Foundations of Earth Science

Eighth Edition

The Atmosphere in Motion

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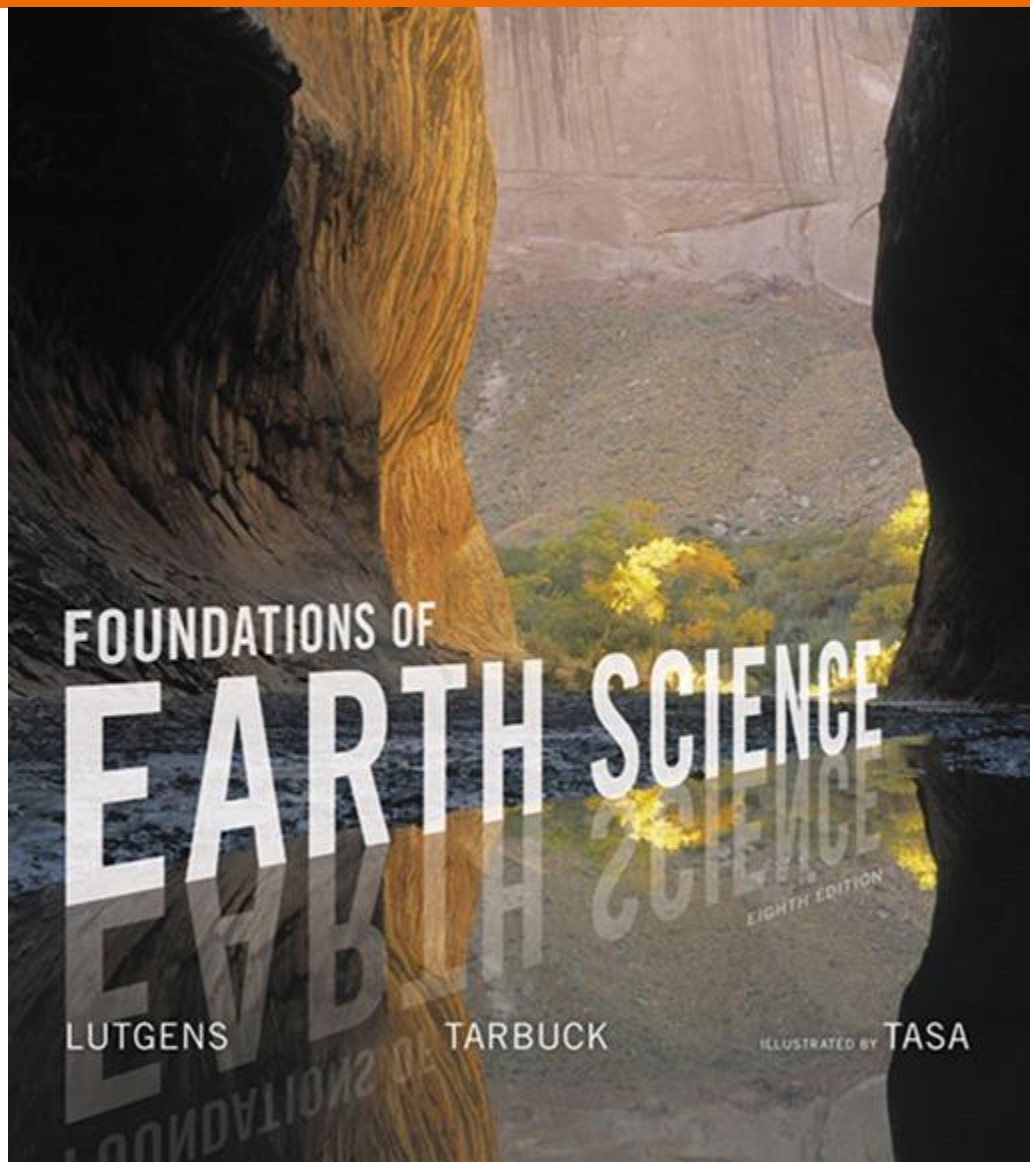

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Focus Questions 13.1

- Define air pressure.
- Describe the instruments used to measure these weather elements.

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Understanding Air Pressure

- **Air pressure** is the force exerted by weight of air above
- Weight of the air at sea level
  - 14.7 psi or 1 kg/cm^2
- Decreases with increasing altitude
- Units of measurement
  - *Millibar* (mb)
    - Standard sea level pressure is 1013.2 mb
  - Inches of mercury
    - Standard is 29.92 inches of mercury

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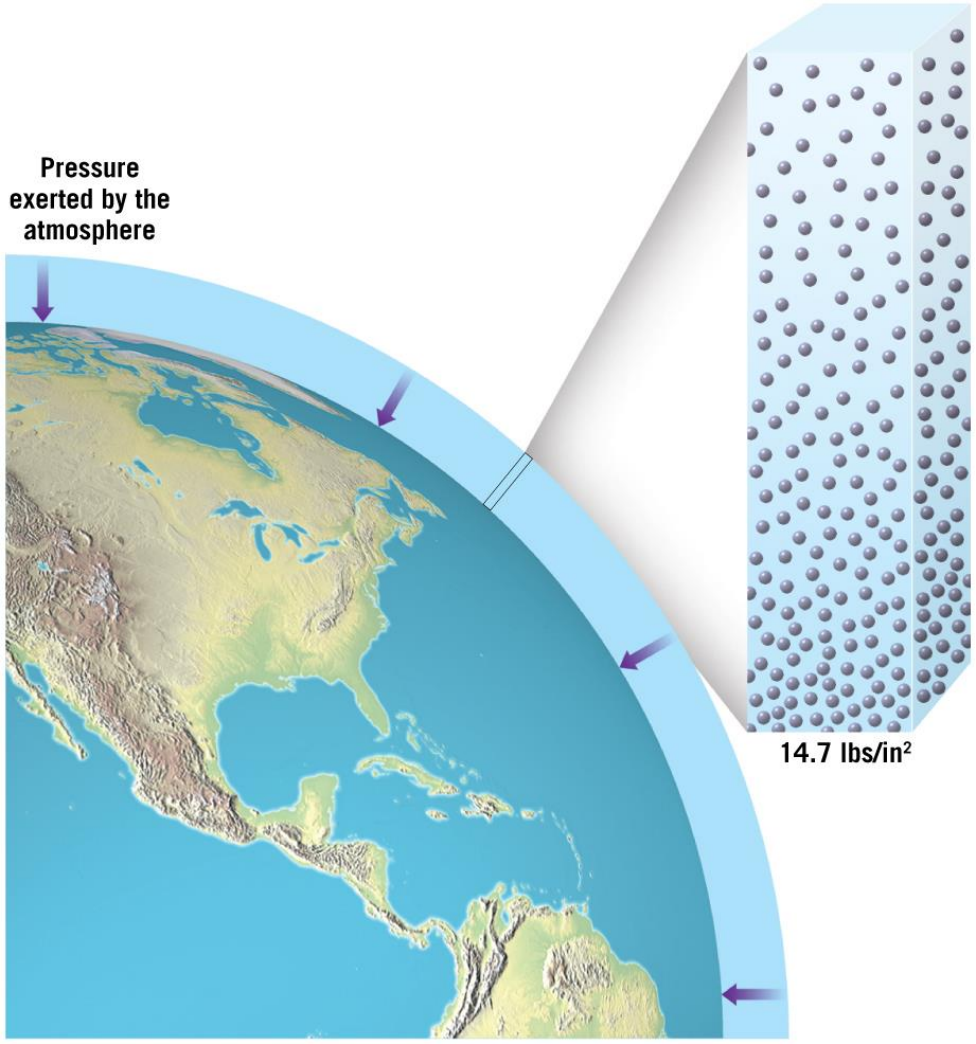
Understanding Air Pressure



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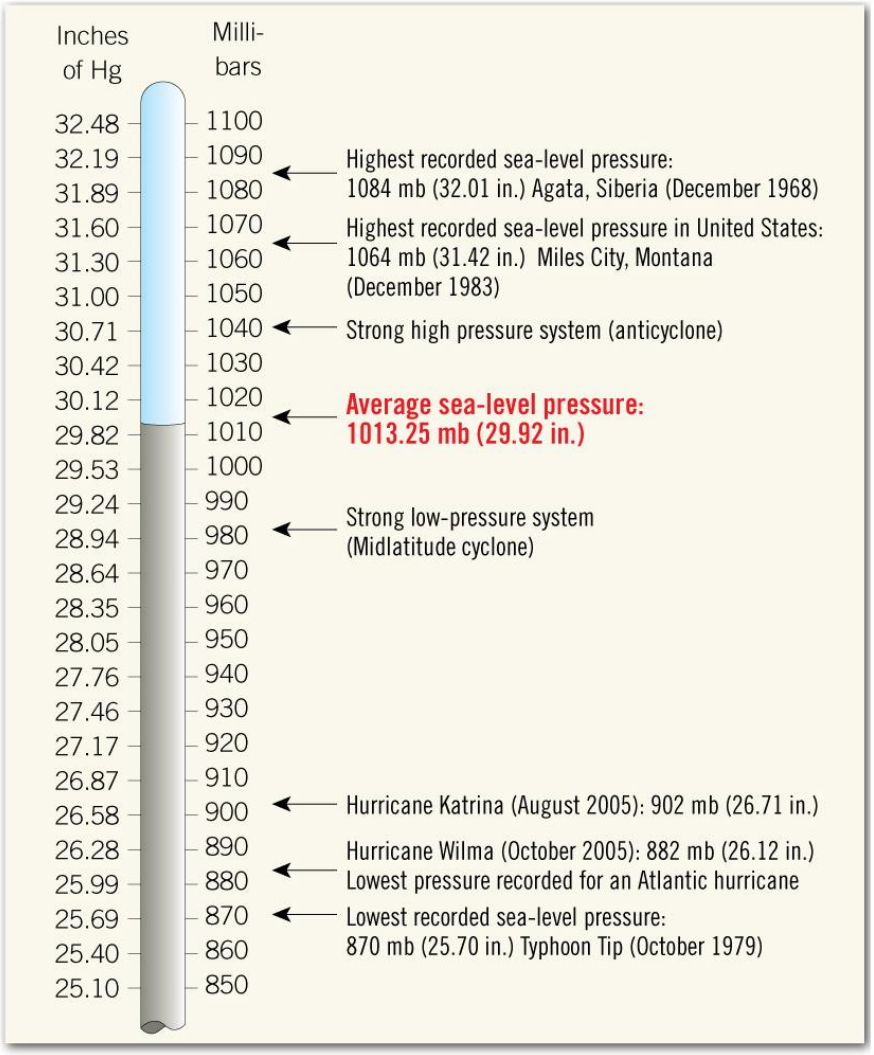
Understanding Air Pressure



