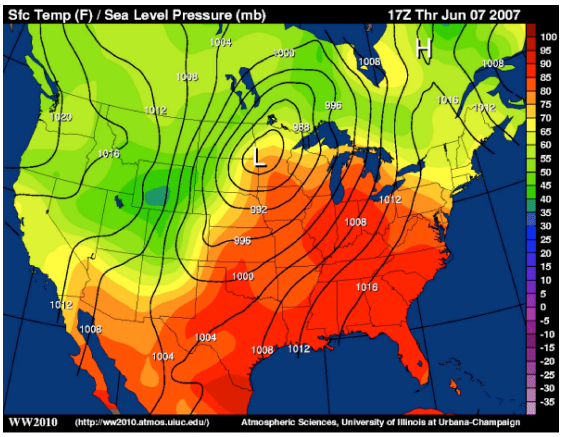
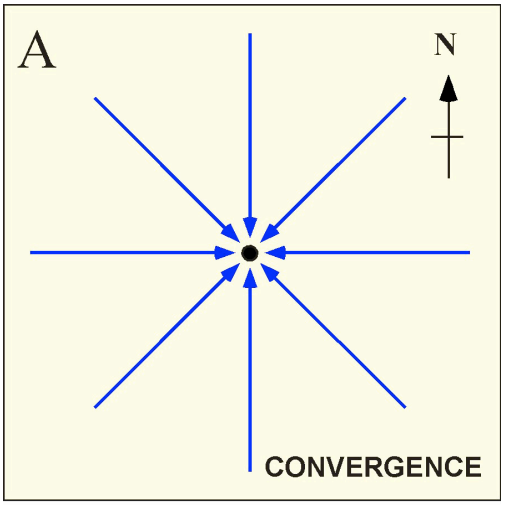


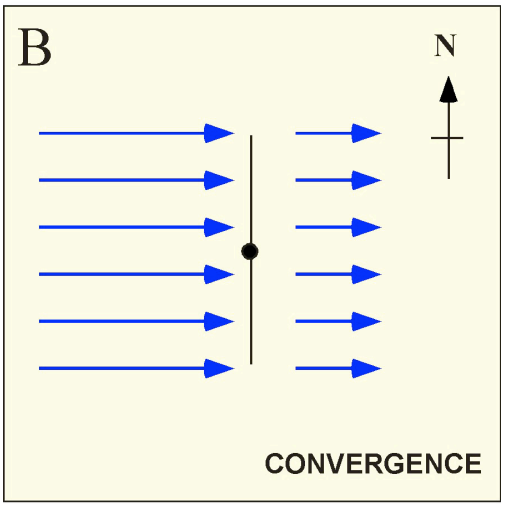
Courtesy of the Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign

Chapter 8
The Development of High and Low Pressure Systems

Convergence and Divergence

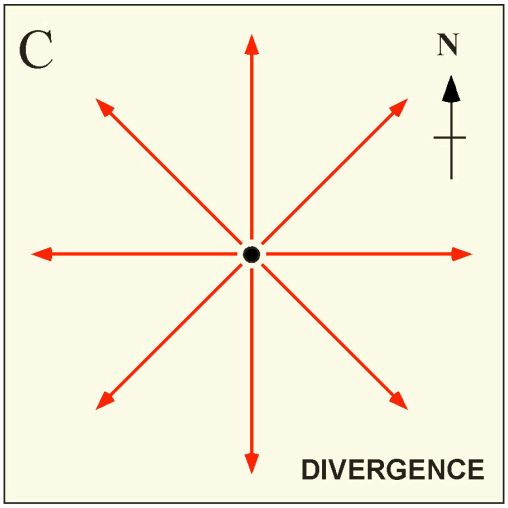
How do high and low pressure systems develop?

