Physical Geography

GEOGRAPHY 1710

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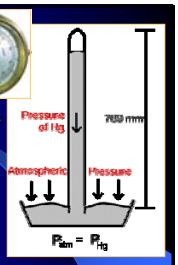
Chapter 6

Atmospheric and Oceanic Circulation

Atmospheric Pressure and Wind

- Wind Essentials
- Driving Forces Within the Atmosphere
- Atmospheric Patterns of Motion

Wind Essentials

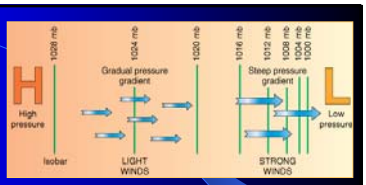


- Air Pressure
  - Force exerted in all directions by gas molecules in the atmosphere
  - Measured using a barometer
  - Changes in any one of pressure, temperature, and density of atmosphere affect the other two
- Wind:
  - Wind – horizontal movement of air
  - Anemometer – measures wind speed
  - Wind vane – measures wind direction
  - Named by direction it is coming from

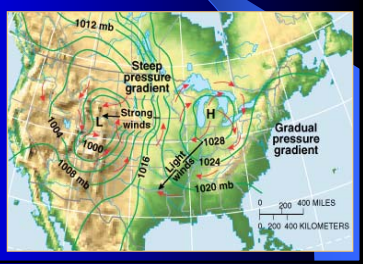
Driving Forces Within the Atmosphere

- **Gravity** – force that pulls an object toward the center of the Earth.
- **Pressure Gradient Force** – horizontal rate of pressure change, representing the "steepness" of the pressure slope; direct effect on speed of wind. "High" and "Low" pressure are relative conditions, depending on the pressure of adjoining areas.
- **Coriolis Force** – apparent deflection of objects moving about the surface of the Earth; to right in Northern Hemisphere and to left in Southern Hemisphere. Proportional to speed of object.
- **Friction Force** – resistance encountered when wind moves about the surface of the Earth, diminishing with altitude and does not exist above 5000 feet.

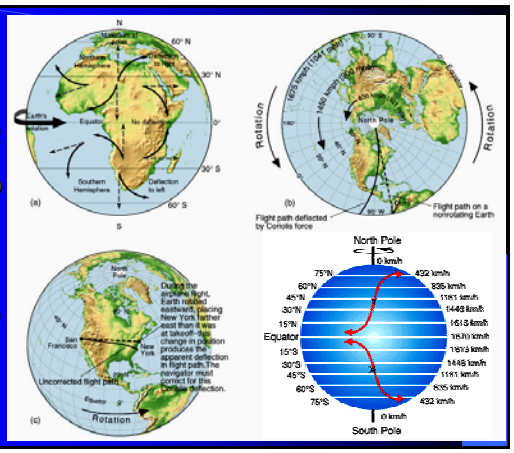
Pressure Gradient



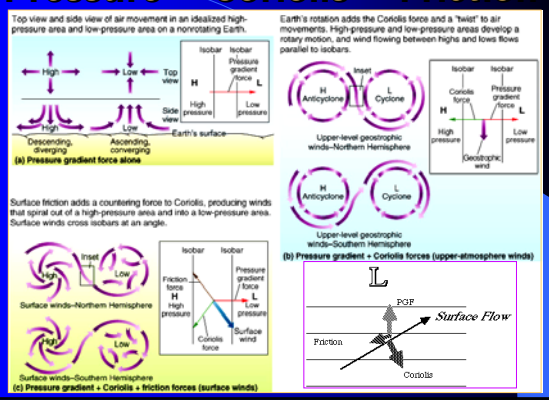
- Density – Amount of matter in a unit volume
- Isobars – Lines connecting points of equal pressure
- Ridge – Area of high pressure that connects two areas of low pressure
- Trough – Area low pressure that connects two areas of high pressure