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Understanding Air Pressure

- Instruments for measuring
  - Barometer
    - ***Mercury barometer***
      - Invented by Torricelli in 1643
      - Uses a glass tube filled with mercury
    - ***Aneroid barometer***
      - "Without liquid"
      - Uses an expanding chamber
  - Barograph
    - Continuously records the air pressure

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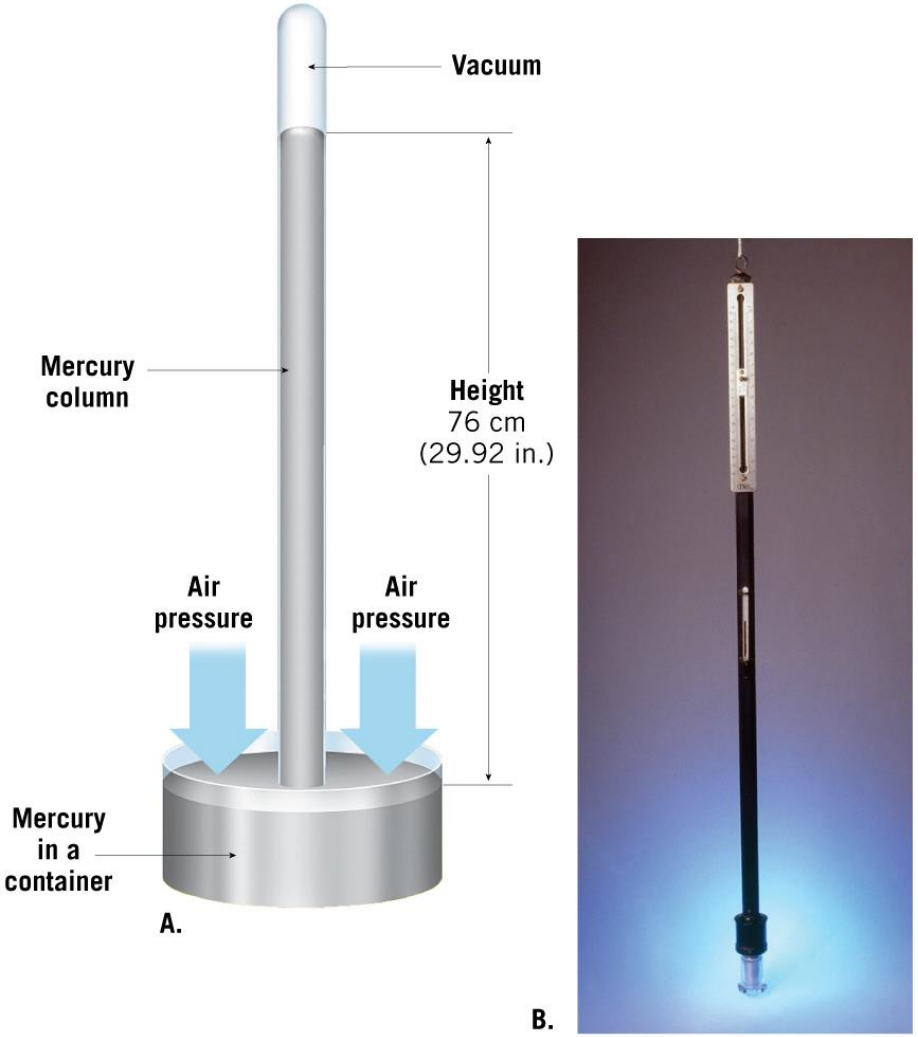
Understanding Air Pressure



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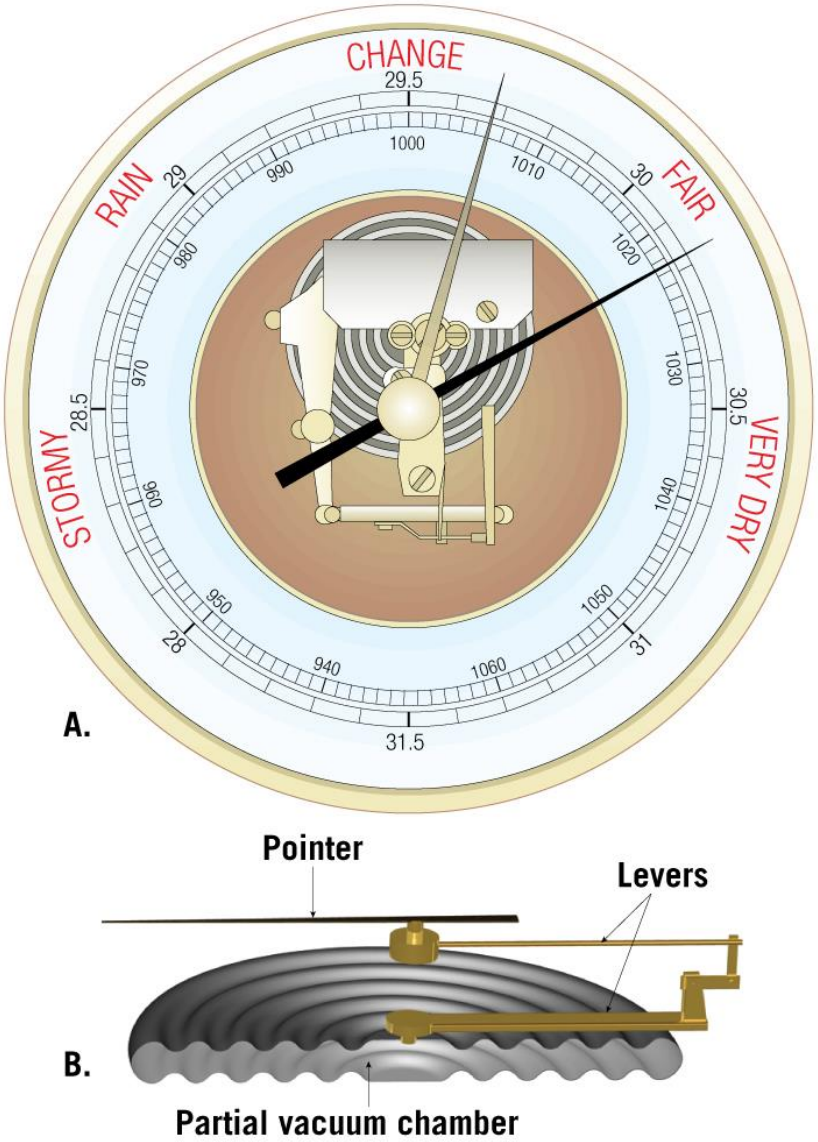
Understanding Air Pressure



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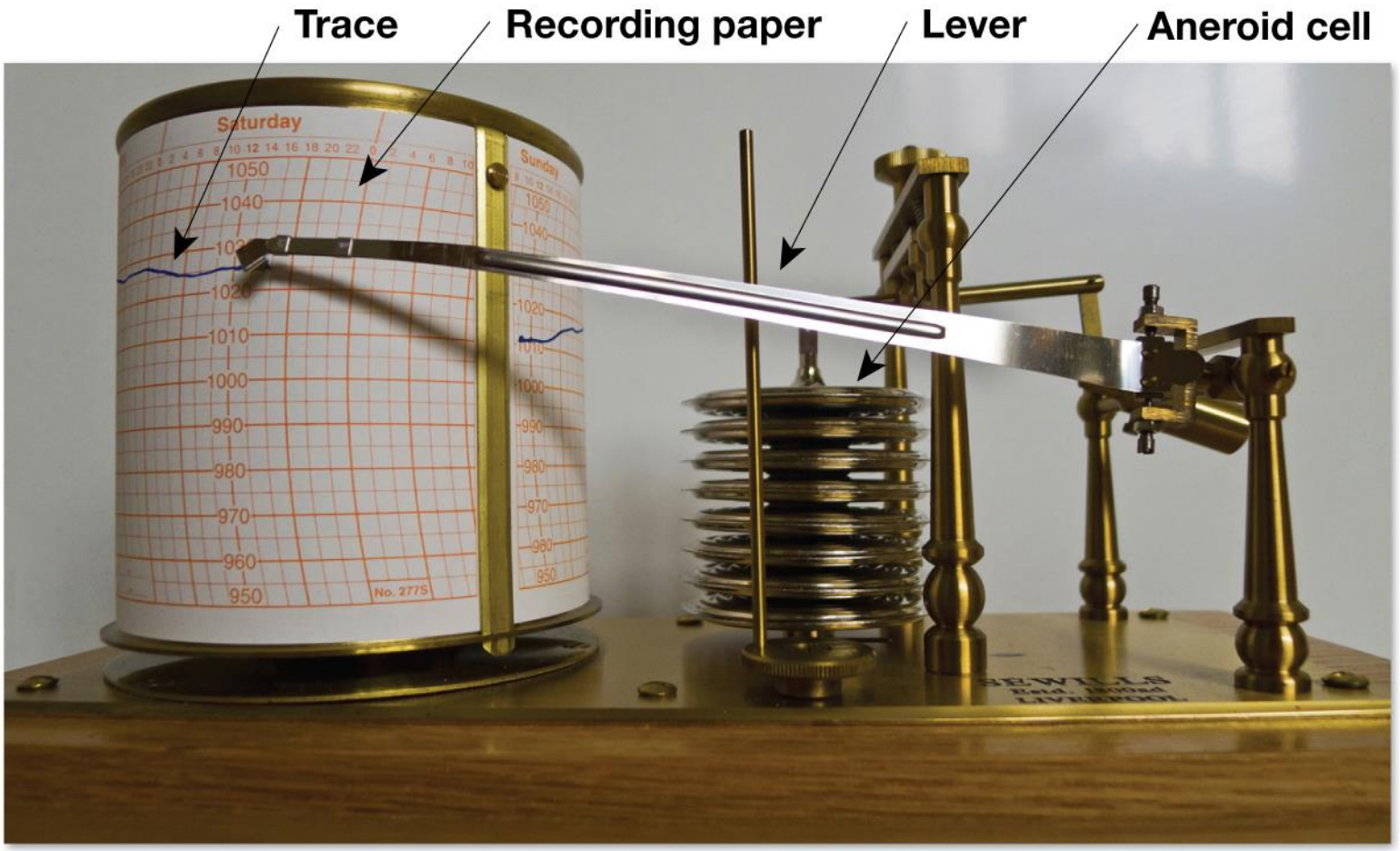
Understanding Air Pressure



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Focus Question 13.2

- Discuss the three forces that act on the atmosphere to either create or alter winds.

