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THE 2004 HURRICANE SEASON IN THE CARIBBEAN/SOUTHERN USA (DME)

Introduction

A hurricane is a severe tropical storm, an intense form of a low pressure system or **cyclone**. Hurricanes are classified on the **Saffir-Simpson scale** according to wind speed (Figure 1). Their characteristics and formation are covered well in various advanced textbooks so we will only consider this briefly.

Hurricanes need moisture, light winds above them and warm tropical oceans below (to provide energy). If the right conditions last long enough, a hurricane can produce violent winds, high and powerful waves, torrential rains and floods.

Hurricanes rotate in an anti-clockwise direction around a core of very low pressure that is marked by clearer skies, known as the **eye**. Hurricanes have wind speeds of at least 119 km per hour. There are on average six Atlantic hurricanes each year; over a three-year period, approximately five hurricanes strike the United States coastline from Texas to Maine.

When hurricanes approach land, the heavy rain, strong winds and heavy waves can damage buildings, trees and cars. The heavy waves result from the very low atmospheric pressure combined with strong winds; this is called a **storm surge**. Storm surges are responsible for the flooding associated with hurricanes.

Figure 1: The Saffir-Simpson scale

Tropical Storm
Winds 39–73 mph

Category One Hurricane:
Winds 74–95 mph (119–153 km/hr). Storm surge generally 4–5 ft (1–1.5m) above normal. No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees.

Category Two Hurricane:
Winds 96–110 mph (154–177 km/hr). Storm surge generally 6–8 ft (1.8–2.5m) above normal. Some roofing material, door, and window damage to buildings. Considerable damage to shrubbery and trees – some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers. Coastal and low-lying escape routes flood 2–4 hours before arrival of the hurricane centre. Small craft in unprotected anchorages break moorings.

Category Three Hurricane:
Winds 111–130 mph (178–209 km/hr). Storm surge generally 9–12 ft (2.8–3.7m) above normal. Some structural damage to small residences and utility buildings. Damage to shrubbery and trees with foliage blown off trees and large trees blown down. Mobile homes and poorly constructed signs are destroyed. Low-lying escape routes are cut by rising water 3–5 hours before arrival of the hurricane centre. Flooding near the coast destroys smaller structures with larger structures damaged by battering from floating debris. Terrain continuously lower than 5 ft (1.5m) above mean sea level may be flooded inland 8 miles (13 km) or more. Evacuation of low-lying residences within several blocks of the shoreline may be required.

Category Four Hurricane:
Winds 131–155 mph (210–249 km/hr). Storm surge generally 13–18 ft (4–5.5m) above normal. More extensive wall failures with some complete roof structure failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Low-lying escape routes may be cut by rising water 3–5 hours before arrival of the centre of the hurricane. Major damage to lower floors of structures near the shore. Terrain lower than 10 ft (3m) above sea level may be flooded requiring massive evacuation of residential areas as far inland as 6 miles (10 km).

Category Five Hurricane:
Winds greater than 155 mph (249 km/hr). Storm surge generally greater than 18 ft (5.5m) above normal. Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage. Low-lying escape routes are cut by rising water 3–5 hours before arrival of the centre of the hurricane. Major damage to lower floors of all structures located less than 15 ft (4.6m) above sea level and within 500 yards (460m) of the shoreline. Massive evacuation of residential areas on low ground within 5–10 miles (8–16 km) of the shoreline may be required.

Box 1: Hurricanes 2004 – Caribbean/southern USA

What follows is an outline of the hurricane season in 2004 (Figure 2) as it affected the Caribbean and the USA (Figure 3). Persevere, as the list makes a point!

Hurricane Alex brought a powerful start to the 2004 Atlantic hurricane season. It first formed as a depression on July 31, and strengthened to a hurricane early in August, offshore but near the southern border of North Carolina. Alex then moved to the north east, paralleling the North Carolina coastline. As Alex moved away from the US coast, it continued to gain strength and became a major hurricane.