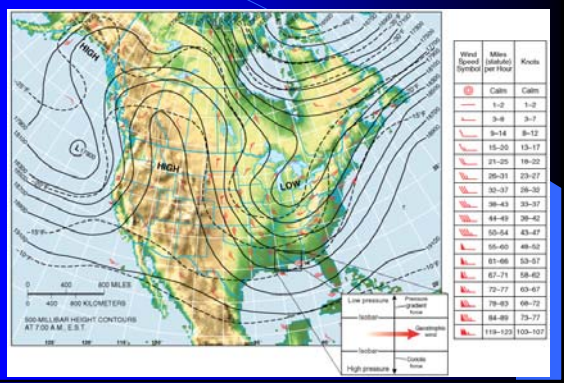
Coriolis Force



Pressure + Coriolis + Friction



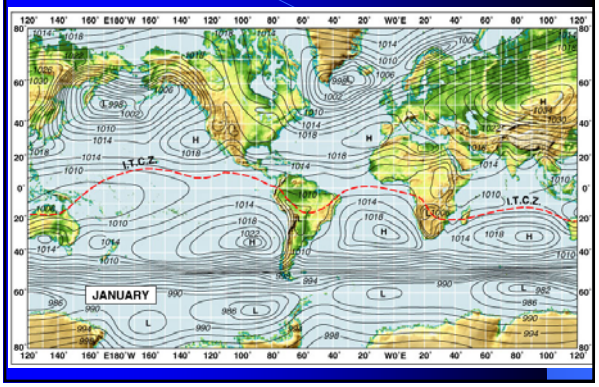
500 mb Pressure Map



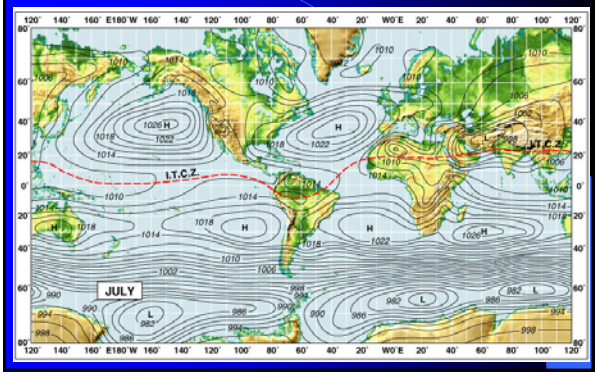
Atmospheric Patterns of Motion

- Primary High-Pressure and Low-Pressure Areas
- Upper Atmospheric Circulation
- Local Winds
- Monsoonal Winds

Global Barometric Pressure



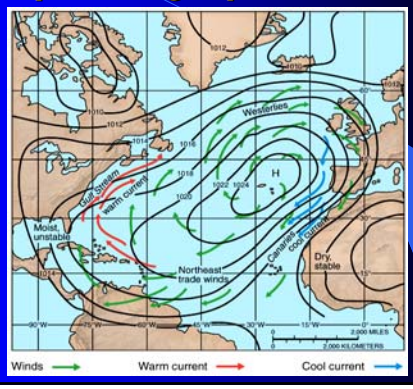
Global Barometric Pressure



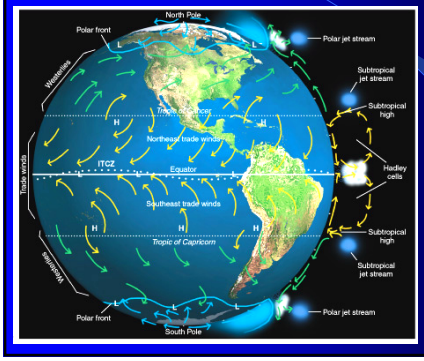
General Circulation of Atmosphere

- **Intertropical convergence zone (ITCZ)** – zone of convergence and weak horizontal air flow. Also known has doldrums because early sailing ships would often becalmed. Approximately parallels equator.
- **Trade winds** – winds covering most of the Earth between 25o N and 25o S latitude. Particularly prominent over oceans. Dominate more of the globe than any other wind system.
- **Subtropical Highs** – centered at about 30o latitude. Weather is nearly always clear, warm, and calm. Anti-cyclonic, divergent clockwise in Northern Hemisphere and counterclockwise in Southern Hemisphere. Known as Horse Latitudes.
- **Westerlies** – winds flow basically from west to east around the world between 30o and 60o north and south latitudes.
- **Subpolar Lows** – zone of low pressure at about 50o – 60o latitude. Zone of conflict between cold polar easterlies and warm westerlies.
- **Polar Easterlies** – from polar highs to 60o north and south. Cold, dry, and variable.
- **Polar Highs** – situated over both polar regions. Typically anti-cyclonic

