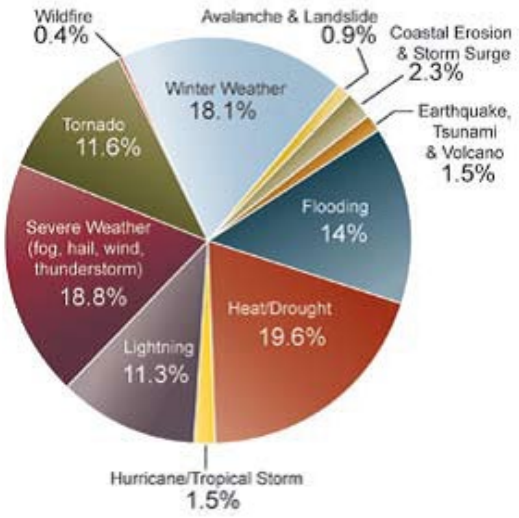
LECTURE #15: Thunderstorms & Lightning Hazards

Date: 12 March 2025

I. Severe Weather Hazards

- focus for next few weeks
  - emphasis on the atmosphere
    - desertification/climate *(last class)*
    - thunderstorms & lightning *(today)*
    - tornadoes *(next class)*
    - hurricanes, flooding and wildfires *(after that)*

- importance *(in general)*
  - weather hazards are the primary or secondary cause of the most damaging and costly disasters on Earth
    - largest loss of life: Cyclone Bhola and storm surge that hit Bangladesh in 1970
    - killed ~500,000 people



  - primary/direct threat
    - tornadoes, hurricanes, ice storms, nor'easters, lightning

  - secondary/indirect cause
    - drought, floods, forest fires, desertification, air pollution

  - Federal Agency most responsible for monitoring weather events: *National Oceanic and Atmospheric Administration (NOAA)*
    - websites:
      - NOAA: http://www.noaa.gov/
      - satellite data: https://www.nesdis.noaa.gov/
      - FEMA: http://www.fema.gov/

      - ***All have taken deep cuts in the last month!***

- importance *(United States)*
  - U.S. is especially prone to weather-related hazards
    - highest number of tornadoes
    - second highest number of lightning strikes (behind Brazil)
    - only country to have large nor'easters
    - one of the highest number of landfall hurricanes

- insured damage in the US
  - 8 of the top 10 costliest disasters in the US between 1994 – 2022 were due to severe weather
    - #1: Hurricane Katrina (2005)
    - #2: Hurricane Maria (2017)

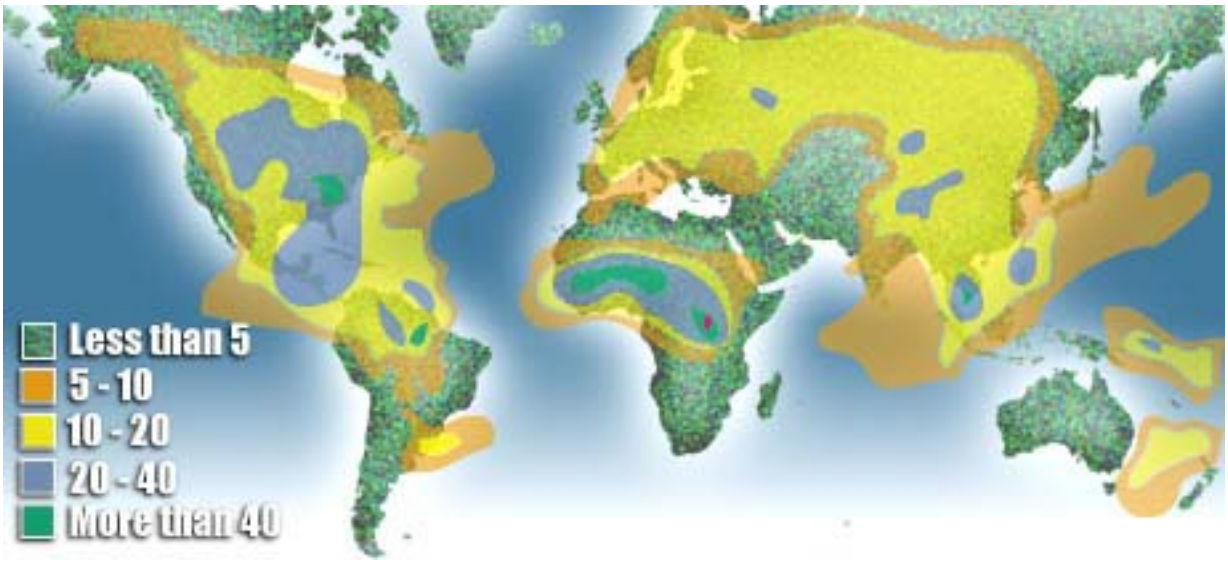
- loss of life
  - deadliest natural disaster
    - hurricane that hit Galveston, TX in 1900
    - killed ~ 6,000 – 12,000 people on Galveston Island

