

LECTURE #17: Severe Weather: Hurricane Science

Date: 24 March 2025

I. Exam 2:

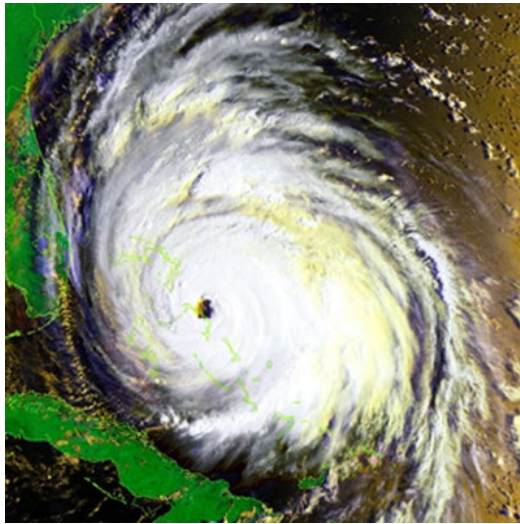
- grades will be posted online by next class
- statistics:
 - high: 100
 - low: 52
 - average: 78
 - did not take: 32
 - went up from exam 1: 66
 - went down from exam 1: 25
 - stayed the same: 5
 - *3 have not taken either exam!*
- come talk to me
 - if you are worried about your grades/progress thus far
 - if you would like to look over your exam

II. Hurricane Overview

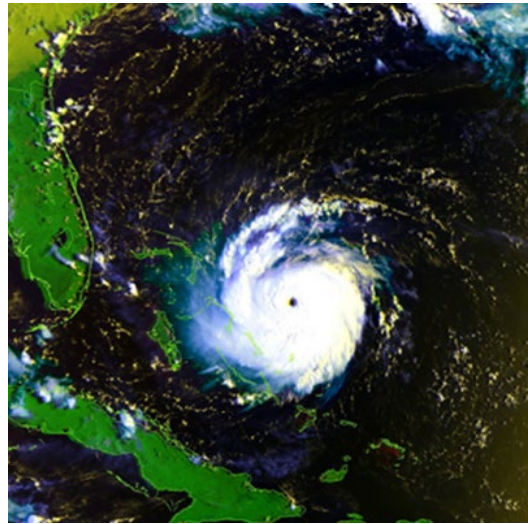
- 2005 Hurricane Season
 - worst on record (until 2020 which had 30 named storms)
 - there were 27 named storms, surpassing the record of 21 set in 1933
 - including Epsilon and Zeta (at the end of the season)
 - 13 of the storms were hurricanes, edging by 1 the previous record set in 1969
 - 7 of the hurricanes were considered major
 - normal seasonal average
 - 10 named storms, 6 hurricanes and 2 major hurricanes
- category 5 hurricanes
 - 1924 to 2024
 - 42 hurricanes have been recorded at Category 5 strength
 - since 1960, only 6 seasons have more than one Category 5
 - 1961, 2005, 2007, 2017, 2019, 2024
 - 2005 is the only season to have more than two
 - **four** Category 5 storms (*Emily, Katrina, Rita and Wilma*)
 - *since 2016, there have been 10!*

III. Background Information

- most wide-spread and destructive weather hazard
- example: Hurricane Floyd (1999)
 - “only” a category 3 (moderate level) hurricane
 - caused \$5.6 billion in losses in NC and 19 fatalities
 - weaker storms do impact larger areas:



Hurricane Floyd (category 3)



Hurricane Andrew (category 5)

- example: largest death toll on record (for any hazard) in the US
 - 1900 hurricane in Galveston, TX
 - killed over > 6,000 on Galveston Island (> 10,000 total)
- another example: cyclone Bhola in Bangladesh in 1970
 - killed ~ 500,000 total
- fatalities in the past 100 years have dropped
 - but insured property loss has sky rocketed