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Factors Affecting Wind

- **Wind** – horizontal movement of air
  - Out of areas of high pressure
  - Into areas of low pressure
- Controls of wind
  - Pressure gradient force (PGF)
    - **Isobars**
      - Lines of equal air pressure
    - **Pressure gradient**
      - Pressure change over distance

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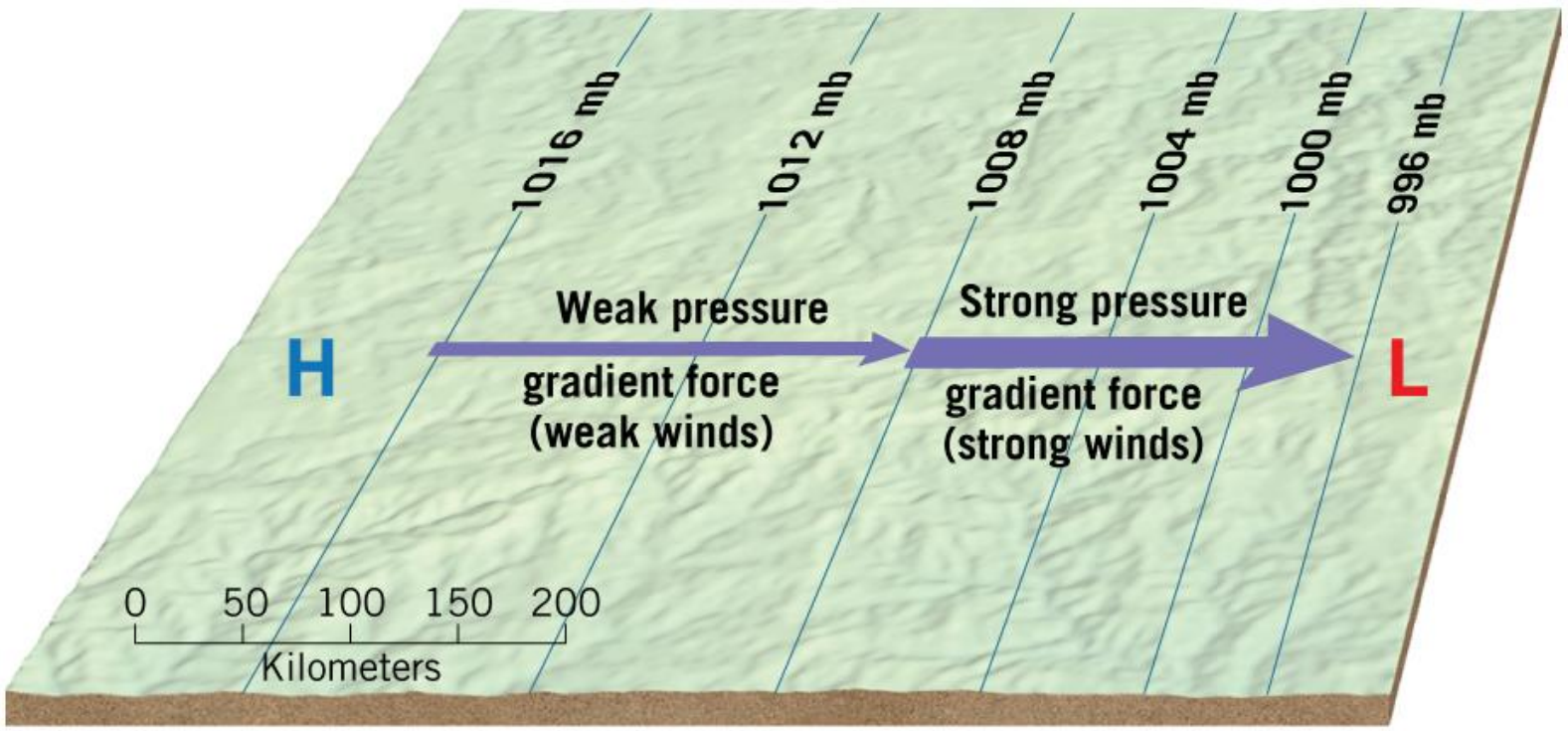
Factors Affecting Wind



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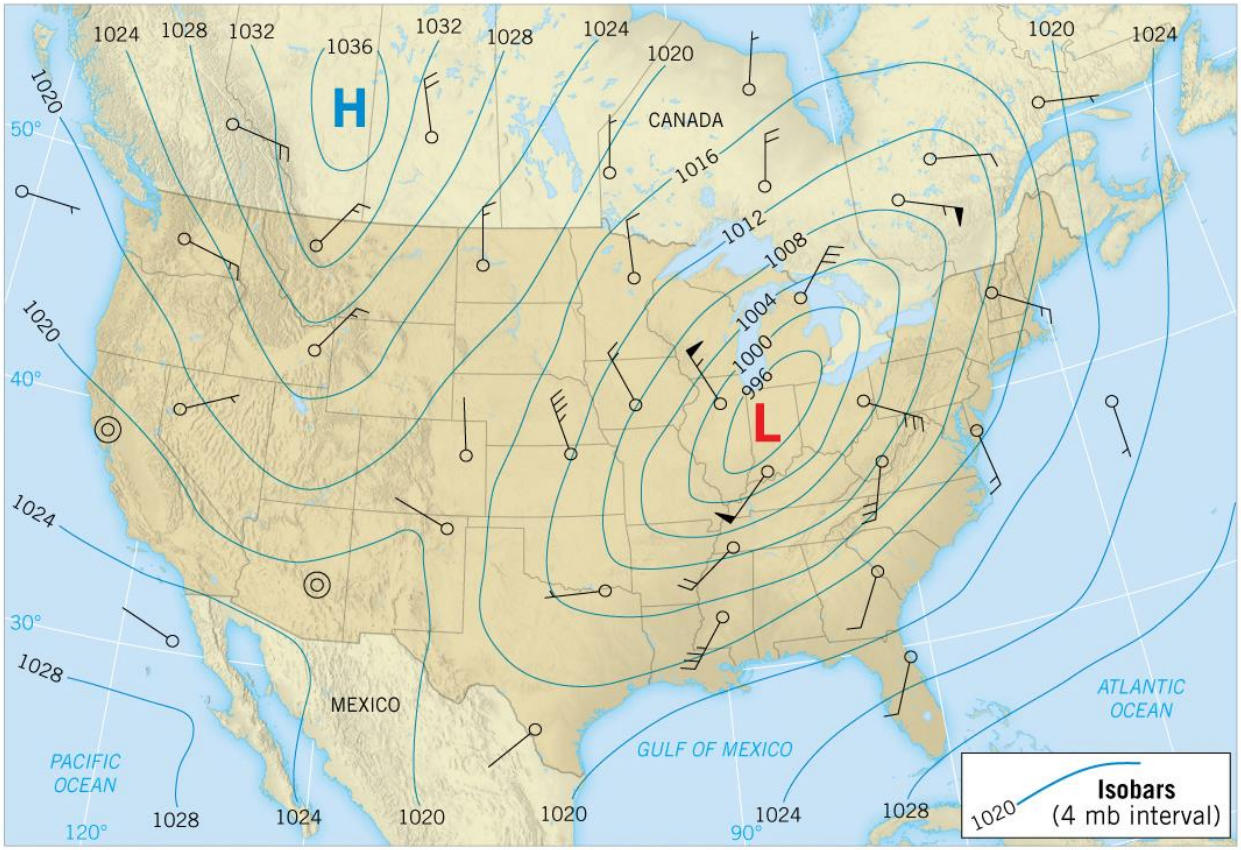
Factors Affecting Wind



Wind speed symbols	Miles per hour
◎	Calm
	1–2
	3–8
	9–14
	15–20
	21–25
	26–31
	32–37
	38–43
	44–49
	50–54
	55–60
	61–66
	67–71
	72–77
	78–83
	84–89
	119–123

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Factors Affecting Wind

- **Coriolis effect**
  - Apparent deflection in wind direction due to Earth's rotation
  - Deflection to the right in Northern Hemisphere
  - To the left in Southern Hemisphere
- Friction
  - Only important near the surface
  - Acts to slow the air's movement

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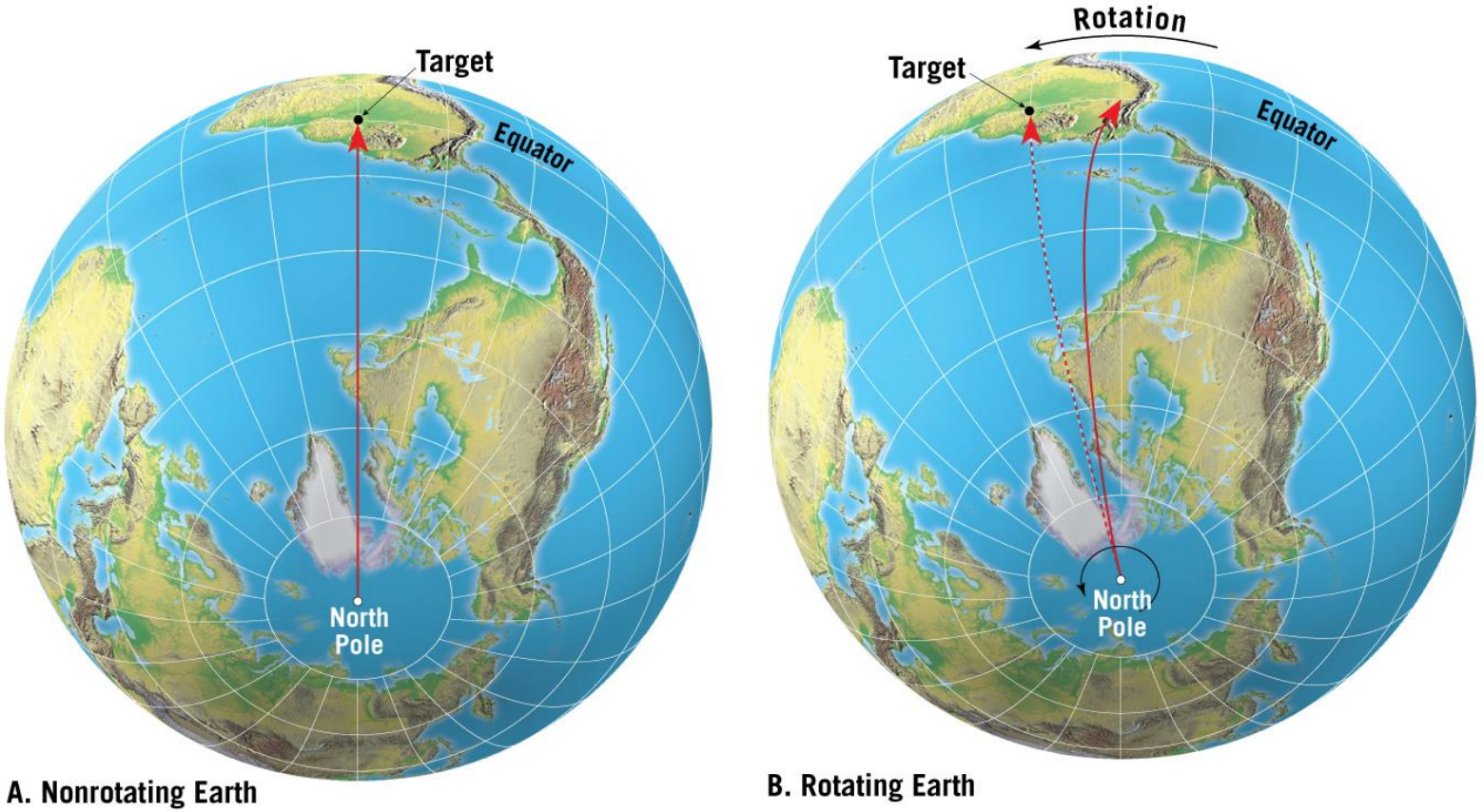
Factors Affecting Wind



