Lecture Outlines
PowerPoint

Chapter 19

Earth Science 11e

Tarbuck/Lutgens

Earth Science, 11e

Weather Patterns and Severe Storms
Chapter 19

Air masses

- Characteristics
  - Large body of air
    - 1600 km (1000 mi.) or more across
    - Perhaps several kilometers thick
  - Similar temperature at any given altitude
  - Similar moisture at any given altitude
  - Move and affect a large portion of a continent

A cold Canadian air mass

Figure 19.2

Air masses

- Source region – the area where an air mass acquires its properties
- Classification of an air mass
  - Two criteria are used to classify air masses
    - By the latitude of the source region
      - Polar (P)
        - High latitudes
        - Cold

Air masses

- Classification of an air mass
  - Two criteria are used to classify air masses
    - By the latitude of the source region
      - Tropical (T)
        - Low latitudes
        - Warm
    - By the nature of the surface in the source region
      - Continental (c)
        - Form over land
        - Likely to be dry

Air masses

- Classification of an air mass
  - By the nature of the surface in the source region
    - Maritime (m)
      - Form over water
      - Humid air
  - Four basic types of air masses
    - Continental polar (cP)
    - Continental tropical (cT)
    - Maritime polar (mP)
    - Maritime tropical (mT)

Air masses are classified on the basis of their source region

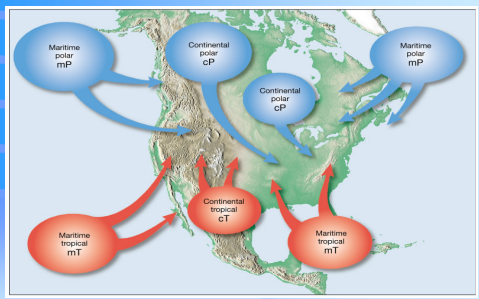


Figure 19.3

Air masses

- Air masses and weather
  - cP and mT air masses are the most important air masses in North America, especially east of the Rockies
  - North America (east of the Rocky Mountains)
    - Continental polar (cP)
      - From northern Canada and interior of Alaska
        - Winter – brings cold, dry air
        - Summer – brings cool relief

Air masses

- Air masses and weather
  - North America (east of the Rocky Mountains)
    - Continental polar (cP)
      - Responsible for lake-effect snows
        - cP air mass crosses the Great Lakes
        - Air picks up moisture from the lakes
        - Snow occurs on the leeward shores of the lakes

Air masses

- Air masses and weather
  - North America (east of the Rocky Mountains)
    - Maritime tropical (mT)
      - From the Gulf of Mexico and the Atlantic Ocean
      - Warm, moist, unstable air
      - Brings precipitation to the eastern United States
  - Continental tropical (cT)
    - Southwest and Mexico
    - Hot, dry
    - Seldom important outside the source region

Air masses

- Air masses and weather
  - Maritime polar (mP)
    - Brings precipitation to the western mountains
    - Occasional influence in the northeastern United States causes the "Northeaster" in New England with its cold temperatures and snow

Fronts

- Boundary that separates air masses of different densities
  - Air masses retain their identities
  - Warmer, less dense air forced aloft
  - Cooler, denser air acts as wedge

Fronts

- Types of fronts
  - Warm front
    - Warm air replaces cooler air
    - Shown on a map by a line with semicircles
    - Small slope (1:200)
    - Clouds become lower as the front nears
    - Slow rate of advance
    - Light-to-moderate precipitation

Warm front

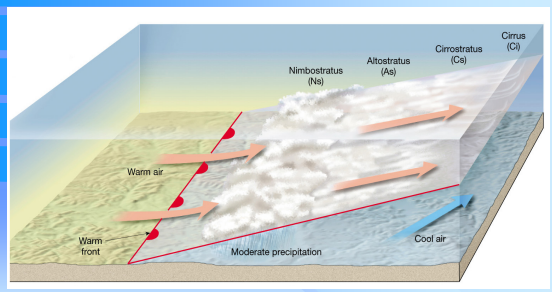


Figure 19.6

Fronts

- Types of fronts
  - Cold front
    - Cold air replaces warm air
    - Shown on a map by a line with triangles
    - Twice as steep (1:100) as warm fronts
    - Advances faster than a warm front
    - Associated weather is more violent than a warm front
      - Intensity of precipitation is greater
      - Duration of precipitation is shorter