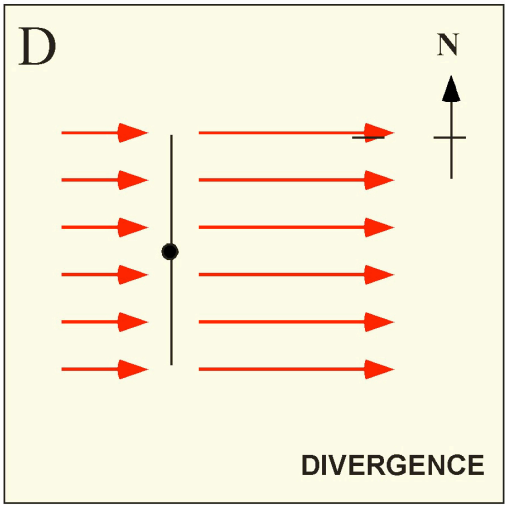




Convergence – a net inflow of air molecules into a region of the atmosphere

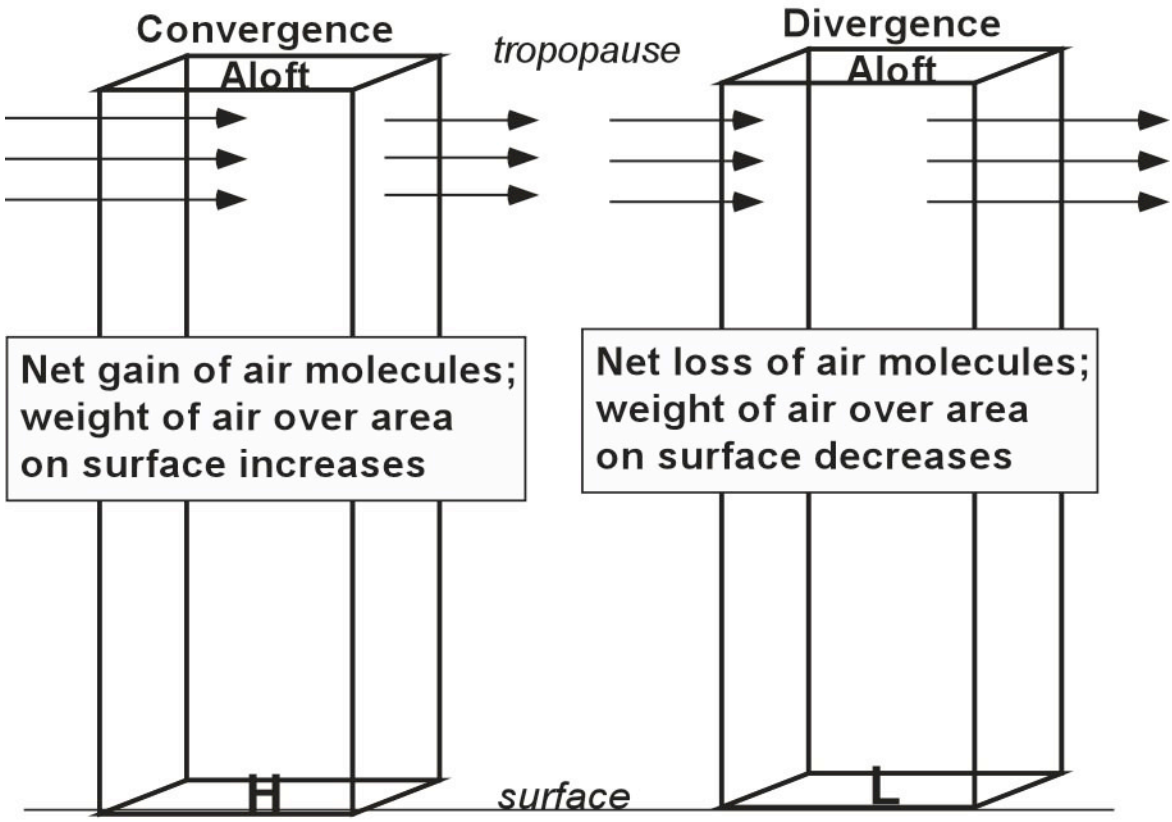
Convergence within an air column is always associated with increasing surface pressure, since the mass per unit area, or weight of the column, will increase with time.





Divergence – a net outflow of air molecules from a region of the atmosphere (the opposite of convergence)

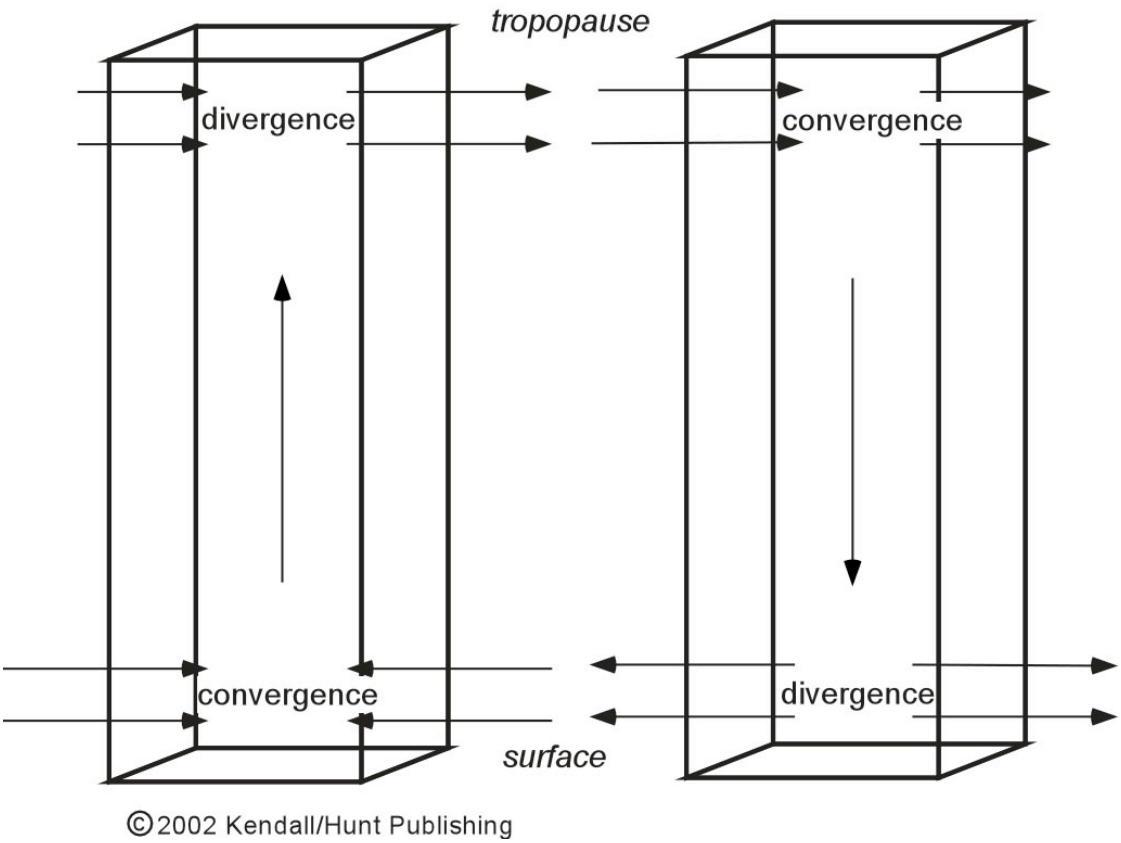
Divergence within an air column is always associated with decreasing surface pressure, since the mass per unit area, or weight of the column, will decrease with time.