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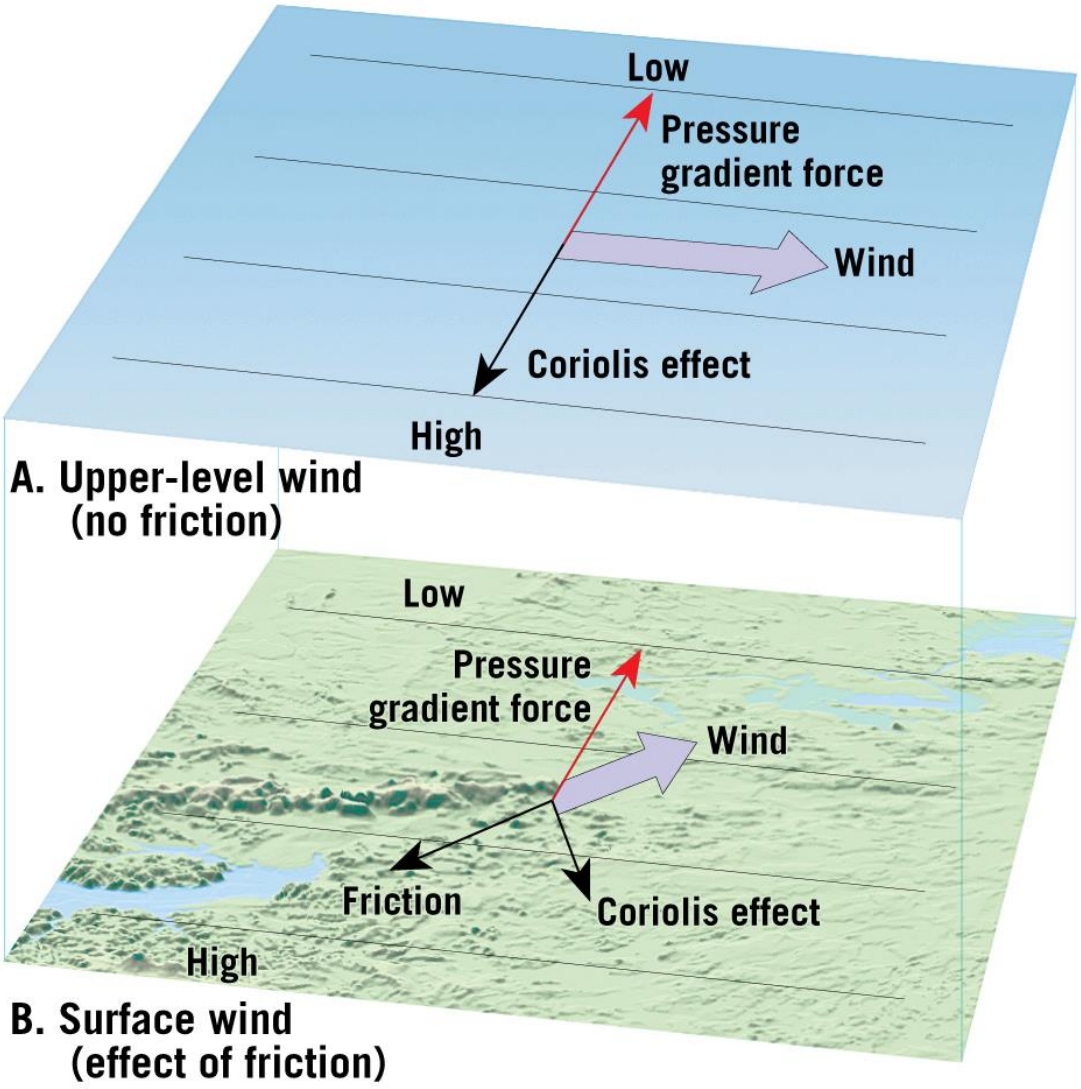
Factors Affecting Wind



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Factors Affecting Wind

- Upper air winds
  - Generally blow parallel to isobars
    - ***Geostrophic winds***
  - **Jet stream**
    - "River" of air
    - High altitude
    - High velocity (120 to 240 kph)

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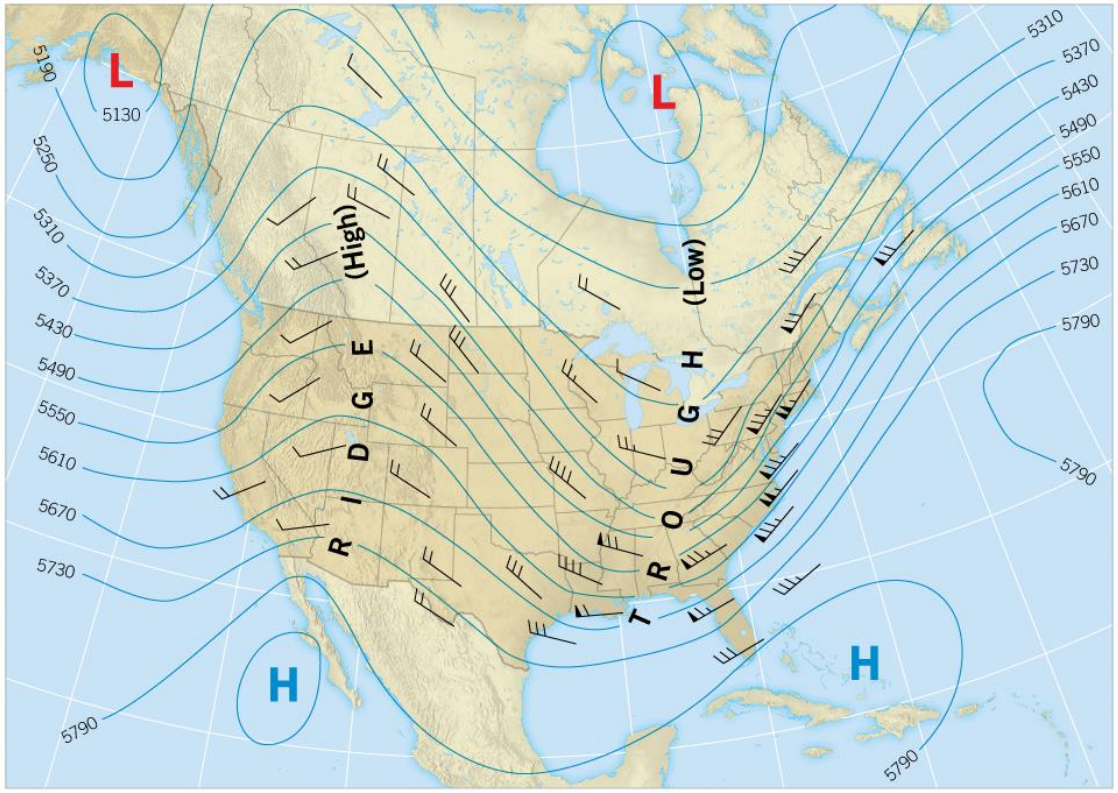
Factors Affecting Wind



Upper-level weather chart

Wind speed symbols	Miles per hour
◎	Calm
	1–2
	3–8
	9–14
	15–20
	21–25
	26–31
	32–37
	38–43
	44–49
	50–54
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	61–66
	67–71
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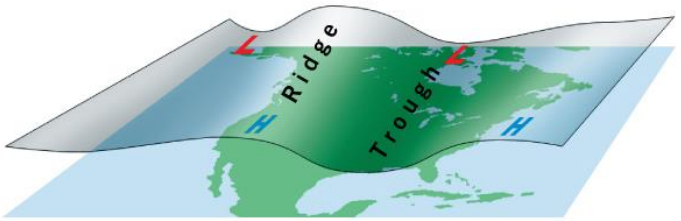
	78–83
	84–89
	119–123



Representation of upper-level chart

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Focus Question 13.3

- Contrast the weather associated with low-pressure centers (cyclones) and high-pressure centers (anticyclones).