Fronts

- Types of fronts
  - Cold front
    - Weather behind the front is dominated by
      - Cold air mass
      - Subsiding air
      - Clearing conditions

Cold front

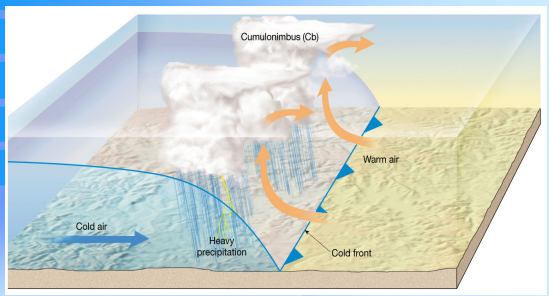
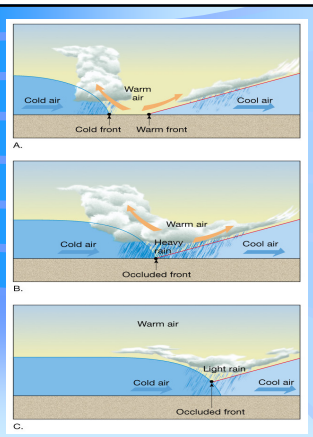


Figure 19.7

Fronts

- Types of fronts
  - Stationary front
    - Flow of air on both sides of the front is almost parallel to the line of the front
    - Surface position of the front does not move
  - Occluded front
    - Active cold front overtakes a warm front
    - Cold air wedges the warm air upward
    - Weather is often complex
    - Precipitation is associated with warm air being forced aloft



Formation of an occluded front

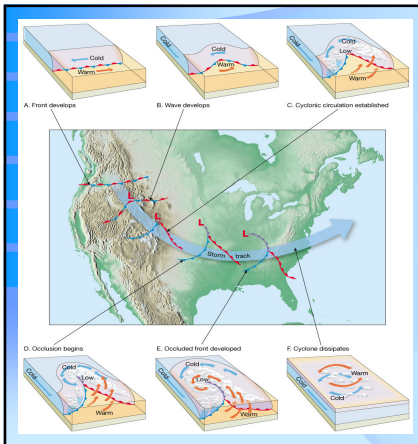
Figure 19.8

Middle-latitude cyclone

- Primary weather producer in the middle-latitudes
- Life cycle
  - Form along a front where air masses are moving parallel to the front in opposite directions
    - Continental polar (cP) air is often north of the front
    - Maritime tropical (mT) air is often south of the front

Middle-latitude cyclone

- Life cycle
  - Frontal surface takes on a wave shape with low pressure centered at the apex of the wave
  - Flow of air is counterclockwise cyclonic circulation
  - Warm front and cold front form
  - Cold front catches up to warm front and produces an occlusion
  - Warm sector is displaced aloft
  - Pressure gradient weakens and fronts discontinue



Stages in the life cycle of a middle-latitude cyclone

Figure 19.9

Middle-latitude cyclone

- Idealized weather
  - Middle-latitude cyclones move eastward across the United States
    - First signs of their approach are in the western sky
    - Require two to four days to pass over a region
  - Largest weather contrasts occur in the spring
  - Changes in weather associated with the passage of a middle-latitude cyclone
    - Changes depend on the path of the storm

Middle-latitude cyclone

- ❖Idealized weather
  - Changes in weather associated with the passage of a middle-latitude cyclone
    - Weather associated with fronts
      - Warm front
        - Clouds become lower and thicker
        - Light precipitation
        - After the passage of a warm front, winds become more southerly and temperatures warm

Middle-latitude cyclone

- ❖Idealized weather
  - Changes in weather associated with the passage of a middle-latitude cyclone
    - Weather associated with fronts
      - Cold front
        - Wall of dark clouds
        - Heavy precipitation – hail and occasional tornadoes
        - After the passage of a cold front winds become more northerly, skies clear, and temperatures drop