High pressure center develops under region of maximum ***convergence*** aloft

Low pressure center develops under region of maximum ***divergence*** aloft

Convergence, Divergence, and Vertical Motion



Why does air rise in the column on the left and sink in the column on the right?

What happens to an air parcel as it rises in the atmosphere?

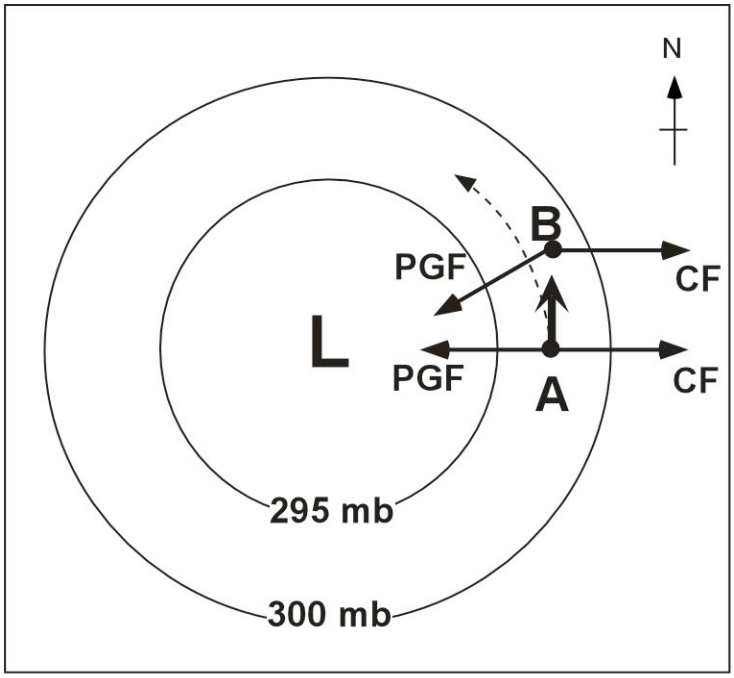
Temperature
Saturation vapor pressure
Relative humidity

What happens to an air parcel as it descends in the atmosphere?

Temperature
Saturation vapor pressure
Relative humidity

Typically, rising motion is associated with clouds and precipitation while sinking motion is associated with clear skies.

Curved Flow



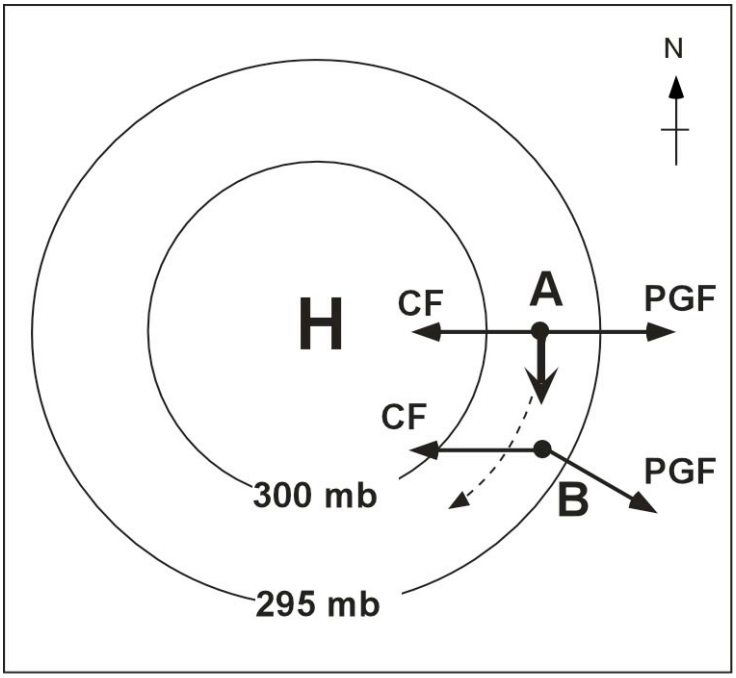
Flow around a circular low pressure center above the boundary layer

At point A the wind is initially in geostrophic balance and the PGF and CF are equal.

