

Chapter 11 – Hurricanes

Intro

- Hurricane Katrina
 - Most expensive
 - 1980 New Orleans
 - most anticipated natural disaster
 - category 5 storm
 - Natural Weather Service
 - 1 million evacuated
 - 1600 people died
 - Why
 - Failure in design, construction, and maintenance of levees and flood walls
 - Over reliance on tech to protect life and property
 - Social and psychological denial of the hazard
 - Poverty and limited education of many residents in the affected area
 - Diversion of military and government resources to the conflict in Iraq
 - Failures in political leadership, communication and public policy
 - System of flood insurance and post disaster aid that encouraged people to live in hazardous coastal areas
 - Rewarded developers, businesses, and individuals for rebuilding in previously flooded zones
- Most powerful storms on earth and among most deadly and costly
- As climate changes and sea levels rise, the threat increases

Cyclones

- General term applied to large cells of moisture-laden air that rotate around an area of low pressure
- Winds blow anticlockwise in the Northern Hemisphere and clockwise in the southern hemisphere
- Tropical or extratropical based on their place of origin and the temp of their centre or core region
- Tropical: form over warm tropical or subtropical oceans typically 5 and 20 degree latitude
 - Not associated with fronts and have warm centres
 - Derive energy from warm ocean water and the latent heat that is released as rising air condenses to form clouds
 - Those that move over land or cooler water lose their source of heat and either dissipate or become extratropical cyclones moving along a front
- Extratropical: develop over land or water in temperate regions, between 30 and 70 degree latitude
 - Associated with fronts and have cool centres
 - Not all extratropical cyclones produce severe weather, whereas hurricanes are severe storms
 - Obtain energy from the contrast between air masses on opposite sides of a front
 - Fed by cold air at the surface and a flow of cool, dry air aloft

- Classification
 - Nor-easter = extratropical cyclone that tracks northward along the east coast of the US and CAN
 - Hurricanes: strong tropical storms, named after a native Caribbean word for an evil god of winds and destruction
 - Typhoons: hurricanes in the western Pacific Ocean and north equator
 - Cyclones: hurricanes in Pacific Ocean south of the equator and in the Indian Ocean
 - Saffir-Simpson Scale – 5 categories based on the highest one-minute average wind speed in the storm
 - 3-5 = major hurricanes
 - category 5 = central atmospheric pressure of less than 920 millibars
 - Hurricane Wilma set the record low pressure for an Atlantic hurricane 882 millibars in 2005
- Naming – where they're from or to track their movement
 - Assigned once the max sustained winds of a tropical depression exceed 63 km/h
 - Initially, Pacific cyclones were given only female names but since 1978 there are boys name too
 - Names are assigned alphabetically each year from a previously agreed-upon list for the region in which the storm forms
 - 6 standard lists of alternating male and female names in rotation

Cyclone Development

- Tropical
 - Low-intensity = tropical depressions and tropical storms
 - High-intensity = hurricanes
 - Sustained winds of minimum 119 km/hr
 - Form only in oceans warmer than 26 degrees C
 - Tropical disturbance: large area of unsettled weather that is typically 200-600 km in diameter, has organized thunderstorms, and persist for more than 24 hours
 - Tough – elongated area of low pressure
 - Form:
 - Along lines of convergence similar to squall lines
 - Upper-level troughs of low pressure
 - Remnant of cold fronts
 - Easterly waves of converging and diverging winds that develop in the tropics
 - Tropical depression: develop from disturbances if winds increase and rotate around the area of disturbed weather
 - Winds increase to 63 km/h becomes a tropical storm and gets a name
 - Few tropical storms develop into hurricanes
 - Hurricane formation
 - Warm ocean waters (at least 26 degrees C) must extend to a depth of several tens of metres
 - Atmosphere must cool fast enough upward from the surface for moist air to continue to be unstable and convect