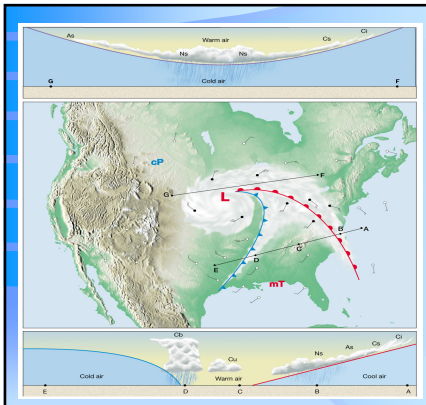


Figure 19.10

Cloud patterns typically associated with a mature middle-latitude cyclone

Satellite view of a cyclone over the eastern United States

Figure 19.11

Middle-latitude cyclone

- ❖Role of air aloft
  - Cyclones and anticyclones
    - Generated by upper-level air flow
    - Maintained by upper-level air flow
    - Typically are found adjacent to one another
  - Cyclone
    - Low pressure system
    - Surface convergence
    - Outflow (divergence) aloft sustains the low pressure

Middle-latitude cyclone

- ❖Role of air aloft
  - Anticyclone
    - High pressure system
    - Associated with cyclones
    - Surface divergence
    - Convergence aloft

Severe weather types

- Thunderstorms
  - Features
    - Cumulonimbus clouds
    - Heavy rainfall
    - Lightning
    - Occasional hail
  - Occurrence
    - 2000 in progress at any one time
    - 100,000 per year in the United States
    - Most frequent in Florida and eastern Gulf Coast region

Average number of days per year with thunderstorms

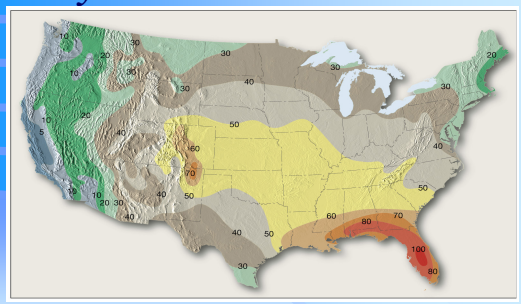


Figure 19.15

Severe weather types

- Thunderstorms
  - Stages of development
    - All thunderstorms require
      - Warm air
      - Moist air
      - Instability (lifting)
        - High surface temperatures
        - Most common in the afternoon and early evening

Severe weather types

- Thunderstorms
  - Stages of development
    - Require continuous supply of warm air and moisture
      - Each surge causes air to rise higher
      - Updrafts and downdrafts form
    - Eventually precipitation forms
      - Most active stage
      - Gusty winds, lightning, hail
      - Heavy precipitation
    - Cooling effect of precipitation marks the end of thunderstorm activity

Stages in the development of a thunderstorm

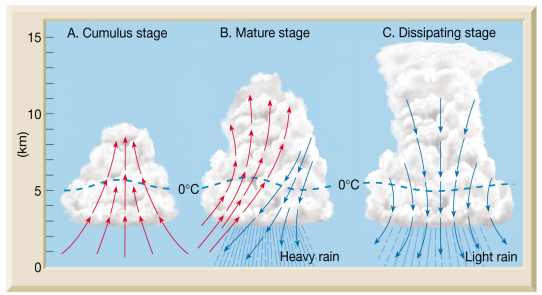


Figure 19.17

Severe weather types

- Tornadoes
  - Local storm of short duration
  - Features
    - Violent windstorm
    - Rotating column of air that extends down from a cumulonimbus cloud
    - Low pressures inside causes the air to rush into the tornado
    - Winds approach 480 km (300 miles) per hour
    - Smaller suction vortices can form inside stronger tornadoes

Severe weather types

- Tornadoes
  - Occurrence and development
    - Average of 770 each year in the United States
    - Most frequent from April through June
    - Associated with severe thunderstorms
    - Exact cause of tornadoes formation is not known
    - Conditions for the formation of tornadoes
      - Occur most often along a cold front
      - During the spring months
      - Associated with huge thunderstorms called supercells

Severe weather types

- Tornadoes
  - Characteristics
    - Diameter between 150 and 600 meters (500 and 2000 feet)
    - Speed across landscape is about 45 kilometers (30 miles) per hour
    - Cut about a 10 km (6 miles) long path
    - Most move toward the northeast
    - Maximum winds range beyond 500 kilometers (310 miles) per hour
    - Intensity measured by the Fujita intensity scale