At point B is the magnitude of the PGF and the CF equal?

What does this imply about the wind speed compared to the geostrophic wind speed at point B?

In flow around a circular low pressure center (or any cyclonic flow), above the boundary layer, the true flow will be slower than the geostrophic value.



Flow around a circular high pressure center above the boundary layer

At point A the wind is initially in geostrophic balance and the PGF and CF are equal.

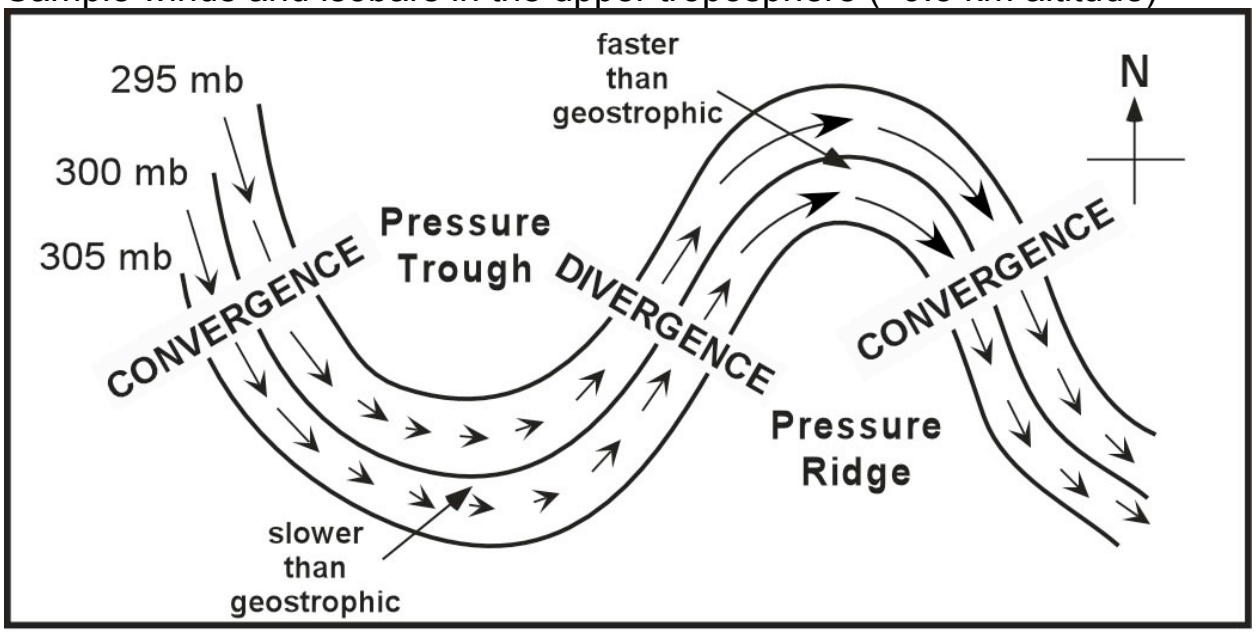
At point B is the magnitude of the PGF and the CF equal?

What does this imply about the wind speed compared to the geostrophic wind speed at point B?

In flow around a circular high pressure center (or any anticyclonic flow), above the boundary layer, the true flow will be faster than the geostrophic value.

Flow around a trough is cyclonic flow and flow around a ridge is anticyclonic flow.

Sample winds and isobars in the upper troposphere (~9.5 km altitude)



How does the wind speed change as an air parcel moves from the base of the trough to the crest of the ridge?

Does this change in wind speed cause convergence or divergence?

How does the wind speed change as an air parcel moves from the crest of the ridge to the base of the trough?

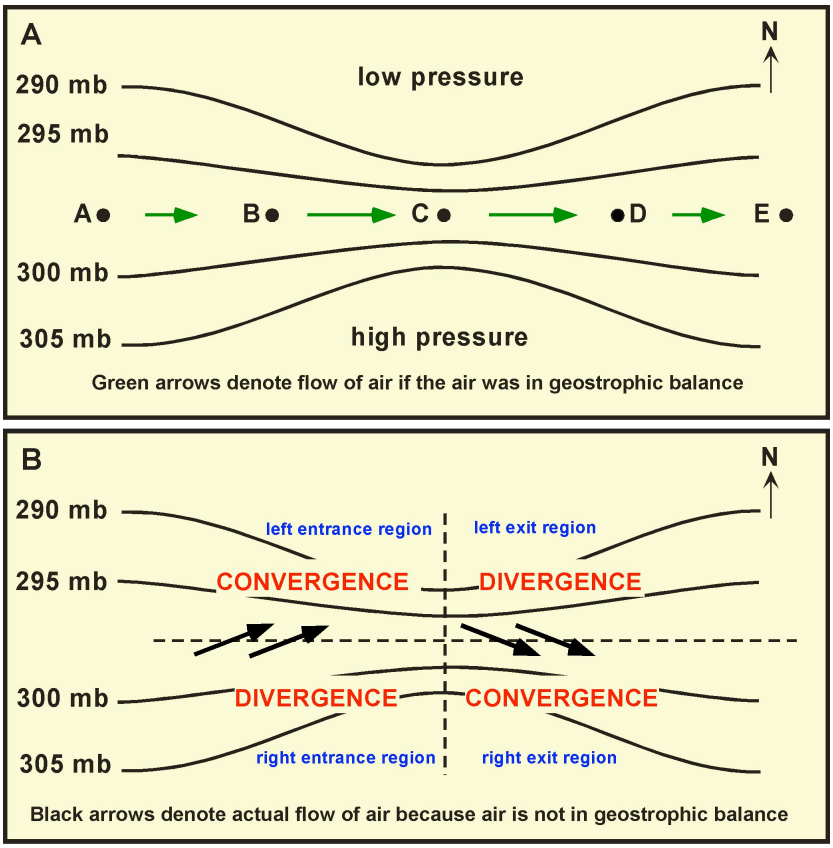
Does this change in wind speed cause convergence or divergence?