Subtropical high-pressure cells

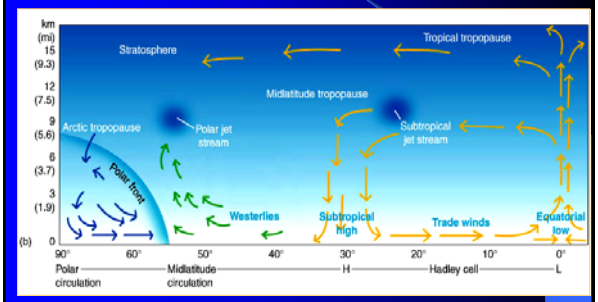


General Atmospheric Circulation

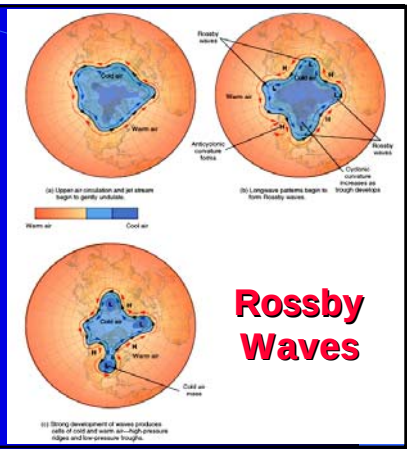


See figure 5-29, cross-section through troposphere

General Atmospheric Circulation

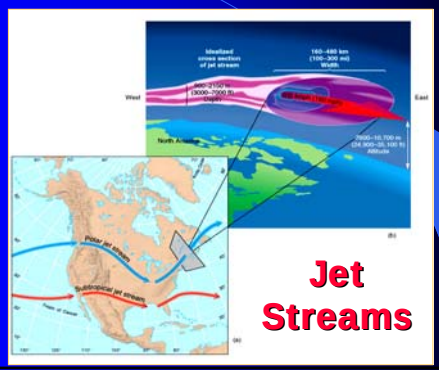


Upper Atmospheric Circulation



Rossby Waves

Upper Atmospheric Circulation

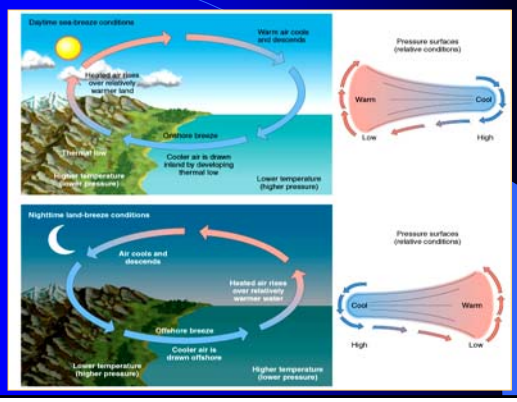


Jet Streams

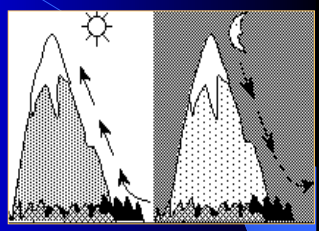
Local Winds

- Land-sea breezes
  - A convectional circulation caused by differential heating of land and water surfaces.
- Mountain-valley breezes
  - A convectional circulation caused by differential heating of higher versus lower elevations.
- Katabatic winds
  - A wind that originates in cold upland areas and cascades toward lower elevations under the influence of gravity.

Land-Sea Breezes



Mountain Valley Breezes

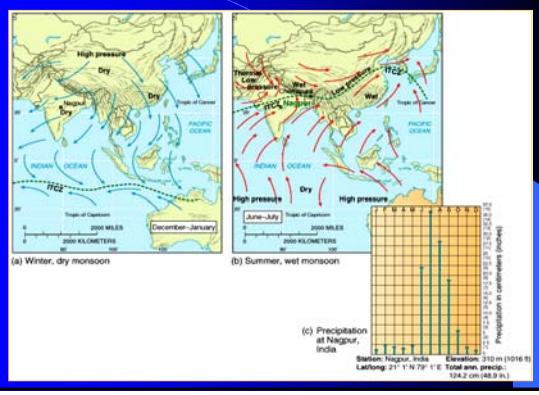


- Valley Breeze
  - An up-slope flow during the day
- Mountain Breeze
  - A down-slope flow during the night

Katabatic Winds

- Mistral – cold, high-velocity wind that sometimes surges down the slopes of the Alps toward the Mediterranean
- Chinook-localized downslope wind of relatively dry and warm air that moves down the leeward slope of the Rockies.
- Santa Anas-high speed, high temperature, and extremely dry prompting wildfires in California.

Monsoonal Winds



The Dynamic Ocean

Ocean water movements

- Surface circulation
  - Ocean currents are masses of water that flow from one place to another
  - Surface currents develop from friction between the ocean and the wind that blows across the surface
  - Huge, slowly moving gyres

Ocean water movements

- Surface circulation
  - Five main gyres
    - North Pacific Gyre
    - South Pacific Gyre
    - North Atlantic Gyre
    - South Atlantic Gyre
    - Indian Ocean Gyre
  - Related to atmospheric circulation

Average ocean surface currents in February-March

Ocean water movements

- Surface circulation
  - Deflected by the Coriolis effect
    - To the right in the Northern Hemisphere
    - To the left in the Southern Hemisphere
  - Four main currents generally exist within each gyre
  - Importance of surface currents
    - Climate
      - Currents from low latitudes into higher latitudes (warm currents) transfer heat from warmer to cooler areas

Ocean water movements

- Surface circulation
  - Importance of surface currents
    - Climate
      - Influence of cold currents is most pronounced in the tropics or during the summer months in the middle latitudes
    - Upwelling
      - The rising of cold water from deeper layers
      - Most characteristic along west coasts of continents
      - Brings greater concentrations of dissolved nutrients to the ocean surface

Ocean water movements

- Deep-ocean circulation
  - A response to density differences
  - Factors creating a dense mass of water
    - Temperature – cold water is dense
    - Salinity – density increases with increasing salinity
  - Called thermohaline circulation

Ocean water movements

- Deep-ocean circulation
  - Most water involved in deep-ocean currents begins in high latitudes at the surface
  - A simplified model of ocean circulation is similar to a conveyor belt that travels from the Atlantic Ocean, through the Indian and Pacific Oceans and back again

Idealized "conveyor belt" model of ocean circulation