the Atlantic Basin starts on the first of June and ends the thirtieth of November. The Gulf of Mexico and Caribbean frequently produce storms in the early and later parts of the season. These areas have shallow waters and thus warm-up first and cool-off last when compared to other areas of the Atlantic Basin. The duration of time from the twentieth of August to the fifteenth of September constitute the highest probability for the formation of a Cape Verde Hurricane (ATMOS, 2002). The changes in the probability for hurricane development are displayed in Figure 1.

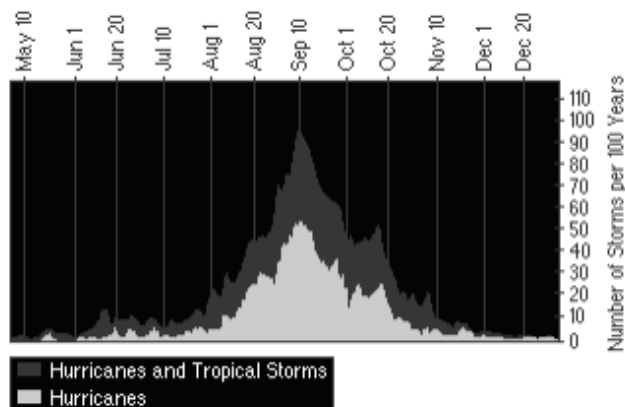


Figure 1: Frequencies of hurricanes by month. Source: National Weather Service, 2003

Cape Verde hurricanes form in the deep waters off the coast of Africa, see Figure 2. The storms developing in the Atlantic have a longer time to develop than those in the Gulf of Mexico. Storms travelling the shallow, warm waters in the Gulf are easily intensified and have a chance to develop into stronger storms, as was the case of Hurricane Katrina in August of 2005 and that of Hurricane Rita in September of 2005. The continental shelf extends far out into the Gulf creating shallower waters that are easily heated providing one of the conditions for a hurricane as mentioned previously (AOML, 2003).



Figure 2: Tracks of Cape Verde hurricanes  
Source: AOML, 2003

Wind speeds created by hurricanes are measured ten metres above ground level using an anemometer calibrated in meters per second (m/s) and by buoys placed in the water at given intervals out into the ocean. Wind speeds in the United States are measured in miles-per-hour. The World Meteorology Organization sets the sustained wind speed and measurement guidelines. Their suggestion is to measure the winds over a ten-minute period to determine an averaged sustained wind speed. The National Hurricane Center (NHC) and the Joint Typhoon Warning Center (JTWC) of the USA recommend an average over a one-minute period. The differences in the methods of measurement do not allow a direct comparison of wind data between the organizations. Adjustments to the measured figures are necessary for a true comparison between the two measurement systems (Landsea, 1998).

The Atlantic Basin is prone to experiencing nine to ten tropical storms (winds of at least 17 m/s) reaching tropical storm strength each year. Of these, on average, five to six reach hurricane strength (winds of at least 74 mph) (Landsea, 1998). This data is often misleading insofar as it is not representative of the number of storms that actually strike the coastline since many of them remain at sea only affecting the shipping lanes and never become a threat to the built environment on land. On average, of the total number of the major hurricanes that are predicted in a normal year, only an estimated 32% impact the coastline [Note 2].

## STORM RATINGS

In the early 1970's, Herbert Saffir and Robert Simpson developed the Saffir-Simpson Potential Damage Scale (Table 1). Herbert Saffir is an engineer from Coral Gables, Florida and Robert Simpson was a former director at the NHC. The scale was developed based on four criteria; barometric (central) pressure, wind speed, storm surge, and damage potential. The Saffir-Simpson scale was developed to assist the rating of storms and to categorize the pertinent data and predict the destruction bands (NWS-2, 2002).

| Category | Winds (mph) | Damage Level |
|----------|-------------|--------------|
| 1        | 74-95       | Minimal      |
| 2        | 96-110      | Moderate     |
| 3        | 111-130     | Extensive    |
| 4        | 131-155     | Extreme      |
| 5        | 156+        | Catastrophic |

Table 1: Saffir Simpson Damage Potential Scale  
Source: National Weather Service

## HURRICANE PREDICTION AND TRACKING

The ability to predict and accurately track hurricanes provides the target areas time to prepare for the impact of the hurricane taking precautionary provisions to protect the building stock. Computer models utilize historic data collected by the National Weather Service and current data to produce a computer simulated model of the impending hurricane (AMS, 1993). The interaction of the hurricane with the ocean and atmospheric conditions, provide the conditions that direct the hurricanes path. Predictions are provided at varying duration's of time as the hurricane approaches coastal areas. The closer the storm is to landfall the strike probability range decreases. The narrowed zone provides a degree of accuracy to issue warnings and possible evacuation orders. Conditions and locations of the storms are provided every six hours. Impact predictions are made every six hours when the storm is approximately thirty-six hours prior to coastal impact (DeMaria, 1997). The tracks of the models are classified into three categories: statistical, dynamical or a combination of the two (NHC, 2002). The models do not determine the damage potential.

“Hurricane Hunters” provide another important data collection method used by the National Hurricane Center (OMAO, 2002). Hurricane Hunters study the affects of hurricanes, or storms that have the potential of becoming hurricanes, by flying directly into the hurricane to gather information on the exact location of the centre of circulation, wind speed, barometric pressure and intensity of the hurricane. This task is accomplished in unison between two government agencies, the U.S. Air Force Reserves' 53 Weather Reconnaissance Squadron and the National Oceanic and Atmospheric Administration's (NOAA) Aircraft Operations Center, stationed at Keesler Air Force Base, Mississippi, USA. The information that is collected is vital for the predicting the hurricane's threat. The level of accuracy obtainable from satellites is insufficient for accurate storm prediction; by flying directly into the hurricane first hand data is collected to provide accurate forecasts of the hurricanes direction and intensity (Aircraft Operations Center, 2001).

## CONCLUSION

This paper presented a primer of the aspects of hurricanes for the technology instructor or construction manager. The formation of hurricanes, hurricane season, hurricane ratings and hurricane prediction and tracking were discussed. Construction managers must adhere to sound hurricane resistant construction methods to minimize destructive effects of possibly more intense future storms.

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