Where would you expect the surface pressure to decrease based on the figure above?

Movement from trough to ridge:	Movement from ridge to trough:
Air speeds up	Air slows down
Divergence	Convergence
Rising motion	Sinking motion
Decreasing surface pressure	Increasing surface pressure

Jetstreak – regions of exceptionally strong winds in the jetstream

Jetstreaks occur where the isobars (or height contours) are very closely spaced.



How does the PGF and CF change between points A and B?

How does the PGF and CF change between points C and D?

Air parcels are displaced northward in the entrance region of the jetstreak and southward in the exit region of the jetstreak.

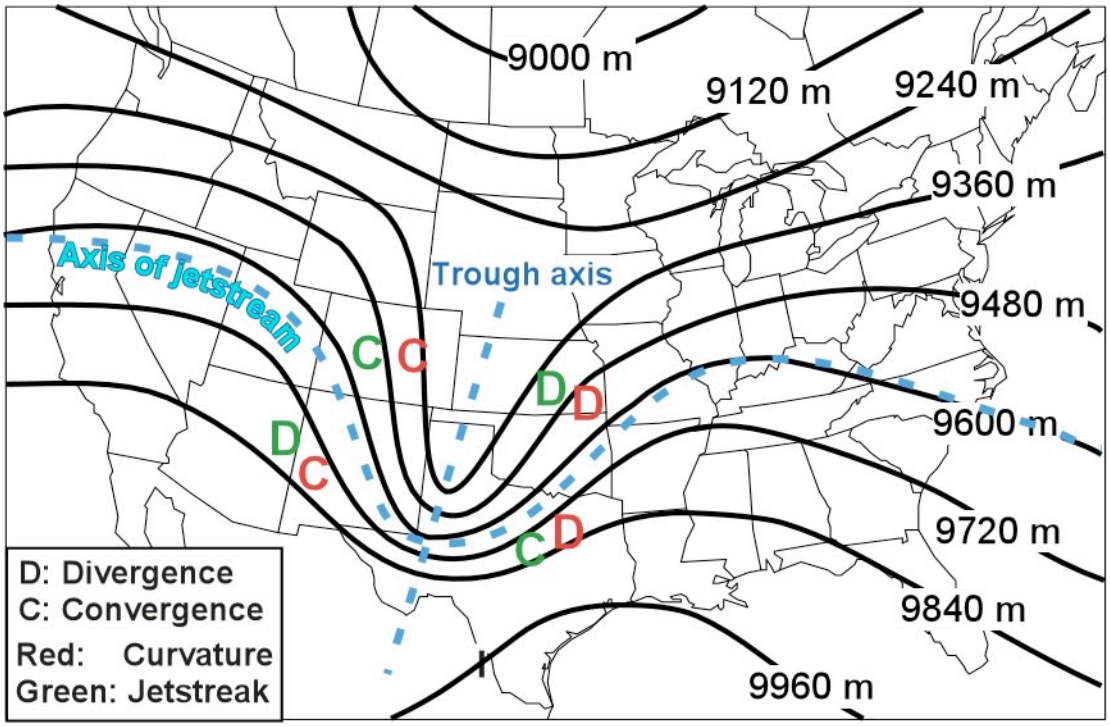
Where does divergence and convergence occur in a jetstreak?

Where would you expect the surface pressure to decrease based on the figure above?

Left entrance region: Convergence Sinking motion Increasing surface pressure	Left exit region: Divergence Rising motion Decreasing surface pressure
Right entrance region: Divergence Rising motion Decreasing surface pressure	Right exit region: Convergence Sinking motion Increasing surface pressure

Combined Effect of Curvature and Jetstreaks

What happens when a jetstream and curved flow occur in the same location?