Hurricane Charley was the second hurricane of the season. It caused major damage to parts of Cuba as it crossed the island as a Category 2 hurricane, and strengthened further before reaching the US. It made landfall in south west Florida as a Category 4 hurricane; it was the strongest hurricane to strike the area since Hurricane Donna in 1960. After following the East Coast of the US, it

Figure 2: Hurricanes in the Atlantic region 2004

Names	Dates	Top winds
H. Alex	July 31–August 6	120 mph (192 km/h)
H. Charley	Aug. 9–15	145 mph (232 km/h)
H. Danielle	Aug. 13–21	105 mph (168 km/h)
H. Frances	Aug. 25–Sept. 7	140 mph (224 km/h)
H. Ivan	Sept. 5–18; Sept. 22–24	165 mph (264 km/h)
H. Jeanne	Sept. 14–27	120 mph (192 km/h)
H. Karl	Sept. 16–24	115 mph (184 km/h)

Source: http://www.usatoday.com/weather/hurricane/current-names.htm

eventually dissipated near Cape Cod.

Hurricane Danielle also occurred in August along with Tropical Storm Earl, but neither reached the coastline.

Hurricane Frances made landfall on the east coast of Florida as a Category 2 hurricane on Sunday, 5 September. Winds were estimated at 170 km per hour. Frances slowly progressed northwestward across central Florida and just northeast of Tampa when it was downgraded to a tropical storm. Frances then emerged into the Gulf of Mexico and continued northwestward through the northern Gulf of Mexico, making a second landfall on the afternoon of September 6 near Tallahassee as a tropical storm.

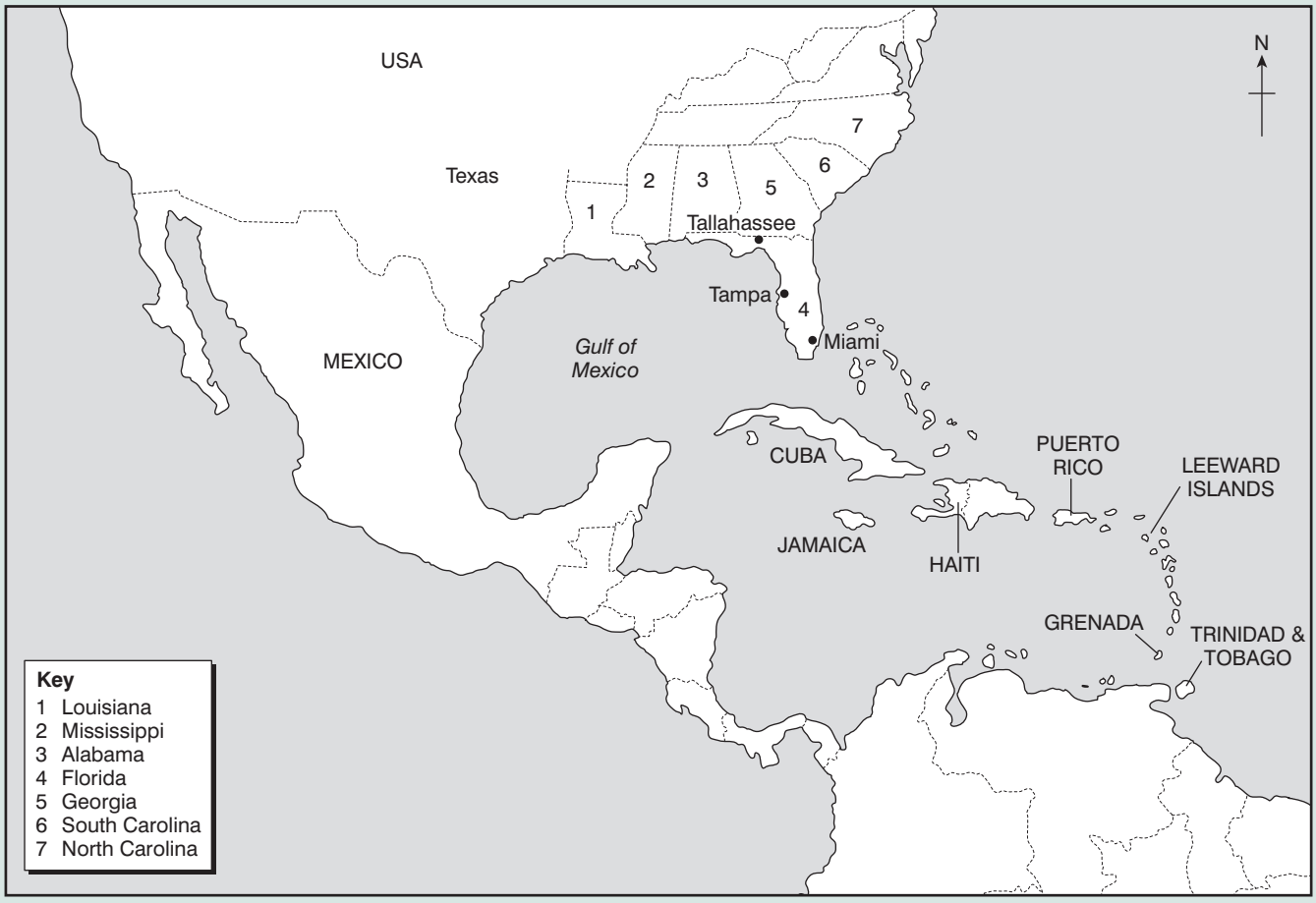
Hurricane Ivan began on September 5 as a category four hurricane but soon grew to become a category five storm (the highest possible), sustaining 225 km per hour winds. It affected Grenada, the Grenadines, Barbados, St. Lucia, St. Vincent, Trinidad and Tobago, Jamaica, Cuba, the Cayman Islands, and Florida.

