Divergence/Convergence/Diffluence

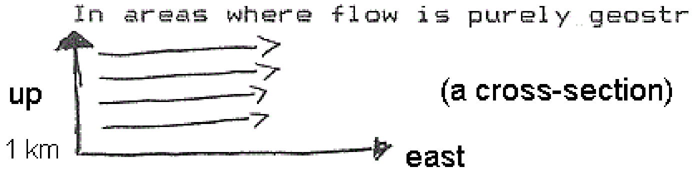
weather.gov/source/zhu/ZHU_Training_Page/Miscellaneous/Divergence/divergence.html

THERE IS NO VERTICAL MOTIONS (ascent or descent). BUT WHERE THERE IS VERTICAL MOTION, THE WINDS WILL NOT BE GEOSTROPHIC, AND THE WORD USED TO DESCRIBE THIS IS AGEOSTROPHIC WINDS.

FINAL SPECIAL NOTE!!! IF WINDS WERE PURELY GEOSTROPHIC EVERYWHERE, THERE WOULD BE NO WEATHER!!!

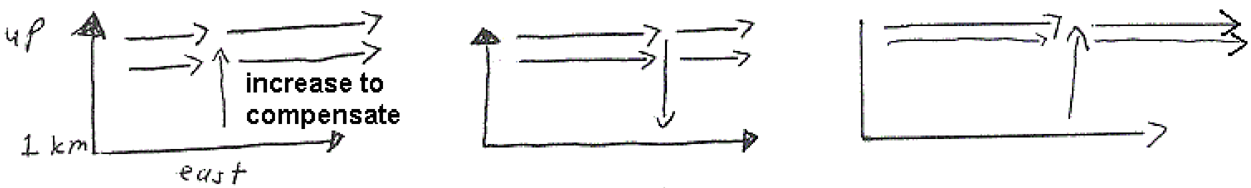
I realize this is somewhat confusing, so let's clarify these statements.

In areas where flow is purely geostrophic, flow looks like this:



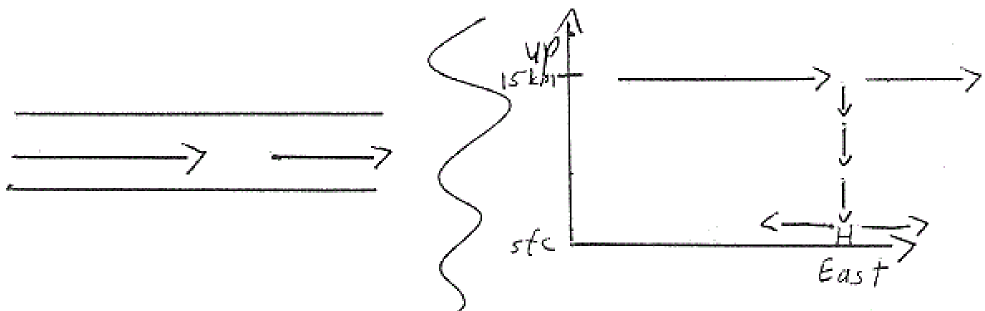
Note that there is no ascent or descent.

But in areas where there is ascent or descent, there is mass being added to (or removed from) the airflow from some other level.



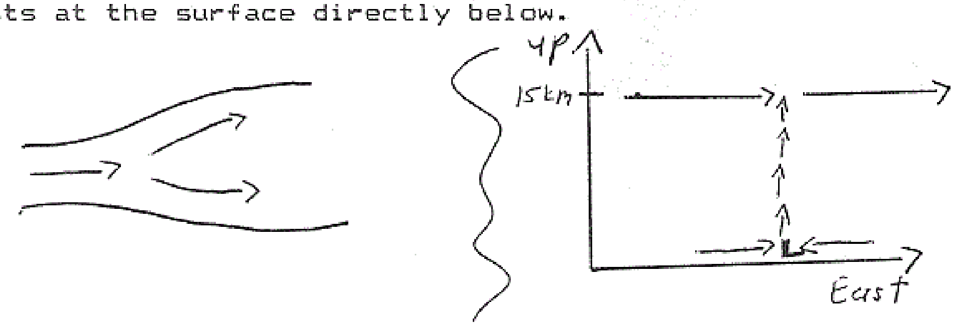
THREE EXAMPLES

I.



