LECTURE #16: Severe Weather: Introduction to Hurricanes

Date: 17 March 2021

I. Exam 2: Next Monday *(Monday, March 22nd)*

- same style as last exam: 50 multiple choice *(maybe 1-2 extra credit questions)*
  - closed book/notes!
  - if you did well on exam 1, you can skip this one *(or take it for practice)!*
  - everyone must take the final exam on **April 28th @ 2:00pm**

- coverage
  - weeks 5 – 9 *(up to today's lecture)*
  - focus on the online notes
    - especially material that I covered in lectures!
    - any notes you took in class
    - TOPICS: *tsunamis (pt. 2), volcanoes (including the video), landslides, extreme heat, thunderstorms & lightning, tornadoes, hurricanes (pt. 1)*

II. Hurricane Overview

- hurricanes
  - what they are?
  - how they form?

- storm growth and movement
  - storm stages:
    - tropical wave → tropical → depression → tropical storm → hurricane

- example: 2005 Hurricane Season
  - worst on record until 2020 (30 named storms)
    - including Epsilon and Zeta *(at the "end of the season")*, there were 27 named storms, surpassing the record of 21 set in 1933
      - thirteen of the storms were hurricanes, edging by one the previous record set in 1969
      - seven of the hurricanes were considered major
    - normal seasonal average is 10 named storms, 6 hurricanes and 2 major hurricanes

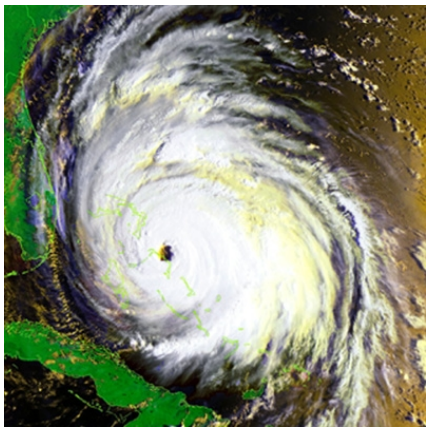
- example: category 5 hurricanes
  - 1924 to 2019
    - 36 hurricanes have been recorded at Category 5 strength

- only 5 seasons have more than one Category 5
  - 1961, 2005, 2007, 2017, 2019
  - 2005 is the only season to have more than two
    - ***four*** Category 5 storms (*Emily, Katrina, Rita and Wilma)*

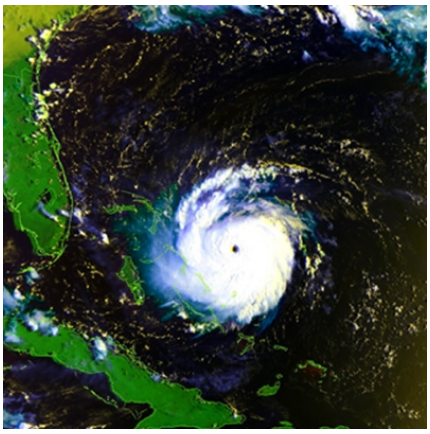
  - *since 2016, there have been 7!*

III. Background Information

- most wide-spread and destructive weather hazard
- <u>example:</u> 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)

- <u>example:</u> 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)

- <u>another example:</u> 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. Atlantic Storms Stages

- tropical wave
  - initial low pressure disturbance (unorganized)
  - moving west
  - winds < 20 m.p.h.

- tropical depression/disturbance
  - moving mass of thunder storms
  - starting to organize
  - winds < 39 m.p.h.

- tropical storm
  - named (alternating male/female names starting with "A")
  - distinct rotary/cyclonic motion
  - winds 39 – 74 m.p.h.

- hurricane
  - well defined circular structure with large rain bands
  - central "eye" of low pressure first forms
  - winds > 74 m.p.h. *(increasing to > 150 m.p.h.)*