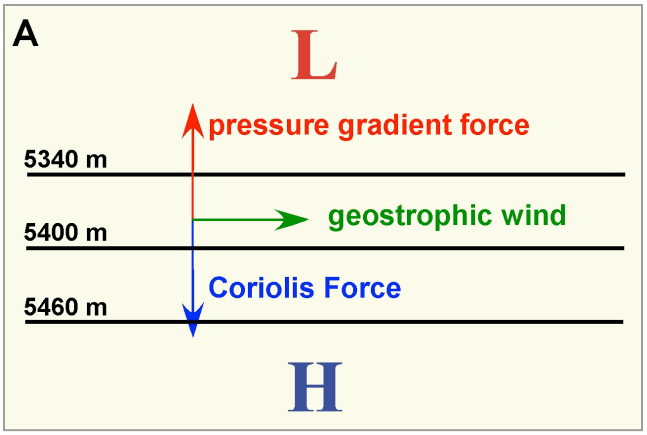


Where does the convergence associated with the jetstreak and the convergence associated with the curved flow coincide?

Where does the divergence associated with the jetstreak and the divergence associated with the curved flow coincide?

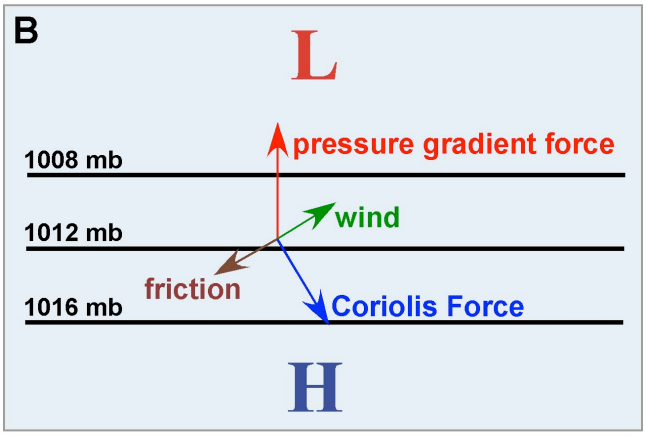
Where would you expect the surface pressure to decrease most rapidly?

The Friction Layer



At upper levels the flow is nearly geostrophic.

What forces do we need to consider for geostrophic flow?



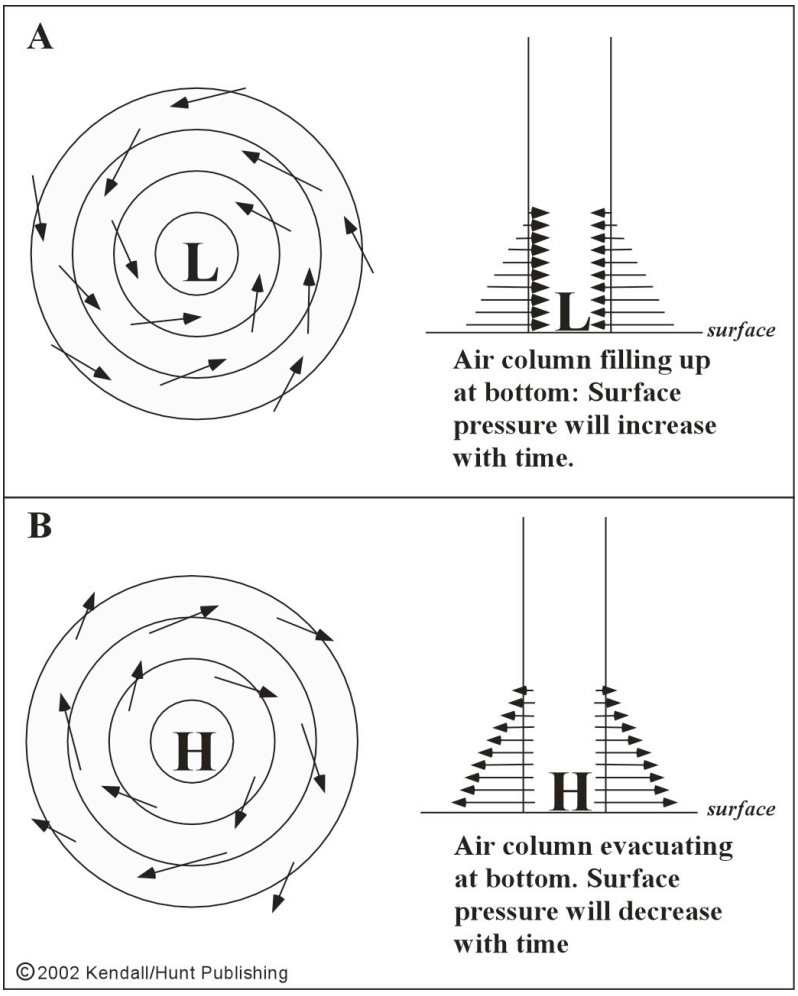
Near the surface friction becomes important.

What forces do we need to consider for horizontal flow in the friction layer?

Friction always decreases the wind speed

This causes the PGF to be larger than the CF.