Hurricane Jeanne struck the Caribbean in late September fluctuating from tropical storm to hurricane strength winds. It brought serious flooding and devastation particularly to Haiti (Figure 4) before swinging towards Florida and it also affected the Bahamas. We will return to the impact of Hurricane Jeanne later in this unit.

Hurricane Karl's 200 km per hour winds were no danger to land as the storm stayed out in the Atlantic Ocean about 1,600 km east-northeast of the Leeward Islands (Figure 3).

It should be apparent by now that this was an exceptional hurricane season, one of the busiest and most destructive in history. Researchers at the National Oceanic and Atmospheric Administration in Miami have not yet determined if 2004 will be the most active season on record, but it's definitely in the top two or three. The 2004 hurricane season compares to 1950, when there were eight major hurricanes. The only other season to approach 1950 was 1995, which produced five major hurricanes.

Figure 3: The Caribbean and southern USA including Gulf Coast and Florida



Box 2: Impacts of the 2004 season

The impacts of these hurricanes are very varied and spatially widespread and examining them could be approached in various ways. We will consider here the differences between the relatively poor Caribbean and the more affluent USA and consider the broad picture rather than referring repetitively to every individual hurricane.

The Caribbean

The Caribbean was affected by a succession of hurricanes. Charley caused serious damage in Cuba early in the season. Ivan struck Tobago on September 7 and carved a deadly swathe through the Caribbean and the Gulf coast, causing more than one hundred deaths. This was swiftly followed by the tropical storm Jeanne, which hit Puerto Rico on September 15. Upgraded to a hurricane, Jeanne moved on to Haiti where there were torrential rains, causing flash floods and mudslides that brought death and misery (Figure 4). Approximately three thousand people were believed to have drowned. Damage to power lines broke communications and added to the confusion.