II. Thunderstorms

- can bring heavy rains that spawn flash flooding, strong winds, hail, lightning and tornadoes

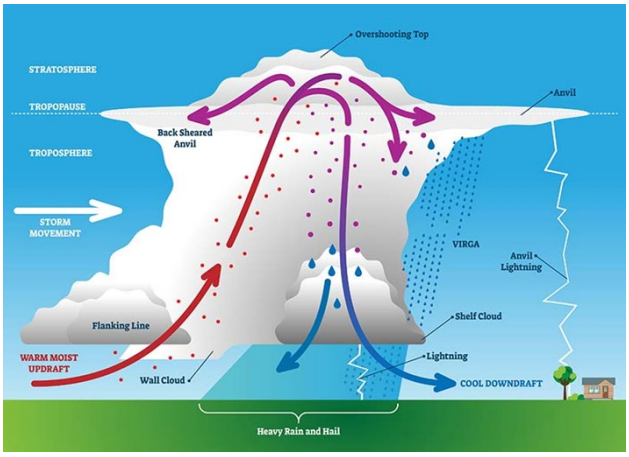
- can be found throughout the United States
  - most likely to occur in the central and southern states
  - highest number of thunderstorm days: Florida

- ~ 1,800 thunderstorms are in ongoing at any one time on Earth
  - the US gets ~ 100,000 thunderstorms each year
    - ~ 1,000 tornadoes develop from these
    - large hail results in nearly $1 billion in damage



average number of severe thunderstorms/year

- what is a thunderstorm?
  - formed from a combination of
    - moisture
    - rapidly rising warm air *(which then cools)*
    - a force capable of lifting air
      - ➢ a warm/cold front, a sea breeze or elevation change



  - all thunderstorms contain lightning
    - lightning is responsible for the thunder

  - can occur singly, in clusters, or in lines
    - possible for several thunderstorms to affect one location over a few hours
    - most severe weather occurs when a single thunderstorm affects one location for an extended time

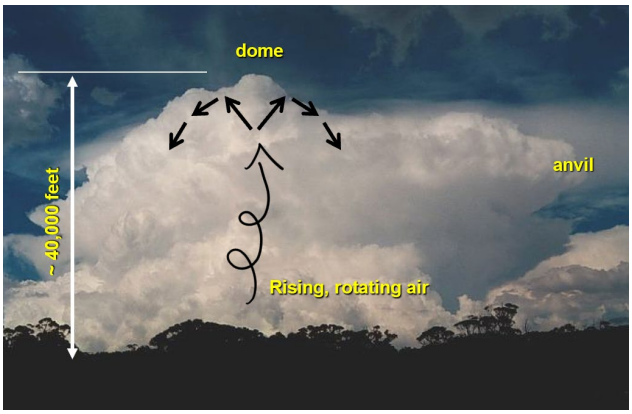
- multi-cell storms
  - each rain cell is a region of intense updraft
  - followed by high rainfall and downdrafts
    - the rainfall eventually chokes off the supply of warm, moist air and the cell dies off

