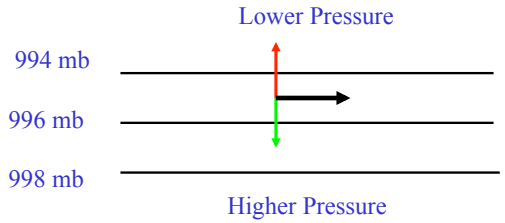
Geostrophic Balance

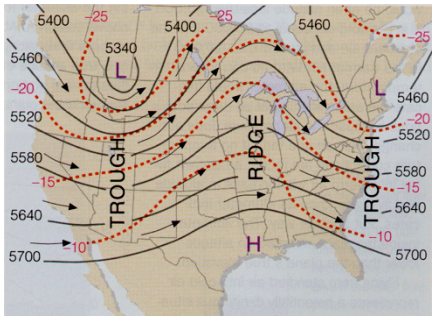
- The "Geostrophic wind" is flow in a straight line in which the pressure gradient force balances the Coriolis force.



Note: Geostrophic flow is often a good approximation high in the atmosphere (>500 meters)

Pressure patterns and winds aloft

At upper levels, winds blow parallel to the pressure/height contours

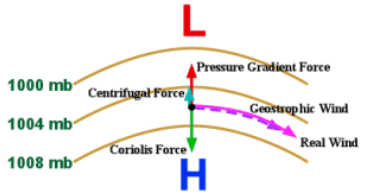


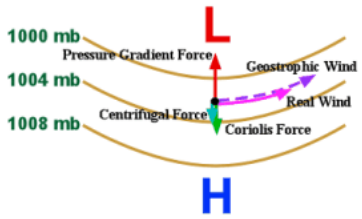
Gradient Wind Balance

- The "Gradient Wind" is flow around a curved path where there are three forces involved in the balance:
  - 1. Pressure Gradient Force
  - 2. Coriolis Force
  - 3. Centrifugal Force
- Important in regions of strong curvature (near high or low pressure centers)

Gradient Wind Balance

- Near a trough, wind slows as centrifugal force adds to Coriolis





- Near a ridge, wind speeds up as centrifugal force opposes Coriolis

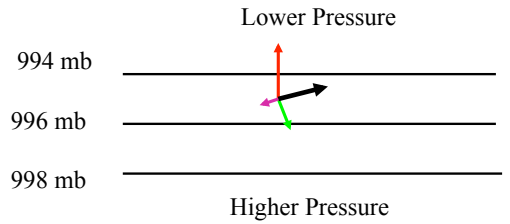
Friction is Important Near Earth's Surface

- Frictional drag of the ground slows wind down
  - Magnitude
    - Depends upon the speed of the air parcel
    - Depends upon the roughness of the terrain
    - Depends on the strength of turbulent coupling to surface
  - Direction
    - Always acts in the direction exactly opposite to the movement of the air parcel
- Important in the turbulent ***friction layer*** (a.k.a. the "planetary boundary layer")
    - ~lowest 1-2 km of the atmosphere
- Flow is nearly laminar aloft, friction negligible!

Three-Way Balance Near Surface (Pressure + Coriolis + Friction)

- Friction can only slow wind speed, not change wind direction
- Near the surface, the wind speed is decreased by friction, so the Coriolis force is weaker & does not quite balance the pressure gradient force
  - Force imbalance (PGF > CF) pulls wind in toward low pressure
  - Angle at which wind crosses isobars depends on turbulence and surface roughness
    - Average ~ 30 degrees

Geostrophic Wind Plus Friction

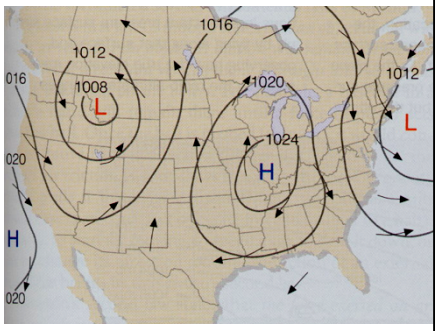


Wind doesn't blow parallel to the isobars, but is deflected toward lower pressure; this happens close to the ground where terrain and vegetation provide friction

Surface Pressure Patterns and Winds

Near the surface in the Northern Hemisphere, winds blow

- counterclockwise around and in toward the center of low pressure areas
- clockwise around and outward from the center of high pressure areas



Converging Wind, Vertical Motion, and Weather!

- Surface winds blow
  - In toward center of low pressure (convergence)
  - Out from center of high pressure (divergence)
- Air moves vertically to compensate for surface convergence or divergence
  - Surface convergence leads to divergence aloft
  - Surface divergence leads to convergence aloft

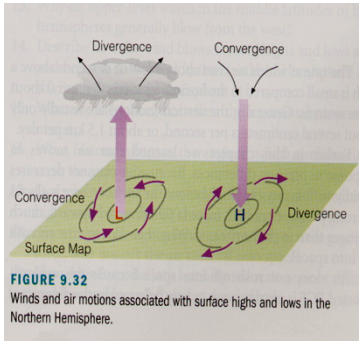


FIGURE 9.32
Winds and air motions associated with surface highs and lows in the Northern Hemisphere.

Remember

- Three real forces (gravity, pressure gradient, and friction) push the air around
- Two apparent forces due to rotation (Coriolis and centrifugal)
- Large-scale flow is dominated by gravity/ pressure and Coriolis … friction and centrifugal important locally