Average annual tornado incidence per 10,000 square miles for a 27 year period

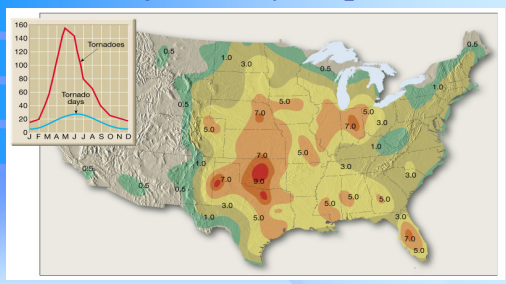


Figure 19.20

Paths of Illinois tornadoes (1916 – 1969)

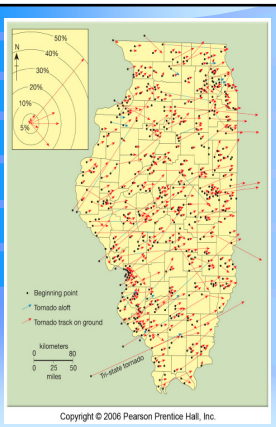


Figure 19.21

Severe weather types

- Tornadoes
  - Tornado forecasting
    - Difficult to forecast because of their small size
    - Tornado watch
      - To alert the public to the possibility of tornadoes
      - Issued when the conditions are favorable
      - Covers 65,000 square km (25,000 square miles)
    - Tornado warning is issued when a tornado is sighted or is indicated by weather radar
    - Use of Doppler radar helps increase the accuracy by detecting the air motion

Severe weather types

- Hurricanes
  - Most violent storms on Earth
  - To be called a hurricane
    - Wind speed in excess of 119 kilometers (74 miles) per hour
    - Rotary cyclonic circulation
  - Profile
    - Form between the latitudes of 5 degrees and 20 degrees

Severe weather types

- Hurricanes
  - Profile
    - Known as
      - Typhoons in the western Pacific
      - Cyclones in the Indian Ocean
    - North Pacific has the greatest number per year
    - Parts of a hurricane
      - Eyewall
        - Near the center
        - Rising air
        - Intense convective activity

Severe weather types

- Hurricanes
  - Profile
    - Parts of a hurricane
      - Eyewall
        - Wall of cumulonimbus clouds
        - Greatest wind speeds
        - Heaviest rainfall

Severe weather types

- Hurricanes
  - Profile
    - Parts of a hurricane
      - Eye
        - At the very center
        - About 20 km (12.5 miles) diameter
        - Precipitation ceases
        - Winds subsides
        - Air gradually descends and heats by compression
        - Warmest part of the storm

Cross section of a hurricane

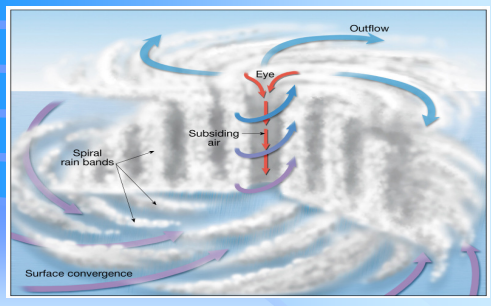


Figure 19.25

Severe weather types

- Hurricanes
  - Profile
    - Wind speeds reach 300 km/hr
    - Generate 50 foot waves at sea
  - Hurricane formation and decay
    - Form in all tropical waters except the
      - South Atlantic and
      - Eastern South Pacific

Severe weather types

- Hurricanes
  - Hurricane formation and decay
    - Energy comes from condensing water vapor
    - Develop most often in late summer when warm water temperatures provide energy and moisture
    - Initial stage is not well understood
      - Tropical depression – winds do not exceed 61 kilometers (38 miles) per hour
      - Tropical storm – winds between 61 to 119 km (38 and 74 miles) per hour

Severe weather types

- ❖Hurricanes
  - Hurricane formation and decay
    - Diminish in intensity whenever
      - They move over cooler ocean water
      - They move onto land
      - The large-scale flow aloft is unfavorable

Severe weather types

- ❖Hurricanes
  - Destruction from a hurricane
    - Factors that affect amount of hurricane damage
      - Strength of storm (the most important factor)
      - Size and population density of the area affected
      - Shape of the ocean bottom near the shore
    - Saffir-Simpson scale ranks the relative intensities of hurricanes

Severe weather types

- ❖Hurricanes
  - Destruction from a hurricane
    - Categories of hurricane damage
      - Storm surge - large dome of water 65 to 80 kilometers (40 to 50 miles) wide sweeps across the coast where eye makes landfall
      - Wind damage
      - Inland flooding from torrential rains

End of Chapter 19