- Little vertical wind shear (change in wind speed) between the surface and the top of the troposphere
 - Averages about 500 km in diameter and consist of anti-clockwise spiralling clouds that swirl toward the storms centre
- Rain bands: clouds that spiral around a hurricane and contain numerous thunderstorms
- Eyewall: intense winds and rainfall occur in the innermost bands
- Hot towers: very tall clouds up to 12 km high
- Eye: circular area of calm conditions and broken clouds that range from 5 km to 60km in diameter
- Movement of hurricane is controlled by the Coriolis effect and by steering winds that are 8-11 km above the surface
- Bermuda High: persistent high-pressure anticyclone that remains anchored in the north Atlantic during the summer and early fall
- In summary, tropical cyclones develop in several stages from tropical disturbances. Each stage represents an increase in sustained winds and a decrease in atmospheric pressure. A tropical disturbance may become a tropical depression, then a tropical storm, and finally a hurricane.
- Hurricane development is favoured where (1) there is a thick layer of surface warm water, (2) warm moist air is free to rise upward toward the top of the troposphere, and (3) upper-level winds are relatively weak.
- Extratropical Cyclones
 - 2 factors:
 - Strong temp gradient in the air near the surface
 - Strongest along cold, warm or stationary front therefore extratropical cyclones develop along fronts
 - Strong winds in the upper troposphere
 - Occur in a concentrated flow of air called a jet stream
 - Northern Hemisphere has two jet streams:
 - one at an average altitude of 10 = polar jet stream
 - the other at an average altitude of 13 km = subtropical jet stream
 - Pineapple Express: flow of warm moist air
 - Dry slot: conveyor-like flow of dry air then sinks behind the cold front
 - Occluded front: cyclone matures and merges with warm front

Geographic Regions at Risk for Cyclones

- Serious threat to Atlantic of CAN and the Atlantic and Gulf coasts of US in summer and early fall
- Starts June 1 and ends November 30
- Season for tropical storms in the southern hemisphere is January – April
- US Atlantic and Gulf coasts experience 5 hurricanes a year & take 1 of 3 tracks
 - Westward across the eastern Caribbean, possibly passing over Caribbean islands such as Puerto Rico, but then changing direction and moving northeast into the Atlantic Ocean without making landfall on the Atlantic coast of the United States.

- Westward over Cuba and into the Gulf of Mexico, where they threaten the U.S. Gulf Coast
- Westward across the eastern Caribbean and then northeastward along the Atlantic coast, threatening the coast from central Florida to New York. A few hurricanes continue north as far as coastal New England and Atlantic Canada
- Gulf of Mexico, Caribbean Sea, east Pacific Ocean
- Hurricane-strike probabilities are highest along the coasts of North Carolina, South Carolina, southern Florida, Louisiana, and east Texas
- New England and Atlantic CAN
- Pacific and Indian oceans have more hurricanes than the North Atlantic
- Larger risk for extratropical cyclones than tropical cyclones

Effects of Cyclones

- Storm Surge: rapid local rise in water level that happens when hurricane winds push water onto a shoreline
 - Caused by:
 - Stress exerted by wind on the sea surface
 - Low atmospheric pressure in the storm, which raises the water level
 - Affected by shape of coastline
 - Resonance: height of the surge may increase as water sloshes back and forth in the enclosed or partially enclosed body of water
 - Stead increase in water level
 - Overwash
- High Winds
 - Over 300 km/hr
- Heavy Rain
 - Inland flooding
 - Affected by:
 - Storm's speed
 - Terrain over which the storm moves
 - Interaction with other weather systems
 - Amount of water in the soil, streams, and lakes before storm arrives

Links between Cyclones and Other Natural Hazards

- Flooding, erosion, and landslides
- Downbursts: wind speeds of over 160 km/h and tornadoes
- Global warming

Natural Service Functions of Severe Weather

- Moisture
- Equalizing temps on planet
- Ecosystems

Human Interaction with Weather

- Construction

- Climate

Minimizing the Effects of Cyclones

- Forecast and advisories
 - Watches/warnings
 - Doppler radar
 - Weather buoys
 - computers
- Improve building codes and evacuation procedures

Perception of and Adjustment to Cyclones

- Perception
- Adjustments
 - Warning systems, evacuation plans, shelters, insurance and building designs