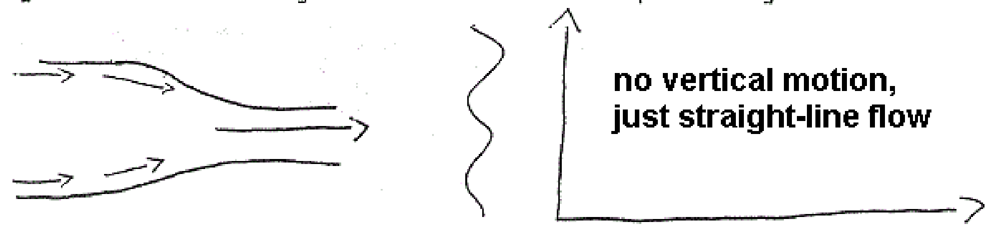
Since Δ X is constant, and the wind speed is decreasing downstream, this is an example of speed convergence. Note that there is an accumulation of mass aloft, so some of this excess mass is pushed down Furthermore, divergence (and a high pressure system) exists at the surface directly below.

II.



Since Δ X increases downstream, but wind speed is the same, this is directional divergence. At surface, there is a low pressure system and convergence. Note that mass is being added to the airflow from below due to rising motion. This explains why the winds are not slowing down even though the isobars are spreading out.

III.



ΔX decreases downstream, which implies directional convergence. But wind speed increases downstream, implying speed divergence. Since there is no rising or sinking motions, no mass is being added to or removed from the system. Therefore, these two terms cancel each other out, and net conv/div is zero.
Neither divergence nor convergence is occuring.

One implication of example III is that if winds were purely geostrophic, there are no rising or sinking motions. Since rising motions are needed for "weather" to occur, this implies that no weather would occur for a strictly geostrophic atmosphere. Ageostrophic winds are needed for weather to occur.

(+) Divergence
(-) Convergence **try to cancel out each other**

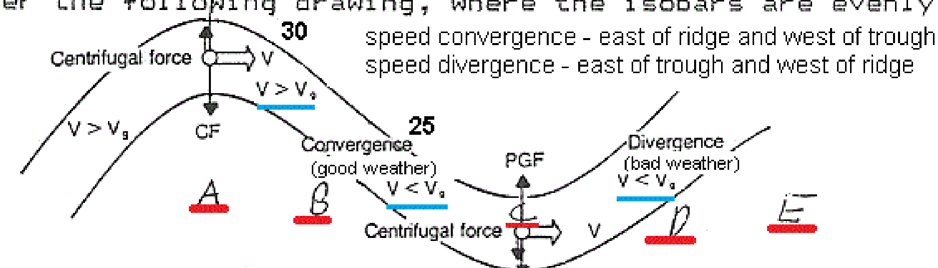
Concluding statements

In regions of little or no vertical motions, div/conv is zero, and the geostrophic wind approximation holds. In regions of vertical motions, div/conv is not zero, and winds are ageostrophic -- but the calculation will yield a small number on the order of 1×10^{-6}, since the two components try to cancel each other out. Thus, this is a tough term to calculate, especially if there are any errors in wind measurements. This is why meteorologists use the concept of vorticity instead (to be explained in a minute)!!! However, we can make some generalizations about div/conv around troughs and ridges.

PGF

Consider the following drawing, where the isobars are evenly spaced.

