Earth Science, 11e

Air Pressure and Wind
Chapter 18
**Atmospheric pressure**

- Force exerted by the weight of the air above
- Weight of the air at sea level
  - 14.7 pounds per square inch
  - 1 kilogram per square centimeter
- Decreases with increasing altitude
- Units of measurement
  - Millibar (mb) – standard sea level pressure is 1013.2 mb
Atmospheric pressure

- Units of measurement
  - Inches of mercury – standard sea level pressure is 29.92 inches of mercury

- Instruments for measuring
  - Barometer
    - Mercury barometer
      - Invented by Torricelli in 1643
      - Uses a glass tube filled with mercury
A mercury barometer

Figure 18.2
Atmospheric pressure

Instruments for measuring

- Barometer
  - Aneroid barometer
    - "Without liquid"
    - Uses an expanding chamber
- Barograph (continuously records the air pressure)
Aneroid barometer

Figure 18.3
A recording aneroid barometer

Figure 18.4
Wind

- Horizontal movement of air
  - Out of areas of high pressure
  - Into areas of low pressure

- Controls of wind
  - Pressure gradient force
    - Isobars – lines of equal air pressure
    - Pressure gradient – pressure change over distance
A weather map showing isobars and wind speed/direction

Figure 18.5
Wind

Controls of wind

• Coriolis effect
  • Apparent deflection in the wind direction due to Earth's rotation
  • Deflection is to the right in the Northern Hemisphere and to the left in the Southern Hemisphere

• Friction
  • Only important near the surface
  • Acts to slow the air's movement
The Coriolis effect

Figure 18.6

B. Rotating Earth
Wind

- Upper air winds
  - Generally blow parallel to isobars – called geostrophic winds
  - Jet stream
    - "River" of air
    - High altitude
    - High velocity (120-240) kilometers per hour
The geostrophic wind

Figure 18.7
Comparison between upper-level winds and surface winds

Figure 18.9
Cyclones and anticyclones

- **Cyclone**
  - A center of low pressure
  - Pressure decreases toward the center
  - Winds associated with a cyclone
    - In the Northern Hemisphere
      - Inward (convergence)
      - Counterclockwise
    - In the Southern Hemisphere
      - Inward (convergence)
      - Clockwise
Cyclones and anticyclones

- **Cyclone**
  - Associated with rising air
  - Often bring clouds and precipitation

- **Anticyclone**
  - A center of high pressure
  - Pressure increases toward the center
Cyclones and anticyclones

- **Anticyclone**
  - Winds associated with an anticyclone
    - In the Northern Hemisphere
      - Outward (divergence)
      - Clockwise
    - In the Southern Hemisphere
      - Outward (divergence)
      - Counterclockwise
  - Associated with subsiding air
  - Usually bring "fair" weather
Cyclonic and anticyclonic winds in the Northern Hemisphere

Figure 18.10
Airflow associated with surface cyclones and anticyclones
General atmospheric circulation

- Underlying cause is unequal surface heating
- On the rotating Earth there are three pairs of atmospheric cells that redistribute the heat
- Idealized global circulation
  - Equatorial low pressure zone
    - Rising air
    - Abundant precipitation
General atmospheric circulation

- Idealized global circulation
  - Subtropical high pressure zone
    - Subsiding, stable, dry air
    - Near 30 degrees latitude
    - Location of great deserts
    - Air traveling equatorward from the subtropical high produces the trade winds
    - Air traveling poleward from the subtropical high produces the westerly winds
General atmospheric circulation

- Idealized global circulation
  - Subpolar low pressure zone
    - Warm and cool winds interact
    - Polar front – an area of storms
  - Polar high pressure zone
    - Cold, subsiding air
    - Air spreads equatorward and produces polar easterly winds
    - Polar easterlies collide with the westerlies along the polar front
Figure 18.15

Idealized global circulation
General atmospheric circulation

- Influence of continents
  - Seasonal temperature differences disrupt the
    - Global pressure patterns
    - Global wind patterns
  - Influence is most obvious in the Northern Hemisphere
  - Monsoon
    - Seasonal change in wind direction
Average surface pressure and associated winds for January

Figure 18.16 A
Average surface pressure and associated winds for July

Figure 18.16 B
General atmospheric circulation

- Influence of continents
  - Monsoon
    - Occur over continents
    - During warm months
      - Air flows onto land
      - Warm, moist air from the ocean
    - Winter months
      - Air flows off the land
      - Dry, continental air
Circulation in the mid-latitudes

- The zone of the westerlies
- Complex
- Air flow is interrupted by cyclones
  - Cells move west to east in the Northern Hemisphere
  - Create anticyclonic and cyclonic flow
  - Paths of the cyclones and anticyclones are associated with the upper-level airflow
Local winds

- Produced from temperature differences
- Small scale winds

Types
- Land and sea breezes
- Mountain and valley breezes
- Chinook and Santa Ana winds
Illustration of a sea breeze and a land breeze

Figure 18.17
Wind measurement

- Two basic measurements
  - Direction
  - Speed

- Direction
  - Winds are labeled from where they originate (e.g., North wind – blows from the north toward the south)
  - Instrument for measuring wind direction is the wind vane
Wind measurement

- **Direction**
  - Direction indicated by either
    - Compass points (N, NE, etc.)
    - Scale of 0° to 360°
    - Prevailing wind comes more often from one direction

- **Speed** – often measured with a cup anemometer
Changes in wind direction

- Associated with locations of
  - Cyclones
  - Anticyclones
- Often bring changes in
  - Temperature
  - Moisture conditions
El Niño and La Niña

El Niño

- A countercurrent that flows southward along the coasts of Ecuador and Peru
  - Warm
  - Usually appears during the Christmas season
  - Blocks upwelling of colder, nutrient-filled water, and anchovies starve from lack of food
- Strongest El Niño events on record occurred between 1982-83 and 1997-98
El Niño and La Niña

El Niño

- 1997-98 event caused
  - Heavy rains in Ecuador and Peru
  - Ferocious storms in California
- Related to large-scale atmospheric circulation
  - Pressure changed between the eastern and western Pacific called the Southern Oscillation
  - Changes in trade winds creates a major change in the equatorial current system, with warm water flowing eastward
Normal conditions

Figure 18.21 A
El Niño and La Niña

- El Niño
  - Effects are highly variable depending in part on the temperatures and size of the warm water pools
El Niño and La Niña

La Niña

- Opposite of El Niño
- Triggered by colder than average surface temperatures in the eastern Pacific
- Typical La Niña winter
  - Blows colder than normal air over the Pacific Northwest and northern Great Plains while warming much of the rest of the United States
  - Greater precipitation is expected in the Northwest
Events associated with El Niño and La Niña are now understood to have a significant influence on the state of weather and climate almost everywhere.
Global distribution of precipitation

- Relatively complex pattern
- Related to global wind and pressure patterns
  - High pressure regions
    - Subsiding air
    - Divergent winds
    - Dry conditions
  - e.g., Sahara and Kalahari deserts
Global distribution of precipitation

- Related to global wind and pressure patterns
  - Low pressure regions
    - Ascending air
    - Converging winds
    - Ample precipitation
  - e.g., Amazon and Congo basins
Average annual precipitation in millimeters
Global distribution of precipitation

- Related to distribution of land and water
  - Large landmasses in the middle latitudes often have less precipitation toward their centers
  - Mountain barriers also alter precipitation patterns
    - Windward slopes receive abundant rainfall from orographic lifting
    - Leeward slopes are usually deficient in moisture
End of Chapter 18