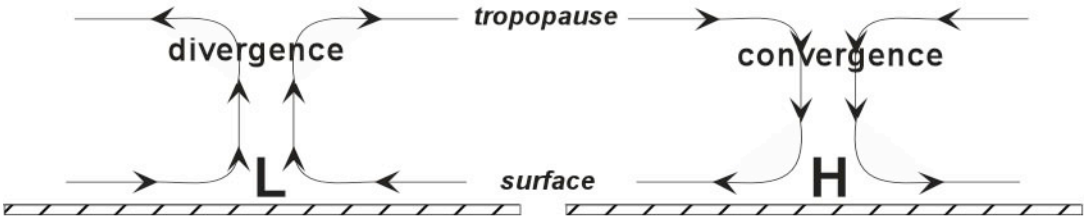
Friction always acts to turn the wind such that the flow has a component from higher pressure to lower pressure.

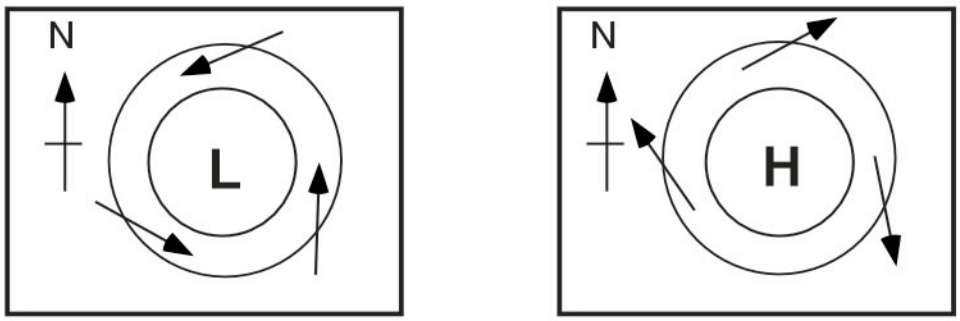


The larger the effect of friction the more the wind will turn to flow from higher pressure to lower pressure.

Friction decreases as you move up and away from the surface.

What is the three-dimensional flow around high and low pressure centers?





Air flows in towards a low pressure center at the surface and rises. This rising air is associated with clouds and precipitation. The air then diverges at upper levels of the troposphere.

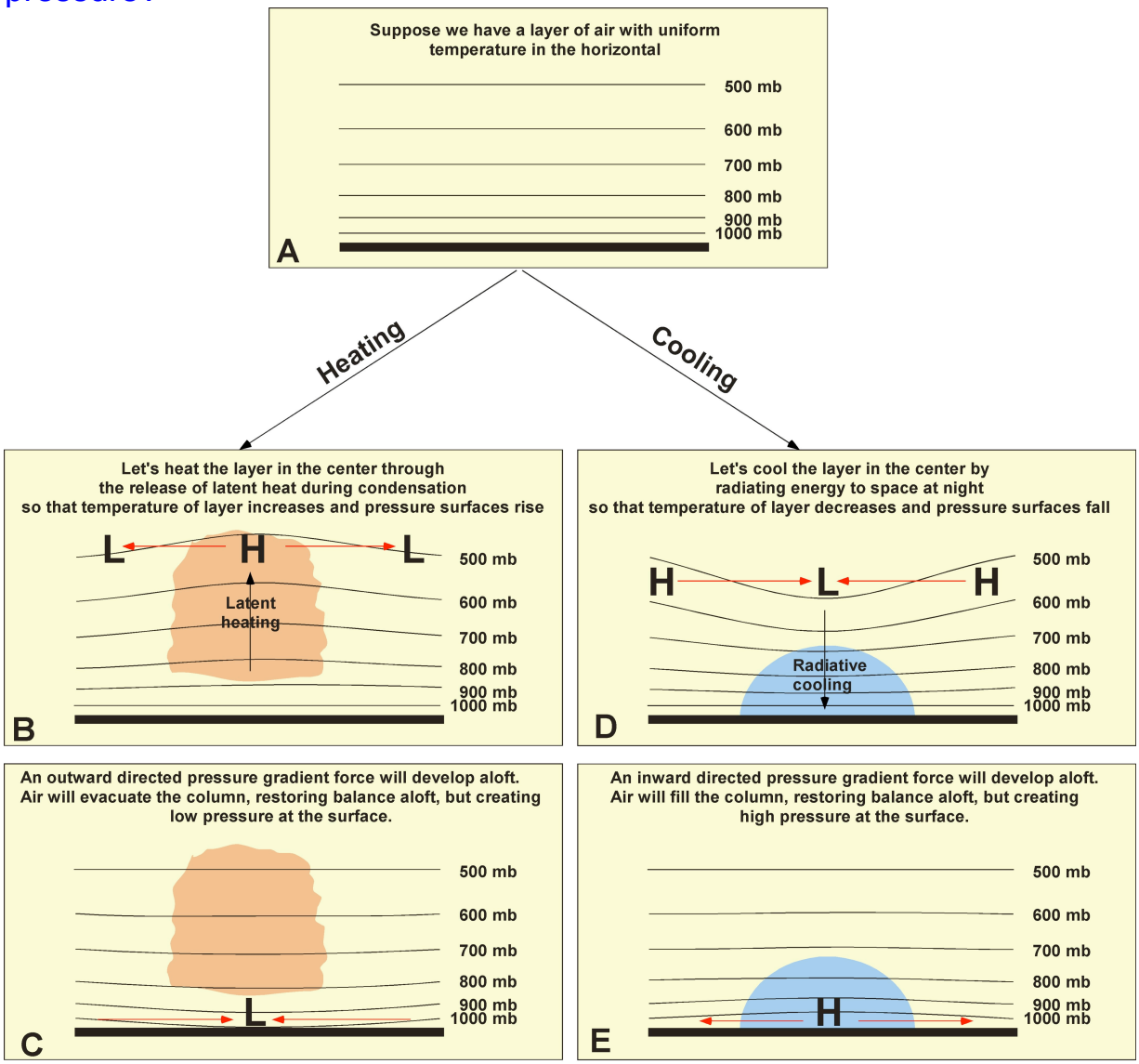
Air flows outward from a high pressure center at the surface, leading to sinking motion above the high pressure center. This sinking motion is typically associated with clear skies. At upper levels air often converges above a high pressure center.