Much of the damage in the Caribbean was to property including businesses like hotels and people's homes. Structural damage in Grenada for example damaged or destroyed 90% of the housing stock. Damage to agriculture was also extensive with loss of crops due to strong winds and flooding. Unlike the USA many individuals and businesses lack insurance cover.

Many of the losses are indirect and it might never be possible to accurately quantify the costs associated with the disruptions in the flow of goods and services, the loss in output and earnings from damaged and destroyed assets, and the loss in productivity.

The 2004 hurricane season caused an 'unprecedented' US$3 billion direct loss for the seven borrowing member countries of the Caribbean Development Bank (CDB) that were affected. This figure was not final, given the considerable cost of the indirect losses. It was certainly exceptional for the region to sustain the billions of dollars in damage by hurricanes Charley, Frances and Ivan, and Tropical Storm Jeanne in one hurricane season. The annual impact of natural hazards on the Caribbean is a major source of concern to the CDB, given their ability to erode economic gains and disrupt the efforts of many countries to reduce poverty.

Figure 4: How CNN reported the impact of Hurricane Jeanne in Haiti

> The bodies of 1,013 people have been found in the city of Gonaives alone. Bloated bodies, many unclaimed, have been piled up outside the city's three morgues. Another 1,250 people have been reported missing and are feared dead. The Red Cross said it would photograph the bodies so they can bury them before they are identified.
>
> Haiti's third-largest city, Gonaives is home to about 250,000 people. Every house in the city was damaged when Jeanne slammed into the impoverished country, bringing deluges of rain and mudslides. Those not rendered completely homeless set up temporary shelters on top of their houses using sheets. Others walked through the flooded streets carrying their belongings on their heads. Dieufort Deslorges, spokesperson for Haiti's civil protection agency, said the death toll would rise as reports come in from outlying villages and rescuers dig through mudslides and rubble. Across the country, about 250,000 people are homeless, Deslorges said. Many roads across the area are impassable.
>
> In some parts of the city, water lines reached up to three metres high. The flood waters, which are slowly receding, still contain the floating, decomposing bodies of goats and pigs.

Source: CNN

One further impact must not be ignored, the psychological effects on people and communities brought on by bereavement and feelings of despair, helplessness, and insecurity in an environment prone to such natural hazards.

The USA

The main areas to be affected were Florida and the Gulf Coast (Figure 3). The death toll exceeded one hundred. The hurricanes left a swathe of damage to buildings, power lines, harbours, boats, road vehicles, businesses and the list continues. The damage though did not always have quite the same causes. Hurricane Charley will be remembered for wind damage. Frances will be remembered most for flooding, including freshwater (overland and river) and tidal (storm surge). Initial storm surge values include an estimated range of between two and two and a half metres. A number of locations experienced moderate to severe beach erosion as a result of the storm. The significant rainfall produced by Frances over the peninsula contributed to the flooding of virtually all rivers in west central and southwest Florida by September 9. Ivan's storm surge was what changed the landscape. Large chunks of beach were washed away, and roads and waterfront homes with them. A large section of bridge, cutting off Interstate 10 and forcing a long detour on the main artery connecting America's southern states, was also destroyed.

In total, more than two million people in three states were told to evacuate as Hurricane Ivan approached. With better forecasting and advanced warning systems and procedures large scale evacuation occurred more than once in 2004.

US President George W Bush asked Congress for money for disaster relief in Florida and other southern states hit by the summer's hurricanes; the package of relief exceeded $12 billion. It has been estimated that damage associated with the storms that hit continental USA in 2004 will exceed $25 billion. Victims are still filing for aid from FEMA (Federal Emergency Management Agency). Houses that were damaged by the hurricanes may have been habitable at first, but a combination of roof damage, heat, humidity and rain has now rendered them uninhabitable. Mould problems are occurring in virtually every county in the state.