IV. Same Storm/Different Names

- Atlantic and Pacific Oceans (eastern)
 - **called hurricanes**
 - average of 10 named storms per season
 - ~6 becoming hurricanes
- Pacific Ocean (western)
 - **called typhoons**
 - average of 16 named storms per season
 - ~9 becoming typhoons
 - waters off Central America are warmer
 - more open ocean in which to grow
- Indian Ocean
 - **called cyclones**

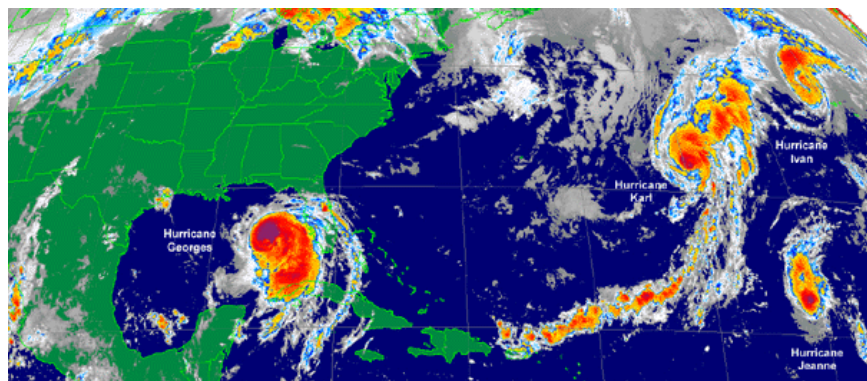
V. Storms Stages

- tropical wave
 - initial low pressure disturbance
 - unorganized
 - moving west
 - winds < 20 mph

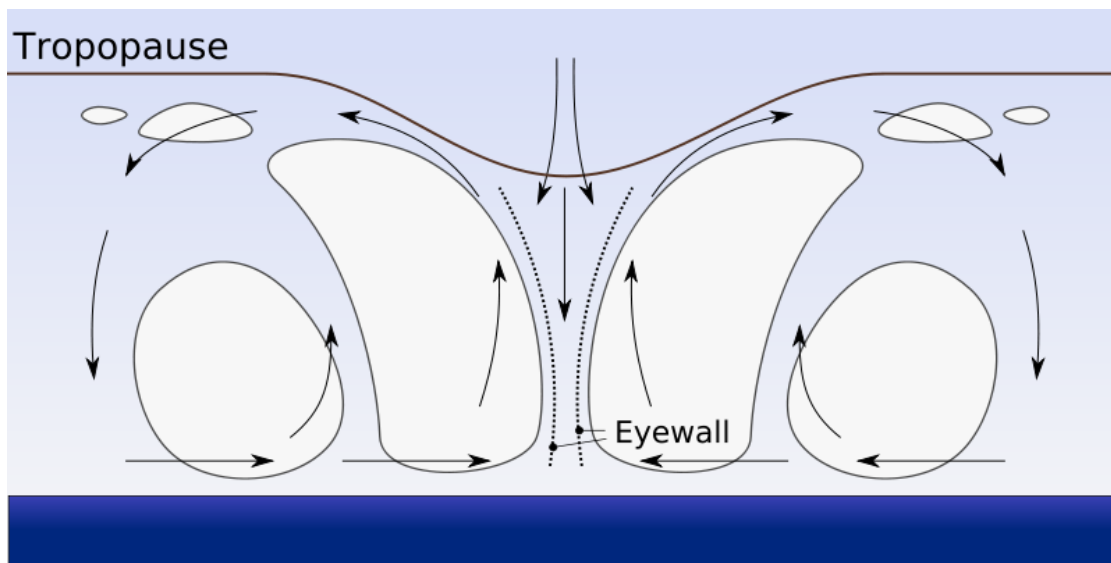
- tropical depression or disturbance
 - moving mass of thunder storms
 - starting to organize
 - assigned a number
 - winds < 39 mph
- tropical storm
 - gets named
 - alternating male/female names starting with "A"
 - distinct rotary/cyclonic motion
 - winds 39 – 74 mph
- hurricane
 - well-defined circular structure with large rain bands
 - central "eye" of low pressure first forms
 - winds > 74 mph (*increasing to > 150 mph*)