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Highs and Lows

- **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

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Highs and Lows

- **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

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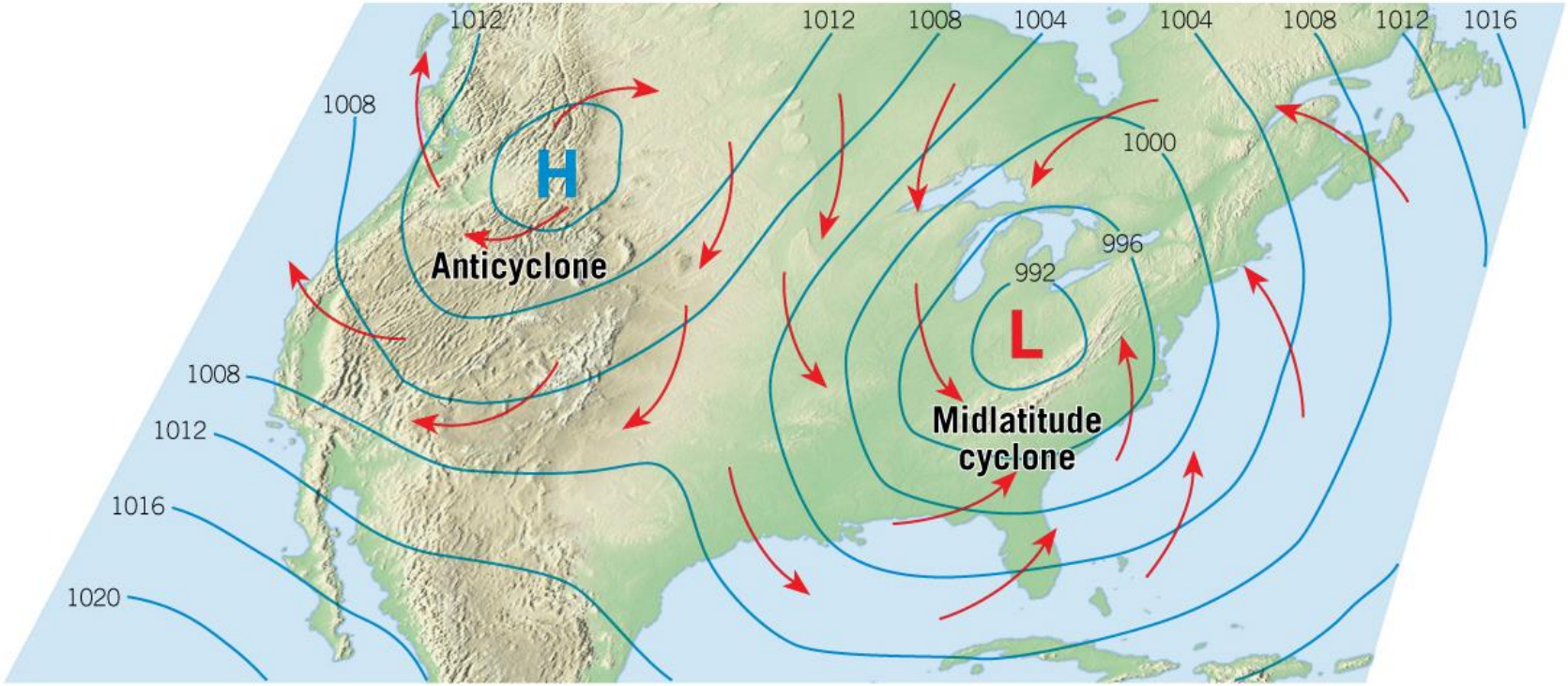
Highs and Lows



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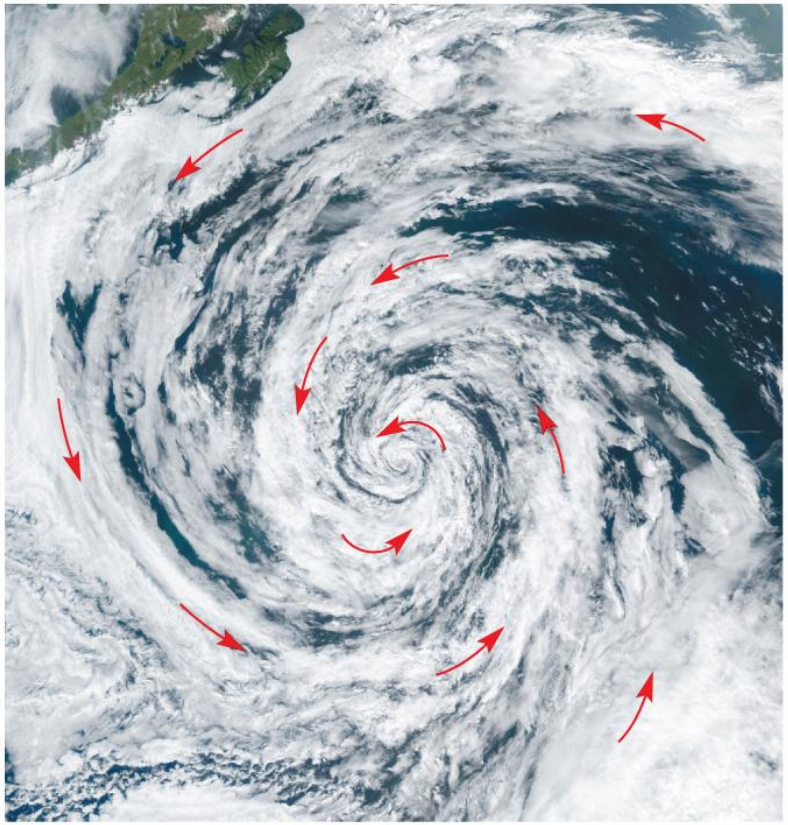
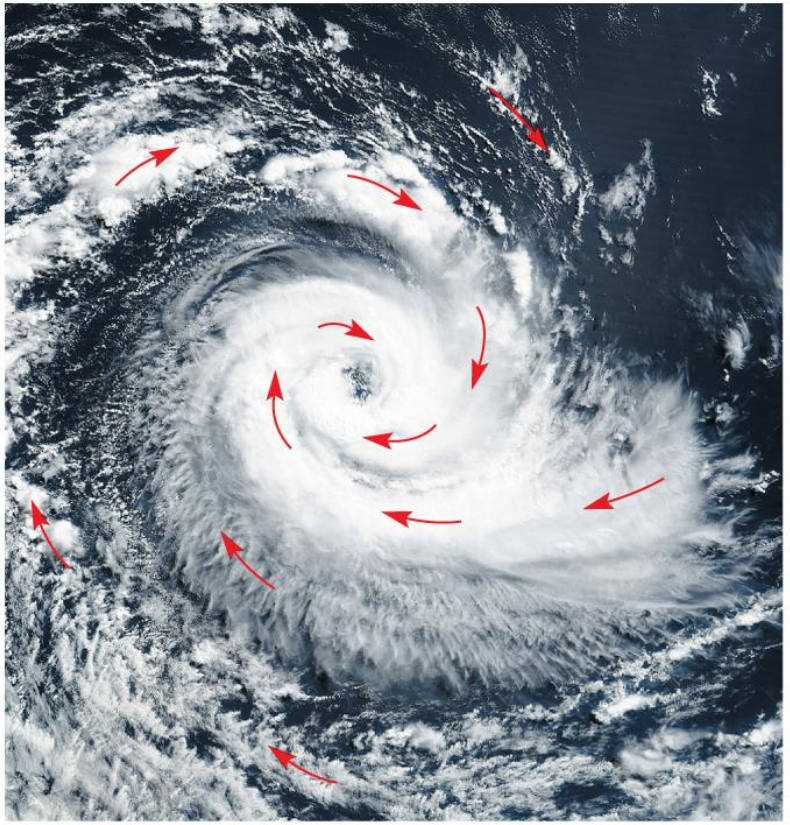
Highs and Lows



A. This satellite image shows a large low-pressure center in the Gulf of Alaska. The cloud pattern clearly shows an inward and counterclockwise spiral.



B. This satellite image shows a strong cyclonic storm in the South Atlantic near the coast of Brazil. The cloud pattern shows an inward and clockwise circulation.

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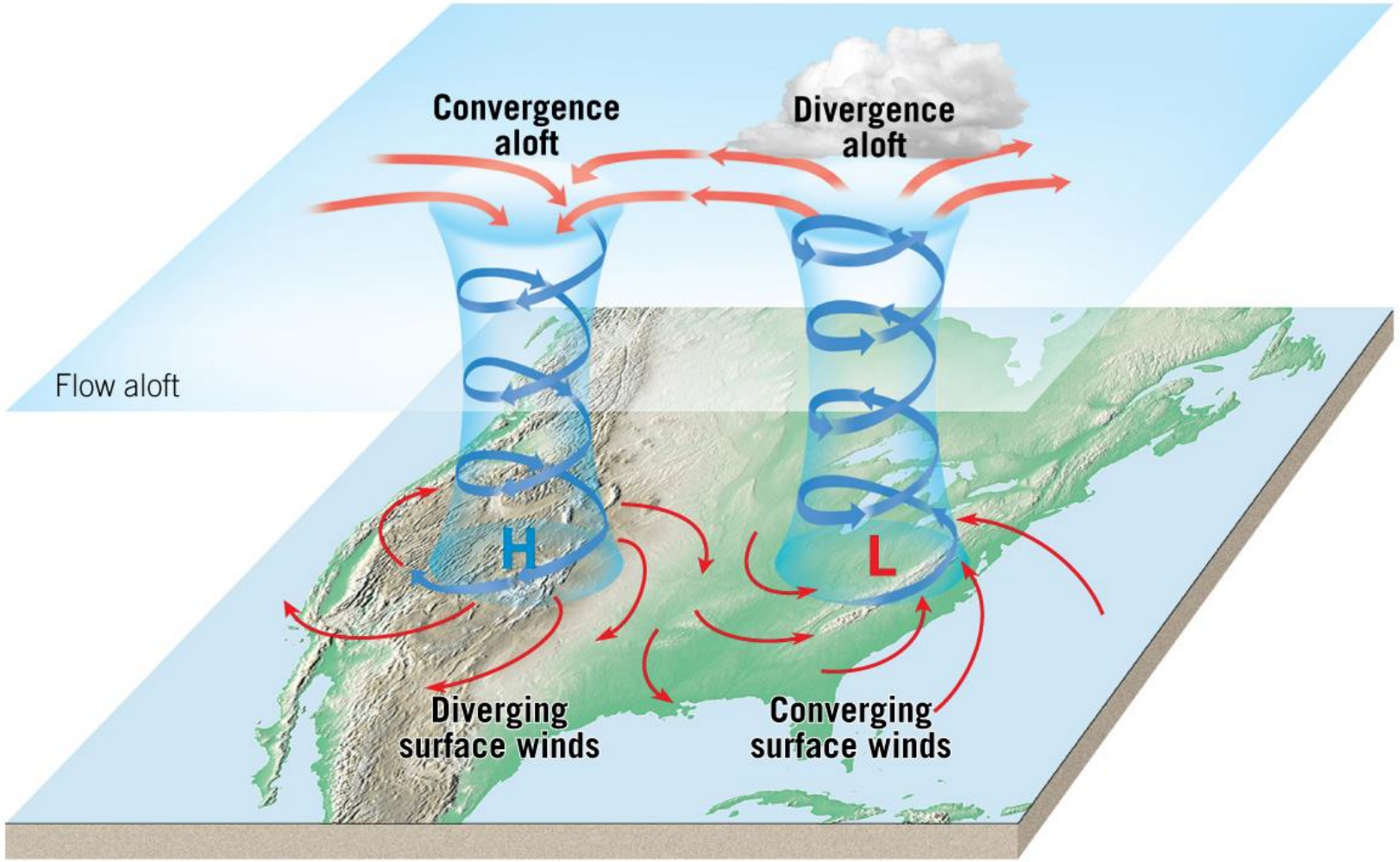
Highs and Lows



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Focus Questions 13.4

- Summarize Earth's idealized global circulation.
- Describe how continents and seasonal temperature changes complicate the idealized pattern.