VI. Atlantic Storm Growth

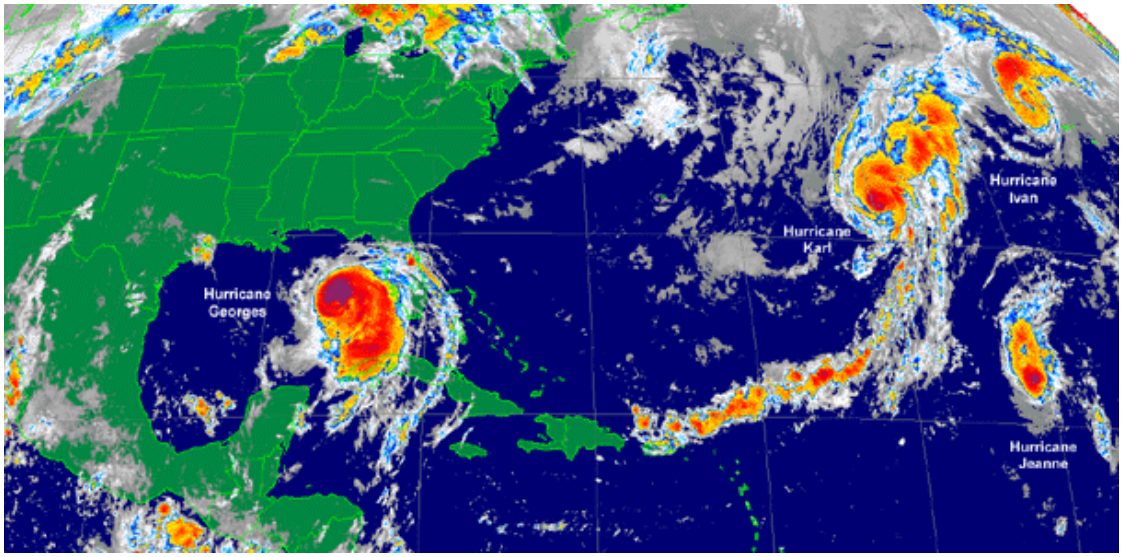
- many start off the coast of Africa
  - between ~5-10 degrees N/S latitude
    - do not form near the equator

  - season is from June-Nov
    - largest storms from Aug to early Oct

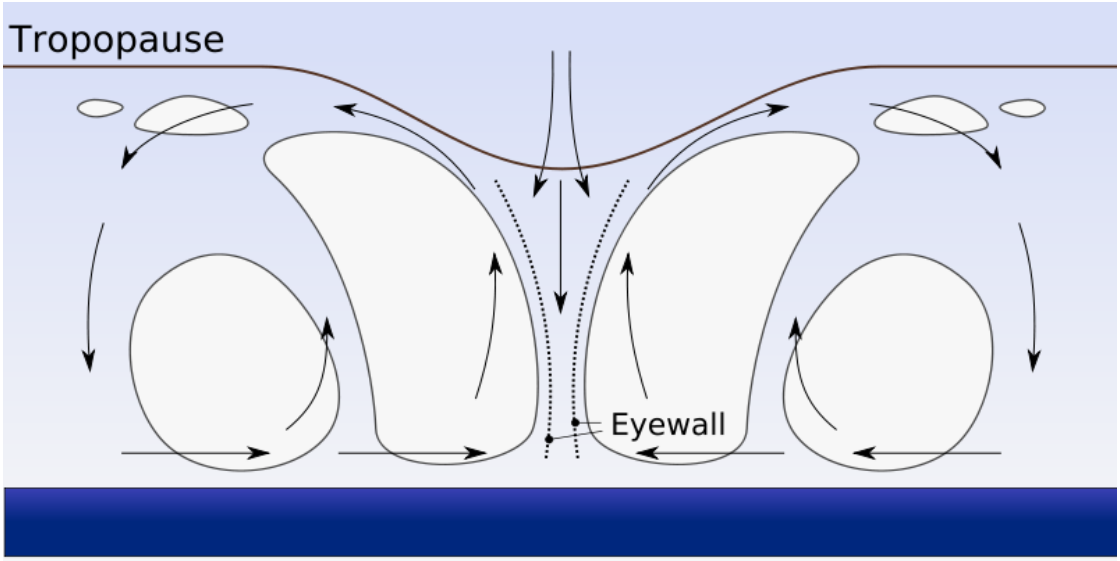
- certain conditions critical for formation of a tropical wave
  - calm wind patterns
    - for several days and 100's of miles
    - large upper level winds will prevent the storm from organizing

  - warm water at surface (> 80 degrees)
    - elevated temperature down to ~200 feet
    - provides large amounts of evaporation and fuel for the storm

  - vertical disturbance in the atmosphere (*"spark")*
    - likely 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
  - <u>example:</u> moderate hurricane
    - energy release = 100's of hydrogen bombs
    - equal to the US energy demands for 6 months
  - global warming estimates: for a 1°C increase in sea surface temperature
    - predicted to result in 3-5 more Atlantic hurricanes/years
    - could be 15-30% more powerful
  - process will continue until energy is dissipated over land
- progression of storms
  - <u>positive feedback loop</u>: *stronger winds → more cyclonic motion → draws up more moisture & heat from the sea → stronger winds*



cross-section of a hurricane

- structure/winds
  - rain bands of thunder storms 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

Category	Winds(mph)	Effects
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. Damage

- storm surge damage
  - large volume of rain/runoff prior to landfall of the hurricane
  - prevented from flowing seaward by the advancing winds
    - 90% of all fatalities in a hurricane

  - comes from 3 main factors:
    - force of the waves (including debris)
    - 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 of the land

- wind damage
  - responsible for the loss of power and utilities
  - wind damage affects large areas (much more so 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)*

---------- *end of material for exam 2* ----------