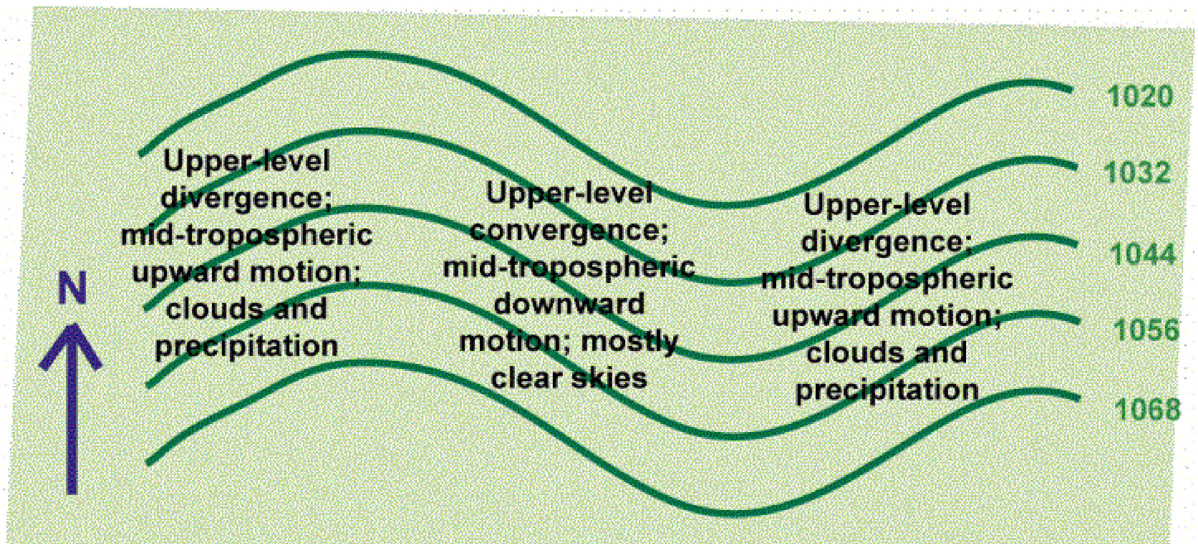
A-B	$V > V_g$
B-C	$V < V_g$
C-D	$V < V_g$
D-E	$V > V_g$



Since more air flows from A to B than from B to C, there will be convergence. Thus, some of the convergent air is forced to descend. THUS DOWNSTREAM OF A RIDGE AND UPSTREAM OF A TROUGH, THERE IS SUBSIDENCE AND GENERALLY GOOD WEATHER. However, less air flows from C to D than flows from D to E. THUS. DOWNSTREAM OF A TROUGH AND UPSTREAM OF A RIDGE, THERE IS ASCENT AND OFTEN CLOUDY AND RAINY WEATHER. Please note that the trough and ridge axis itself is generally a neutral area Of course, the spacing of the isobars usually are not constant, which complicates this scenario, but in general the capitolized statements are good rules to follow.

Finally, there is one more important fact to notice: THE UPPER LEVEL TROUGH IS LOCATED BEHIND, OR TO THE WEST, OF THE SURFACE LOW. LIKEWISE, AN UPPER LEVEL RIDGE IS LOCATED TO THE WEST OF THE SURFACE HIGH.

Note that these convergence and divergence patterns apply to the level of the upper-level trough or ridge, not to the entire troposphere. Since vertical motion is inhibited in the stratosphere, upper-level convergence is usually associated with downward motion beneath the level of convergence, in the interior of the troposphere. Conversely, upper-level divergence is found in association with upward motion in the interior of the troposphere. So we expect upward motion, and clouds and precipitation, on the downstream side of an upper-level trough and on the upstream side of an upper-level ridge. Clear skies and downward motion should be found on the upstream side of an upper-level trough and on the downstream side of an upper-level ridge. Of course, the actual weather may be different, due to topographic effects and other complications.