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General Circulation of the Atmosphere

- Caused by unequal surface heating
- 3 pairs of atmospheric cells redistribute heat
- Idealized global circulation
  - **Equatorial low pressure zone**
    - Rising air
    - Abundant precipitation
    - **Intertropical convergence zone**
  - **Subtropical high pressure zone**
    - Subsiding, stable, dry air
    - Near 30º latitude
    - Location of great deserts

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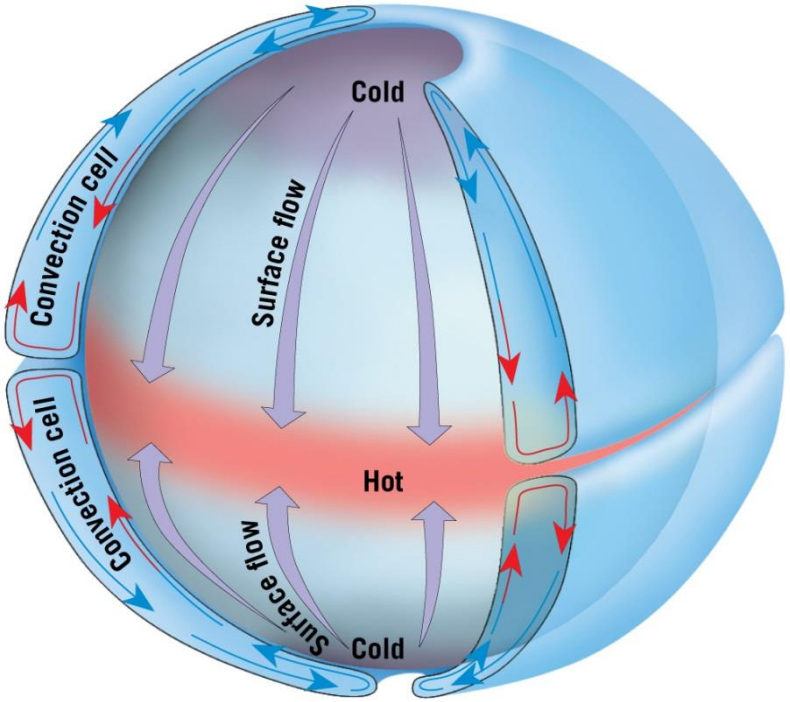
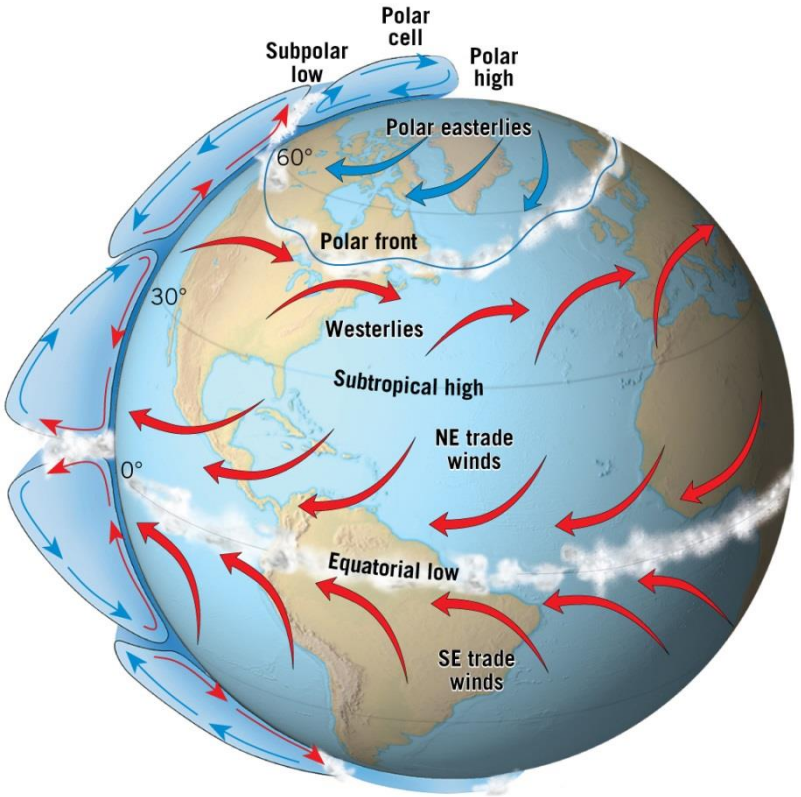
General Circulation of the Atmosphere





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General Circulation of the Atmosphere

- Air traveling to equator from subtropical high produces the ***trade winds***
- Air traveling to poles from subtropical high produces the ***westerly winds***

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General Circulation of the Atmosphere

- Subpolar low-pressure zone
  - Warm and cool winds interact
  - **Polar front**: an area of storms
- Polar high-pressure zone
  - Cold, subsiding air
  - Air spreads to equator and produces **polar *easterly winds***
  - Polar easterlies collide with the westerlies along the polar front

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General Circulation of the Atmosphere

- Influence of continents
  - Seasonal temperature differences disrupt the
    - Global pressure patterns
    - Global wind patterns
  - Influence is greatest in N. Hemisphere
- **Monsoon**
  - Seasonal change in wind direction occurring over land
    - *During warm months*
      - Air flows onto land
      - Warm, moist air from the ocean
    - *Winter months*
      - Air flows off the land
      - Dry, continental air

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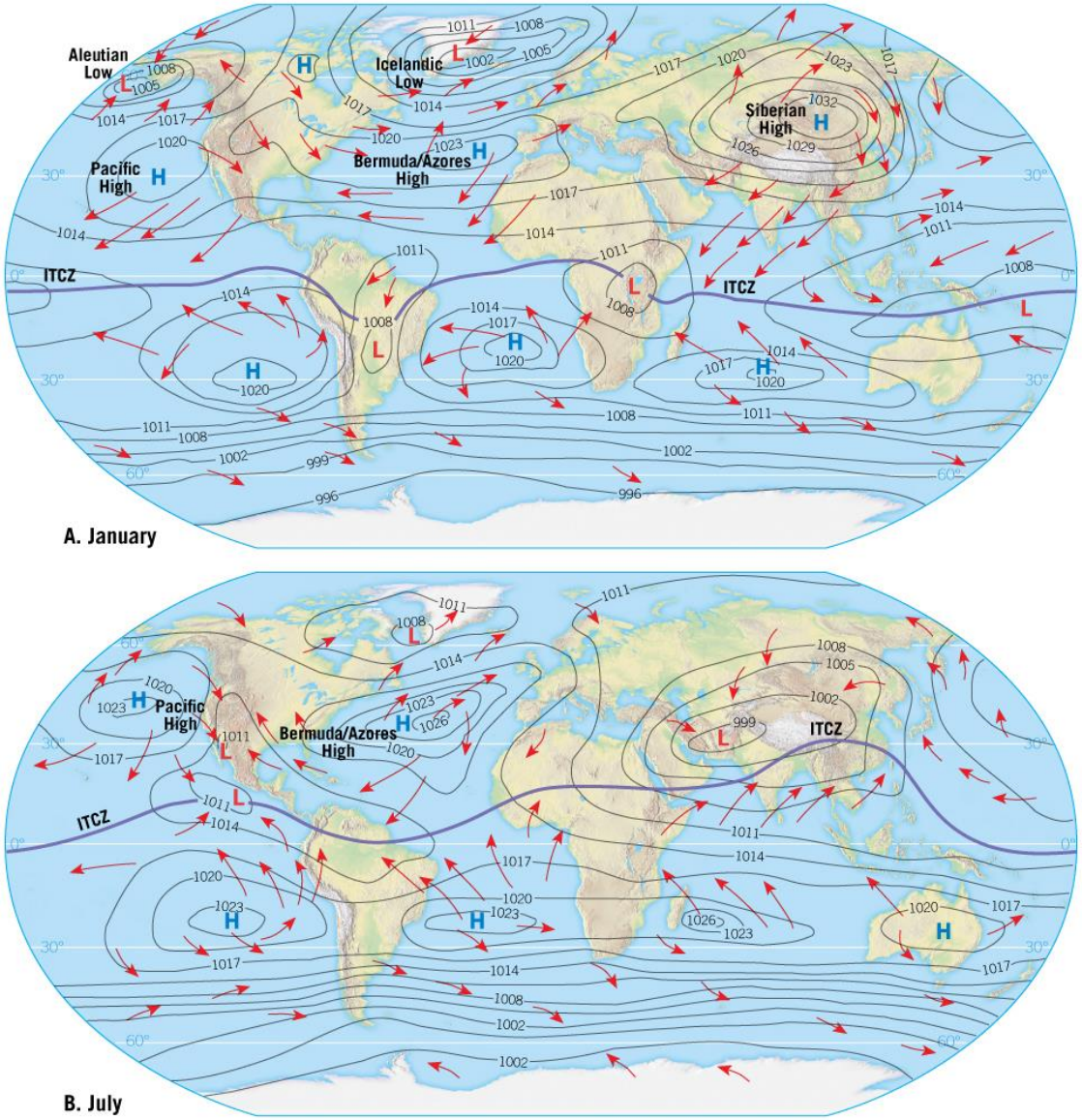
General Circulation of the Atmosphere



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General Circulation of the Atmosphere

- The Westerlies
  - Complex pattern
  - Air flow is interrupted by cyclones
    - Cells move west to east in the N. Hemisphere
    - Create anticyclonic and cyclonic flow
    - Paths of cyclones and anticyclones are associated with the upper-level airflow

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Focus Questions 13.5

- List three types of local winds.
- Describe their formation.