  - down drafts can force updrafts of warm, moist air elsewhere
    - spawn new cell formation
    - create a “line” of thunderstorms

- super cell thunderstorms
  - largest, strongest and longest-lasting storms

  - capable of producing tornadoes, large hail, dangerous bursts of wind or flash floods as well as lightning

  - characterized by rotating winds rising into the storm called a “mesocyclone”

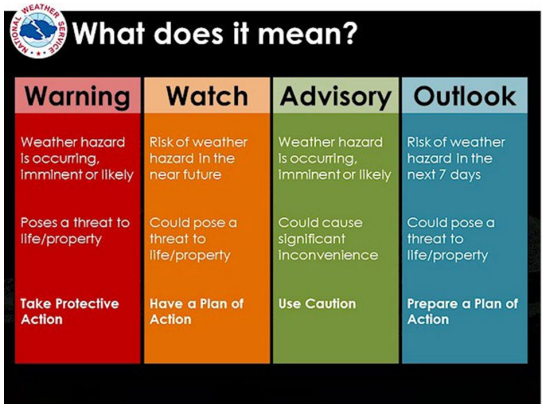


super cell thunderstorm

  - characteristics
    - air rises and turns at speeds up to 170 mph
    - it cools, causing the condensation of water droplets → *energy released*
    - quickly these droplets turn into ice crystals → *more energy released*
    - “overshooting” top (dome) forms at top of the column of rising air
    - tornadoes usually drop from the super cell near the edge (wall cloud)

- monitoring & warnings
  - locally
    - news weather centers
    - National Weather Service field stations

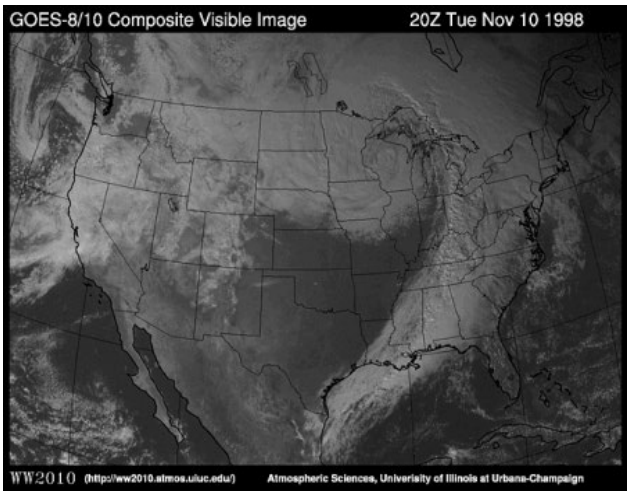
  - nationally
    - the National Weather Service issue storm watches and warnings



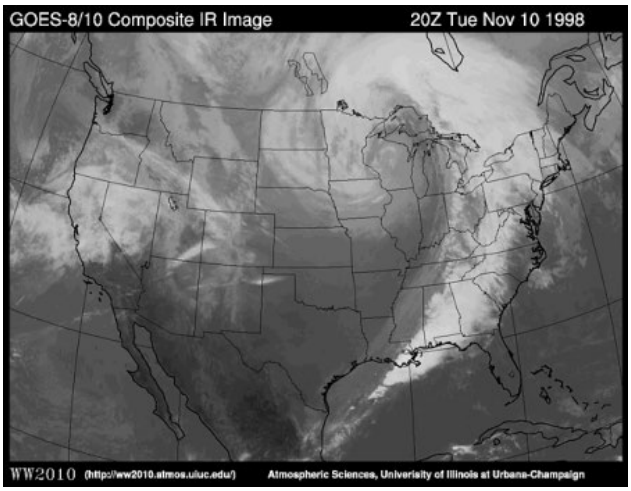
    - severe thunderstorm **watch**:
      - ➢ severe thunderstorms are possible
      - ➢ watch the sky and be prepared