There are many long-term implications. Florida's tourism industry is already looking ahead to next year with caution. 'Visit Florida', the state's tourism marketing organisation, will ask lawmakers for an additional $14.5 million in marketing money to counter the negative images of this year's hurricanes. A study conducted by Visit Florida towards the end of 2004 showed that 21% of potential visitors say they are reluctant to come to Florida for holidays next summer and autumn, while 11% said they would avoid Florida.

Conclusions

A major question to ask is how unusual was this season? We can elicit the opinions of experts to guide us although the factors involved are complex and there is not always agreement. We need to remember that, as with volcanoes and earthquakes, we are not dealing with perfectly predictable phenomena. What follows reflects that meteorological forecasts are based on long-term trends, rather than a hasty reaction to individual or just recent events.

Meteorologist William Gray of Colorado State University, a pioneer in long-range hurricane forecasting, predicts there might not be another hurricane season like this for 100 years. Gray and other researchers note that hurricane seasons run in 25-year cycles of alternating active and less-active seasons. Meteorologists think a new cycle of active seasons started in 1995.

The nation's top hurricane forecaster said 2004's deadly storm season was a case of the nation's luck running out, adding that future years will likely bring more frequent and more powerful storms. National Hurricane Centre Director Max Mayfield said a block of high pressure in the Atlantic was responsible for steering storms to Florida. While it's too early to know whether those conditions will repeat next year, he said the last 10 years have been more active than any previous period, conditions that could last for another 30 years.

Figure 5 reflects the views of the Intergovernmental Panel on Climate Change, one of the foremost authorities on climate change and would include their research and data on global warming and its impact on tropical storms.

There is no certain way of knowing whether a hurricane season will be similar to the previous year's. During the summer of 2005, forecasters and emergency managers will be urging residents in the southern USA to brace their homes and buy window coverings and assemble supplies and form a plan for the next storms. But how can the Caribbean cope more effectively?

Useful sources of information

Warburton P. (2001) *Atmospheric Processes and Human Influence*, Harper Collins; second edition now available.

http://www.cnn.com/SPECIALS/2004/hurricanes/

Excellent site for details on individual hurricanes and satellite images:
http://www.ncdc.noaa.gov/oa/climate/research/2004/hurricanes04.html

For news reports enter into search engine like Google – 'Hurricane season 2004 +BBC' (or CNN).

Figure 5: The Intergovernmental Panel on Climate Change (IPCC) from Working Group I Report, Technical Summary, 2001

- **About the past**: 'Based on limited data, the observed variations in the intensity and frequency of tropical and extra-tropical cyclones and severe local storms show no clear trends in the last half of the 20th century, although multi-decadal fluctuations are sometimes apparent.'
- **About the future, as greenhouse gas concentrations rapidly increase over the next century:** 'There is little consistent evidence that shows changes in the projected frequency of tropical cyclones and areas of formation. However, some measures of intensities show projected increases, and some theoretical and modelling studies suggest that the upper limit of these intensities could increase. Mean and peak precipitation intensities from tropical cyclones are likely to increase appreciably.'

Decision-making Exercise

1. The physical environment
Explain why coastlines affected by hurricanes are one example of high energy coasts.

2. The human/economic environment
a) Suggest why the death toll from hurricanes was lower in the USA than in the Caribbean during the summer of 2004.
b) Classify the various impacts of hurricanes into environmental, economic and social groups. How do these impacts vary in MEDCs and in LEDCs?
c) Using the following headings, discuss what you think might be some of the long-term implications for areas like Florida if hurricanes continue to become more frequent. Consider future population growth in the state from people wanting to migrate or retire to Florida. Think about the expansion of settled areas and tourist developments. What decisions do you think the state authorities should take? Should future growth be controlled? You could do this in small groups and then feedback to your class.
Structural engineering
Tourism (consider insurance in this context)
Population change and distribution
Financial support/aid from the US government.

3. The physical/human interface
What are some of the difficulties in forecasting changes in hurricane intensity and frequency?
Can you think of any businesses or organisations that particularly need this information?