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Local Winds

- Produced from temperature differences
- Small scale winds
  - Land and sea breezes
  - Mountain and valley breezes
  - Chinook and Santa Ana winds

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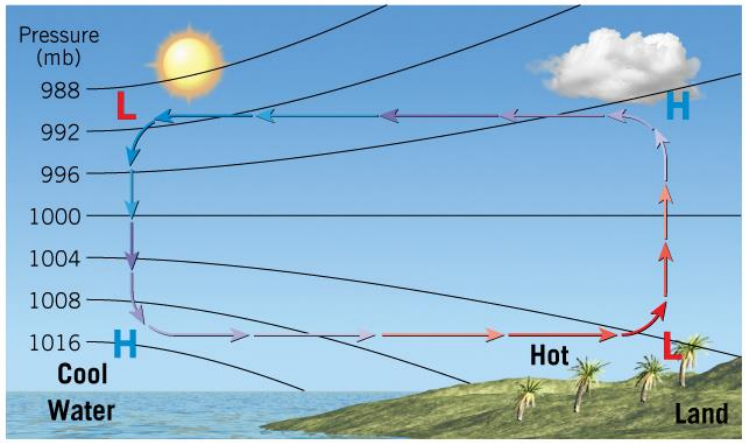
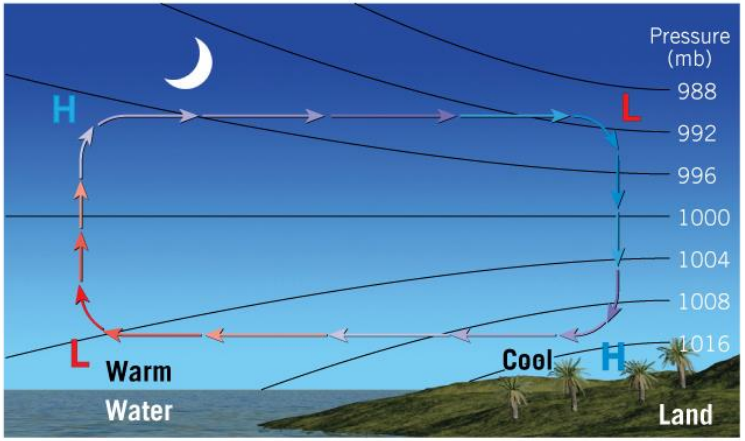
Local Winds

- Land and sea breezes
  - A **sea breeze** develops because cooler air over the water moves toward the land
  - Reaches greatest intensity during the mid- to late afternoon
  - At night it reverses, and a **land breeze** develops



A. During daylight hours, cooler and denser air over the water moves onto the land, generating a sea breeze.



B. At night the land cools more rapidly than the sea, generating an offshore flow called a land breeze.

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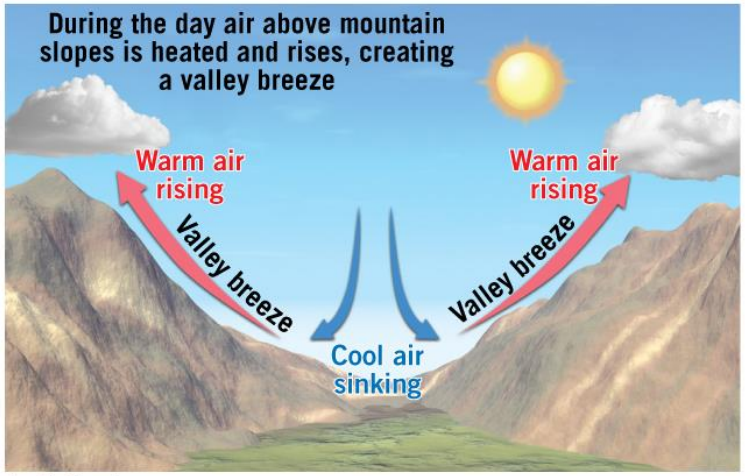
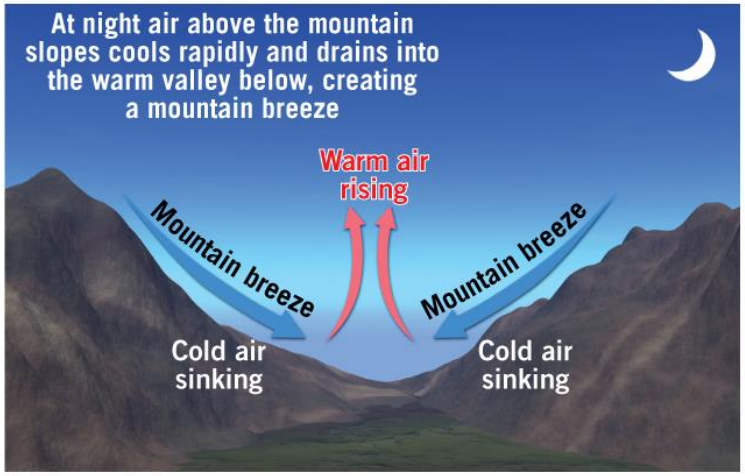
Local Winds

- Mountain and valley breezes
  - Air on mountain slopes is heated more than air at the same elevation over the valley floor
  - Glides upslope and generates a **valley breeze**
  - Cool air is denser than warm air and drains downslope into the valley as a **mountain breeze**



A. Valley breeze



B. Mountain breeze

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Local Winds

- Chinook and Santa Ana winds
  - **Chinooks**
    - Warm, dry winds moving down the east slopes of the Rockies
  - **Santa Anas**
    - Chinook like wind that occurs in southern California

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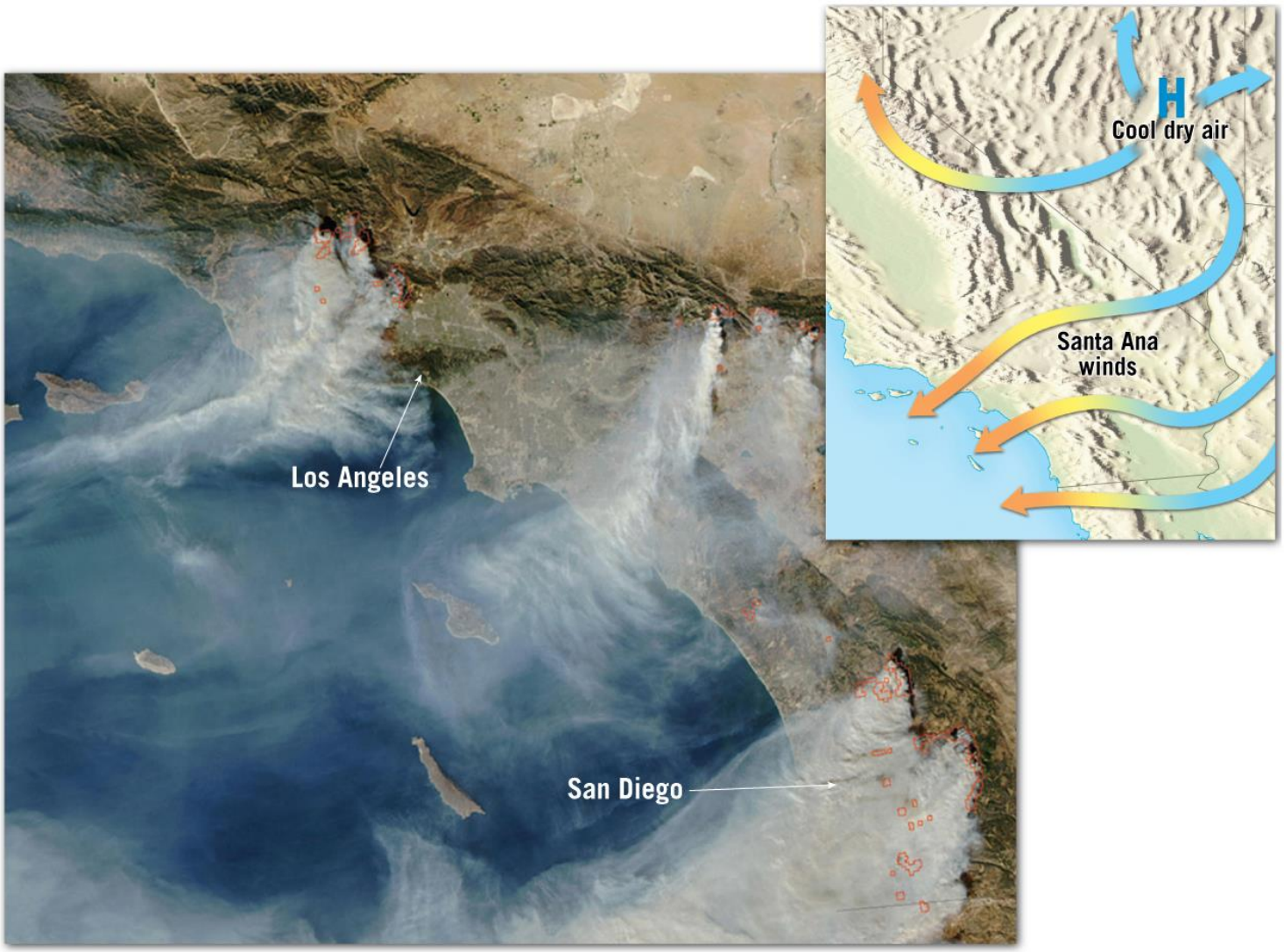
Local Winds



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Focus Questions 13.6

- Describe the instruments used to measure wind.
- Explain how wind direction is expressed using compass directions.