    - severe thunderstorm **warning**:
      - ➢ severe thunderstorms are occurring
      - ➢ take shelter and wait

    - use of technology:
      - ➢ <u>satellites</u> *(space-based)*
      - ➢ different wavelength regions used to detect clouds, the amount of water vapor, the intensity of the storms



visible wavelength satellite image



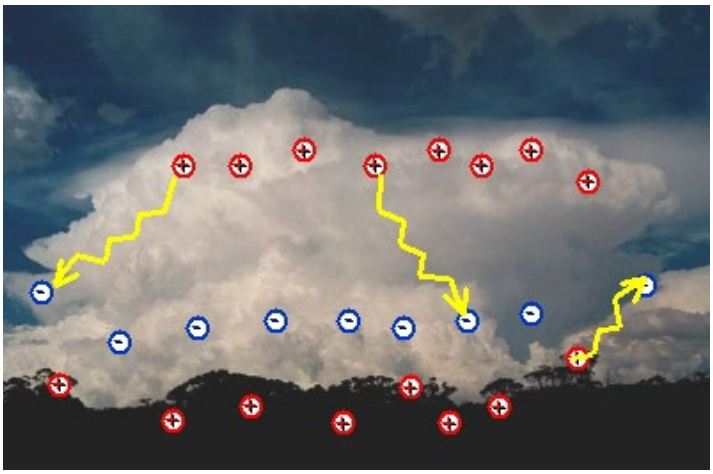
infrared wavelength satellite image

- ➢ <u>Doppler radar</u> *(ground-based)*
- ➢ sends out radar waves from an antenna
- ➢ objects such as rain drops, snow, hail scatter or reflect some of the energy back
- ➢ also measure the frequency change
- ➢ objects moving away from the antenna change to a lower frequency
  - – used to identify tornado formation

III. Lightning

- information
  - lightning can electrocute on contact, split trees, ignite fires and cause electrical failures
  - more deaths from lightning occur on the East Coast
  - more forest fires are started in the West as the lightning season coincides with the dry season
    - ~10,000 forest fires are started each year by lightning
    - ~$100 million in annual losses result from fires
  - 6000 bolts hit the earth every minute
  - kills ~ 2,000 people each year worldwide
  - each bolt
    - 3-4 miles long
    - only ~1-inch wide
    - *hotter than the surface of the sun (55,000°F)!*

- so, what is lightning?
  - electrical discharge that results from the buildup of positive and negative charges within a thunderstorm
  - how do these charges build and get distributed in a cloud?
    - likely: separation of ice crystals due to wind currents
      - collisions between the particles causes charges to develop
      - positively charged ice crystals rise to the top of the thunderstorm
      - negatively charged ice particles and hailstones drop to the bottom
  - if buildup of charges becomes strong enough
    - cloud releases negatively charged electrons toward the ground
      - called “stepped leaders”
    - ground returns with a buildup of positively charged electrons
      - lightning appears as a “bolt” from cloud to ground or within the cloud (cloud to cloud)
    - rapid heating and cooling of air near the lightning causes thunder



- lightning strikes
  - cloud to ground lightning is the most dangerous
    - but, only about 20% of all lightning

  - victims
    - more men than women
    - ~25% of lightning victims are struck dead immediately
    - others suffer varying degrees of heart, brain, skin, auditory and ocular damage
    - many are struck due to being in close proximity to tall objects *(trees, poles or towers)*
    - most killed in open fields - *why??*

  - equipment costs
    - ~5% (~$1 billion) of annual insurance claims
    - ~30% (~$1 billion) of annual power outages
    - > 100,000 PCs (~$100 million) are destroyed annually