Chapter 1

Introduction

A hurricane is an extremely violent whirling and spiraling tropical cyclone, shaped somewhat like a funnel, that frequently originates in tropical regions of the North Atlantic Ocean, Caribbean Sea, Gulf of Mexico and eastern North Pacific Ocean. The term cyclone, used by weathermen and meteorologists, refers to an area of low pressure in which winds move around the pressure center and are usually attended by foul weather and strong wind speeds. A tropical cyclone is a nonfrontal, warm-core, low pressure synoptic scale storm that develops over tropical or subtropical waters and has a definite organized circulation.

Tropical Cyclones are called typhoons in the western North Pacific Ocean, hurricanes in the eastern north Pacific, baguios in the South China Sea, cyclones in the Indian Ocean, and willy-willies in Australia.

The size of a typical hurricane can vary considerably depending on the extent of the tropical storm's wind fields and rain fields. In a relatively large hurricane, such as the Florida hurricane of September 1947, hurricane force winds can extend 100 miles from the center (i.e. a distance from Palm Beach to Melbourne). However, in August 1992 Hurricane Andrew, the most destructive hurricane ever to strike Florida, or the U.S. mainland for that matter, had maximum winds with a radius of only about 12.5 miles. Thus hurricanes vary considerably in their size.

To be classified officially as a hurricane, wind speed in a tropical cyclone must be 74 miles per hour or greater. The direction of rotation of wind in a hurricane is counterclockwise in the northern hemisphere, and clockwise in the southern hemisphere. The average hurricane's center, referred to as the eye, is about 14 miles in diameter. The eye is surrounded by hurricane force winds, and is known as the wall cloud, or eye wall. Outside the wall cloud, or area of maximum winds, winds decrease fairly rapidly to tropical storm or gale force.

Within the hurricane, barometric pressure is 1-3 inches of mercury below the standard atmospheric pressure at sea level which is 29.92 inches of mercury.

The North Atlantic hurricane season occurs during the months of

June through November, with September generally having the largest number. The total number of hurricanes or tropical storms show great variation from year to year. In fact, certain past multi-decade periods had significantly greater numbers of hurricanes than others. This is supported by the recent study of William M. Gray in 1990 who reported that the period from the late 1940s through the late 1960s had a much larger number of hurricanes (i.e. a strong cycle) than during the 1970s and 1980s, except for 1988 and 1989 (i.e. a weak cycle).

Quoting a passage from Gray's 1990 article entitled *Strong Association Between West African Rainfall and U.S. Landfall of Intense Hurricanes*:

> Seasonal and multi-decadal variations of intense hurricane activity are closely linked to seasonal and multi-decadal variations of summer rainfall amounts in the Western Sahel region of West Africa.
>
> In general, the annual frequency of intense Atlantic hurricanes was appreciably greater from 1947 to 1969, when plentiful amounts of rainfall occurred in West Africa, than during the years between 1970 to 1987, when drought conditions prevailed.

The average forward movement of a hurricane approaching the Florida coastline is about 6-15 miles per hour. The direction of hurricane movement relative to the coastline has a large bearing on added destructive forces, with the perpendicular landfall of a hurricane being the most dangerous situation. This is because the wind field in a hurricane is typically asymmetric with the strongest wind generally within the right-front quadrant of the storm as viewed from the direction of movement and with the forward speed added to the wind speed. The right-front quadrant is the side of the wind field which produces the strongest storm surge, which, in most cases, is the most destructive part of the hurricane.

A storm surge, also called a hurricane surge, is the abnormal rise in sea level accompanying a hurricane or any other intense storm. The height of the storm surge is the difference between the observed level of the sea surface and the level in the absence of the storm. The storm surge is estimated by subtracting the normal or astronomical tide from the observed or estimated storm tide. Surge heights

vary considerably and result from a combination of direct winds and atmospheric pressure. Water transport by waves and swells, rainfall, and shoreline configuration, bottom topography, and tide heights at the time the storm or hurricane hits the coast are also factors. As an example of an extreme storm surge, Hurricane Donna which struck the Florida Keys in 1960, caused a surge of an estimated 12 to 14 feet, which is very significant considering the fact that there are few structures and little terrain that high in the Keys. A more catastrophic surge was the 24.4 foot surge which resulted from Hurricane Camille which struck the Mississippi coastline in 1969. The potentially devastating effects of the storm surge are further illustrated if one considers that a cubic yard of seawater weighs nearly three-fourths of a ton which pretty well guarantees destruction of anything in its path.

The storm surge has a tendency to dissipate the farther inland it goes, particularly if the land rises in elevation. However, winds and some degree of flooding are still remaining problems. High winds, the storm surge, battering waves, and high tide make a hurricane a potentially deadly killer with accompanying devastation and huge losses to property. In addition, tornadoes can be spawned by hurricanes, adding to the overall threat.

Torrential rainfall, which can also occur in a hurricane, adds to life-threatening and major damaging effects of a hurricane by causing floods and flash floods. For example, the aftermath of Hurricane Agnes, which was a relatively weak Florida hurricane, but well known as one of the costliest hurricanes in the mid-Atlantic states, resulted in severe inland flooding from torrential rainfall from its merging with another weather system in mountainous areas. In this case the hurricane surge had little part in the destruction that resulted.

High winds alone can lead to a barrage of flying debris, including tree limbs and branches, signs and sign posts, roofing (including entire roofs in major storms), and metal siding, all of which can move through the air like missiles.

Except when crossing completely flat, wet areas, such as extreme south Florida, hurricanes usually weaken rapidly as they move inland. However, the remnants of a hurricane can bring 6 to 12 inches of rain or more to an area as the storm passes. Should a weakened hurricane on land return to the sea, it can regain strength.

It is clear then that entire communities, including residential and business buildings, can be wiped out by a hurricane.

Because of the difficulty in relating the different and varying factors or characteristics of a hurricane to the destruction, the Saffir-Simpson Scale was conceived in 1972 and introduced to the public in 1975 (Simpson and Riehl, 1981). This scale, named in behalf of Herbert Saffir and Robert Simpson, has been used for 20 years to estimate the relative damage potential of a hurricane due to wind and storm surge. The Saffir-Simpson Scale categorizes a hurricane as being either a one, two, three, four or five, depending upon the barometric pressure, the wind speed, and the storm surge (Table 1). A Category 1 hurricane would inflict minimal damage, for example, primarily to shrubbery, trees, foliage, unanchored structures, small craft, and low lying areas which could become flooded. A Category 5 hurricane would cause catastrophic damage such as blown down trees and power lines and poles, overturned vehicles, torn down or blown away buildings, complete destruction of mobile or manufactured homes and in certain instances entire mobile home parks, and massive flooding. For the first time after Hurricane Andrew, the Fujita Tornado Scale was used to assess damage. Dr. Theodore Fujita is an expert on tornadoes and severe weather. F1 to F5 indicates winds from 73 MPH to over 261 MPH.

The practical usefulness of the Saffir/Simpson Scale is that it relates properties of the hurricane to previously observed damage. Historically and before the Saffir/Simpson Scale was developed, hurricanes were referred to as either Great Hurricanes, or Minimal, Major, or Extreme Hurricanes; because these terms are no longer used, the reader is referred to the glossary for an explanation of the these historical terms and to Tables 1 and 3. Tropical storms are named but are not assigned a Saffir/Simpson category number.