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Measuring Wind

- Two basic measurements:
  - Direction
    - Winds are labeled from *where they originate*
      - North wind blows from the north
    - Instrument for measuring wind direction is the **wind vane**: direction indicated by either
      - Compass points
      - Scale of 0º to 360º
    - **Prevailing wind** comes more often from one direction
  - Speed
    - Often measured with a **cup anemometer**

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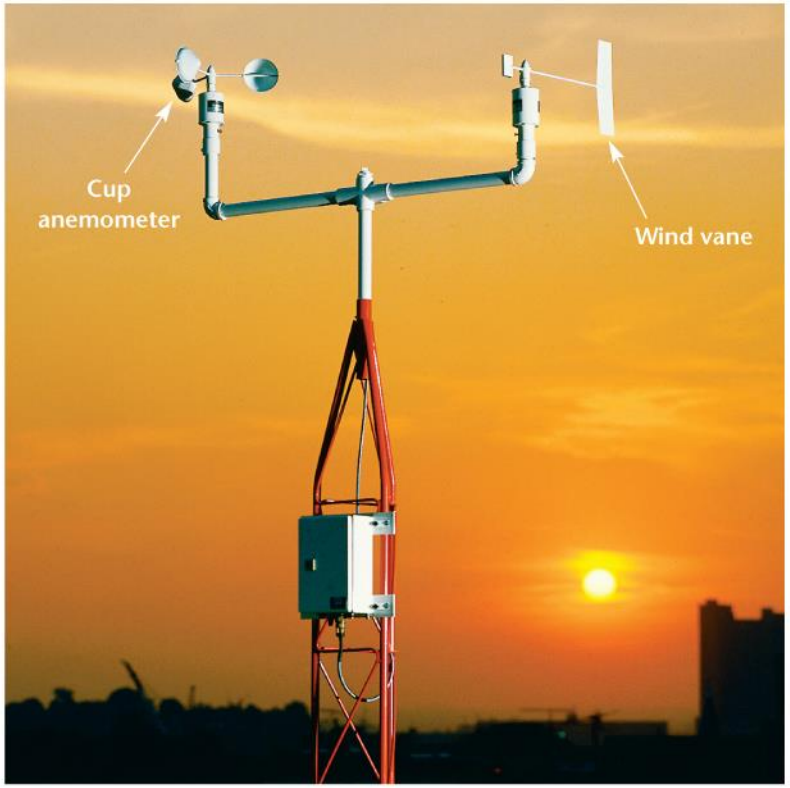
Measuring Wind

A.



B.

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Measuring Wind

- Changes in wind direction
  - Associated with locations of
    - Cyclones
    - Anticyclones
  - Often bring changes in
    - Temperature
    - Moisture conditions

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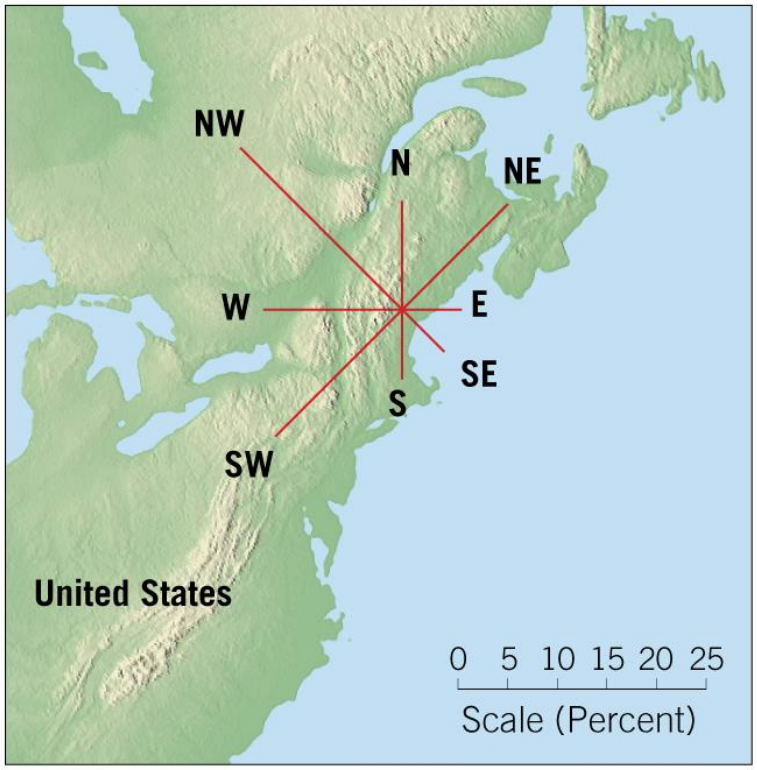
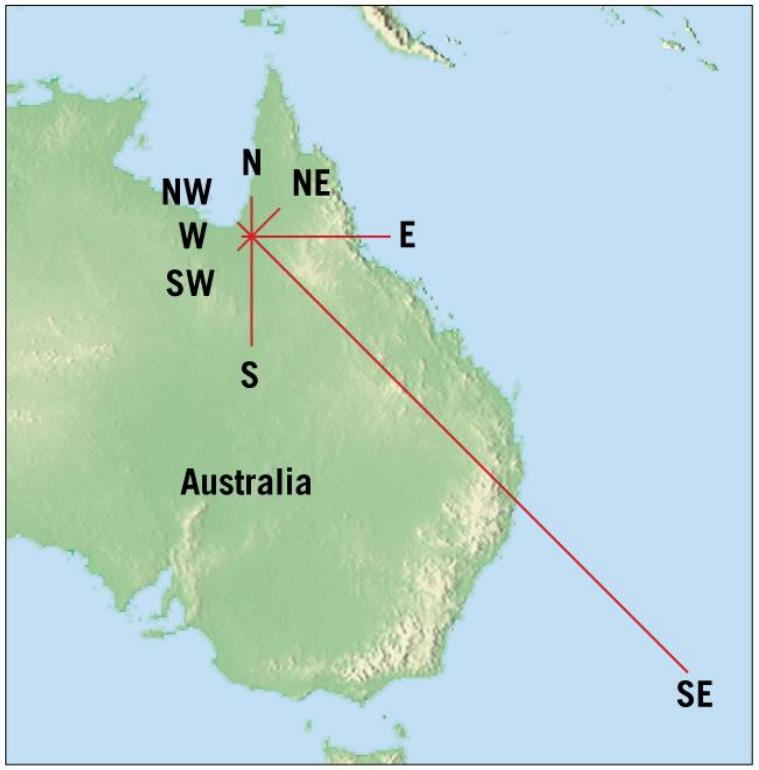
Measuring Wind



A. Wind frequency for winter in the northeastern United States.



B. Wind frequency for winter in northeastern Australia. Note the reliability of the southeast trade winds in Australia as compared to the westerlies in the northeastern United States.

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Focus Question 13.7

- Discuss the major factors that influence the global distribution of precipitation.

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Global Distribution of Precipitation

- Regions influenced by high pressure experience relatively dry conditions
- Regions influenced by low pressure receive ample precipitation
  - Tropical regions (equatorial low) are the rainiest
  - Subtropical deserts (subtropical high) are arid

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Global Distribution of Precipitation

- Other factors influencing precipitation
  - Nature of the air
    - Moisture capacity
  - Latitude
  - Distribution of continents and oceans
    - Distribution of mountains

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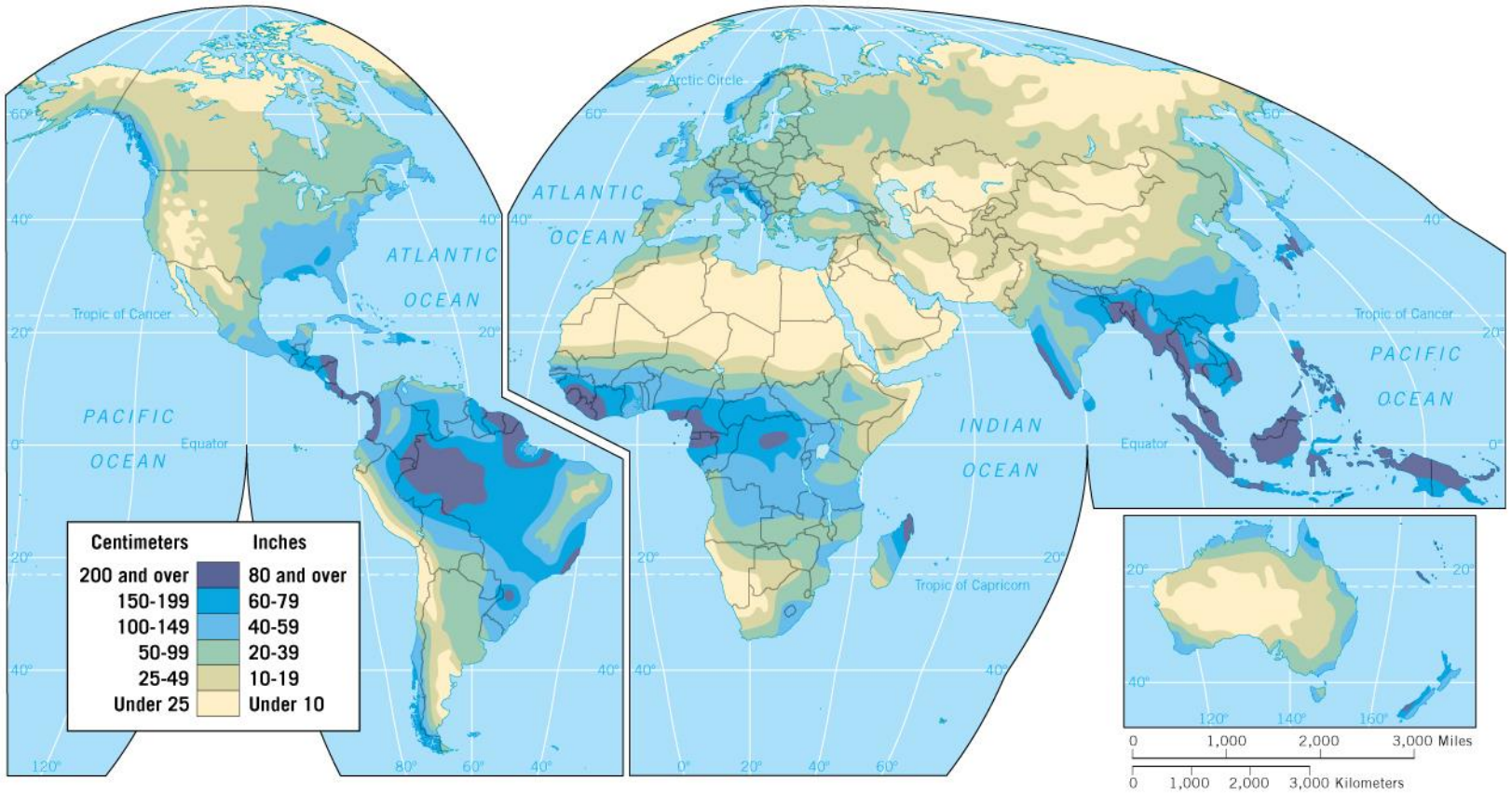
Global Distribution of Precipitation



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