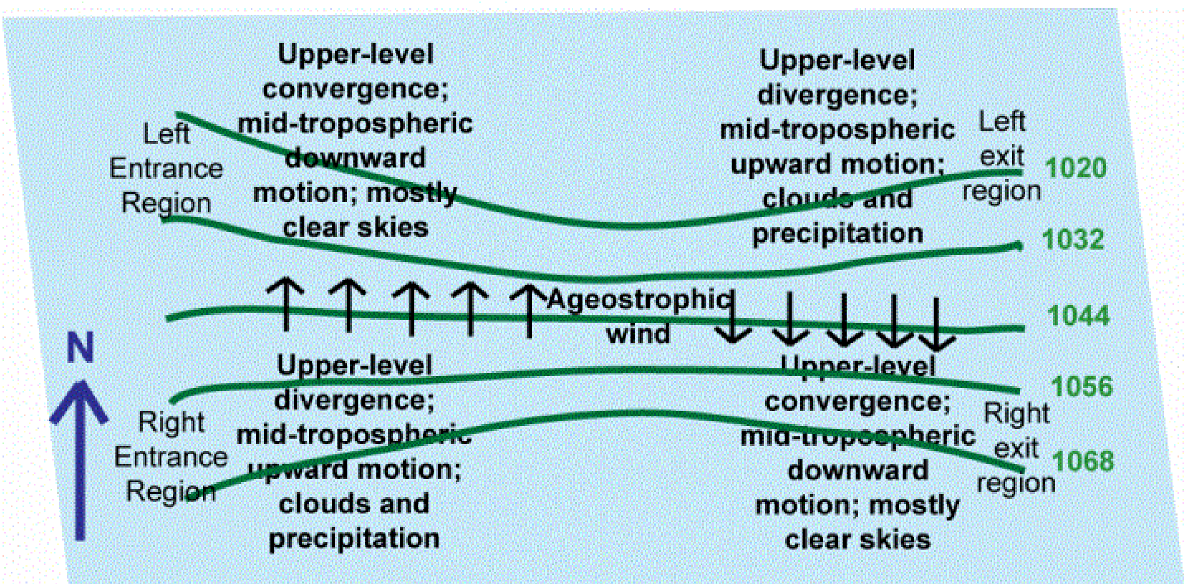


The relationship between upper-level troughs/ridges and vertical motion

The same sort of analysis can be conducted regarding a jet streak. Again, if we are aloft and air is flowing through the jet streak, the entrance of the jet streak will feature air drifting toward lower heights. The ageostrophic wind in this case is directed from higher heights toward lower heights. That means that there ought to be convergence on the low-height side of the entrance region and divergence on the high-height side of the entrance region.

Downstream, in the exit region of the jet streak, the wind is slowing down and the height contours are becoming farther apart. The ageostrophic wind has to have a component toward the higher heights if the air is to slow down.

This gives us a four-cell convergence pattern. If we imagine we are standing on the jet streak facing the direction in which it's moving, the right-hand side of the entrance region should be an area of divergence and the left-hand side should be an area of convergence. At the exit region, with the ageostrophic wind opposite, the divergence pattern is also opposite: divergence on the left side and convergence on the right side.



The relationship between an upper-level jet streak and vertical motion. Left and right refer to an observer facing downstream moving with the air.

These prototypical examples are the basic ones, but reality will tend to be more complex. In real situations, you might have to just look in the neighborhood of interest and figure out whether the air you care about is speeding up, slowing down, or turning, and estimate the ageostrophic wind accordingly.

Divergence in Natural Coordinates

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A. Background

While it is easy to visualize how divergence occurs with respect to pressure patterns when there is NO Coriolis effect (air moves at right angles to pressure or height contours towards low values), how does divergence "appear" on charts on which the wind is flowing parallel (or nearly parallel) to contours.

While it is difficult to visualize this, or actually see it on charts, divergence can be conceptualized better if one transforms it into the natural coordinate system. (As before, divergence in natural coordinates takes the form of $\Delta V/\Delta s$, and has conventional units).