Summary of the effects of friction:

Low pressure center:	High pressure center:
Wind spirals in towards low pressure center	Wind spirals out from high pressure center
Convergence	Divergence
Rising motion (cloudy skies)	Sinking motion (clear skies)
Increasing surface pressure	Decreasing surface pressure
Weakening low pressure	Weakening high pressure

Effects of Heating and Cooling

How does heating or cooling of the atmosphere change the surface pressure?

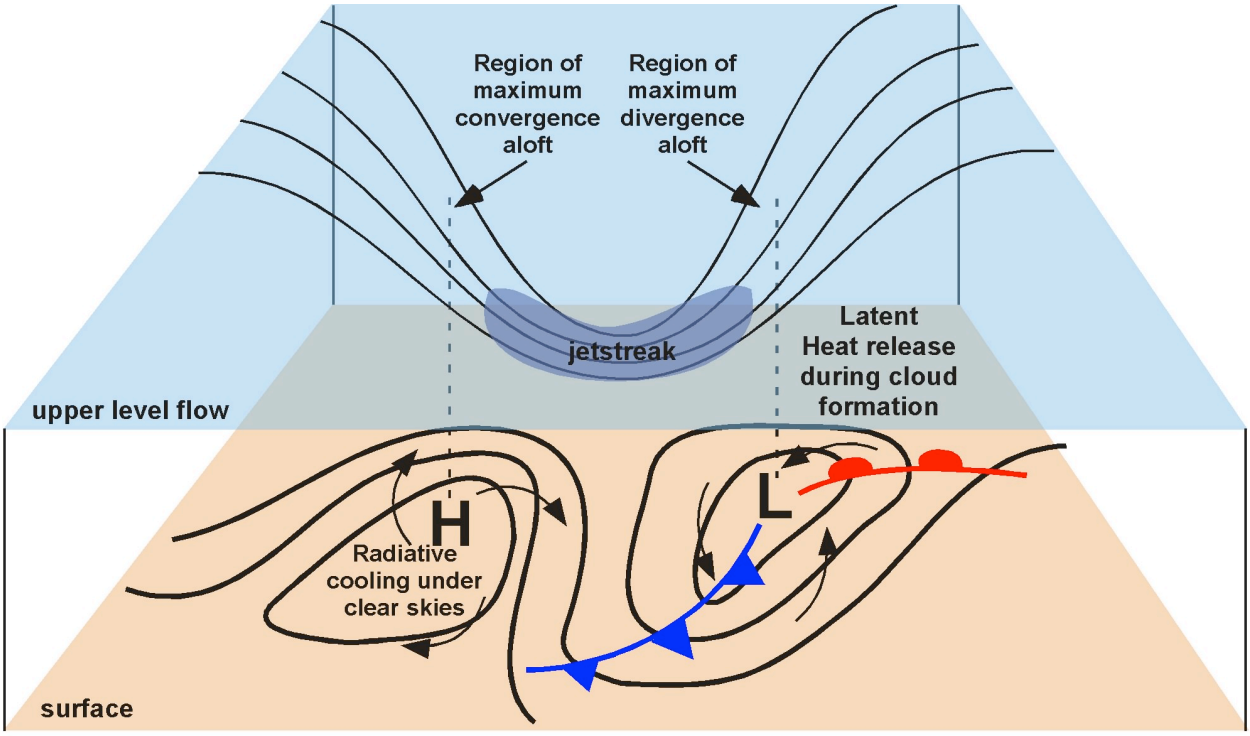


Warming of the atmosphere will lead to the formation of low pressure at the surface.

Cooling of the atmosphere will lead to the formation of high pressure at the surface.

The Development of High and Low Pressure Centers

(A synthesis of what we've learned in the chapter)



Dynamic processes (curvature, jetstreaks, and friction) and thermodynamic processes (heating and cooling) cause a redistribution of mass in the atmosphere and create high and low pressure centers.

We need to consider all of these processes (curvature, jetstreaks, friction, heating, and cooling) to understand why high and low pressure centers form in a particular location.

Low pressure at the surface usually forms initially due to upper level features such as troughs and jetstreaks

High pressure at the surface usually forms due to cooling of the air