VI. Atlantic Storm Growth

- many start off the coast of Africa
 - between ~5-10 degrees N/S latitude
 - do not form near the equator
 - season is from early June to late Nov
 - largest storms from Aug to early Oct
- certain conditions critical for formation of a tropical wave
 - calm wind patterns
 - for several days and 100's of miles
 - large upper-level winds will prevent the storm from organizing
 - warm water at surface (> 80 degrees)
 - as well as ~200 feet below
 - provides large amounts of evaporation (fuel) for the storm
 - vertical disturbance in the atmosphere ("*spark*")
 - caused by the interaction of the westerly mid-latitude winds with the easterly trade winds
 - allows a pathway to form for moisture transport from sea to upper atmosphere



- immense power generation
 - release of heat energy from the condensation of the water
 - just like thunderstorms only much larger
 - example: for a moderate (cat 2) hurricane
 - energy release = 100's of hydrogen bombs
 - equal to the US energy demands for 6 months
 - increasing global warming of $\sim 1^{\circ}\text{C}$ higher sea surface temperature
 - predicted to result in 3-5 more Atlantic hurricanes/years
 - could be 15-30% more powerful
 - hurricane growth process will continue until energy is dissipated over land
- progression of storms
 - positive feedback loop: *stronger winds \rightarrow more cyclonic motion \rightarrow draws up more moisture & heat from the sea \rightarrow stronger winds* - - -



cross-section of a hurricane

- structure/winds
 - rain bands of thunderstorms spiraling around a central (low pressure) eye
 - greatest winds are in the eye wall
 - moist, warm air is drawn up in the eye wall and within the spiraling arms
 - cool, dry air is drawn down through the eye
 - forms a large convection cell with both vertical and CCW rotation

VII. Saffir-Simpson Scale

- measured in categories (1 through 5)
- function of
 - wind speed
 - storm surge
 - potential damage
- potential damage is not linear with category

<u>Category</u>	<u>Winds(mph)</u>	<u>Effects</u>
1	74-95	No real damage to building structures.
2	96-110	Minor damage to buildings. Considerable damage to vegetation.
3	111-130	Some structural damage to small residences. Mobile homes are destroyed. Flooding near the coast.
4	131-155	Complete roof structure failure on small residences. Major erosion of beach. Major damage to lower floors of structures.
5	>155	Complete roof failure and major damage to all structures located less than 15 feet ASL.

VIII. Hurricane Damage

- storm surge
 - large volume of rain/runoff prior to landfall of the hurricane
 - prevented from flowing seaward by the advancing winds
 - can cause large amounts of erosion
 - 90% of all fatalities in a hurricane caused by storm surge
 - comes from 3 main factors:
 - force of the waves (including debris in the water)
 - hydraulic lift (upward force) under structures
 - reflected wave energy from man-made structures
 - several factors combine to determine the severity of the surge
 - wind speed
 - higher winds "push" more water onto the land
 - tide stage at the time of hurricane landfall
 - low pressure
 - lower pressure causes more water to "dome" up under the hurricane center
 - two types of surge
 - flood surge: water brought onto the land by the storm
 - ebb surge: water floods off the land to the sea
- wind damage
 - responsible for the loss of power and utilities
 - wind damage affects larger areas than surge
 - turbulent air in the eye wall
 - most intense wind
 - can generate short-lived tornadoes (*called "mini-swirls"*)
 - interaction with structures
 - winds increase with height due to less frictional drag from the ground (*problem for tall buildings*)
 - can channelize between buildings increasing the velocity (*wind tunnel effect*)