B. Diffluence and Speed Divergence

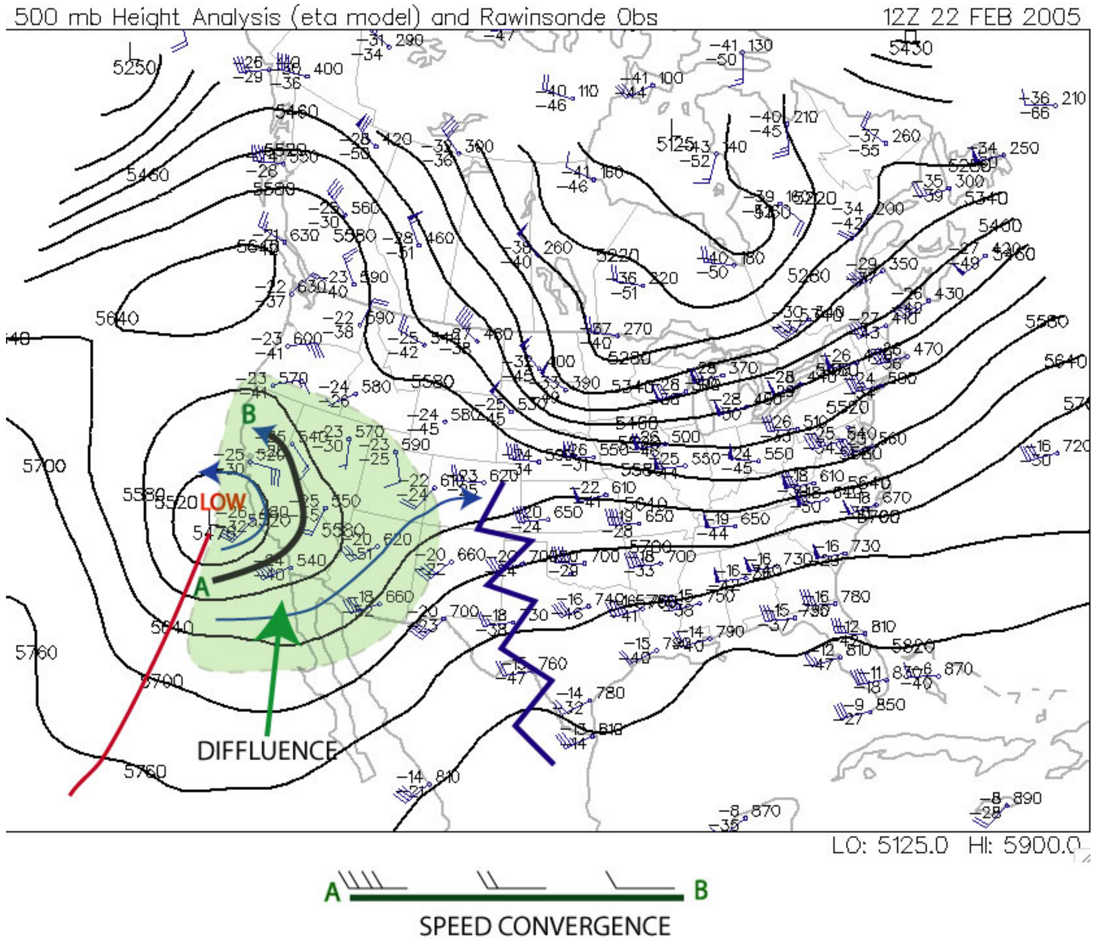
The concept equation for divergence in natural coordinates is as follows:

Horizontal Divergence = Diffluence + Speed Divergence

(Note: if diffluence is negative, it is called confluence, and if speed divergence is negative it is called speed convergence). The plus sign merely means you have to consider both effects, although the algebraic sign of one or both of the terms can be negative.

Let's consider this using the 500 mb level, since that is near the Level of Non-divergence. The concept equation above should produce a value near zero, therefore, when applied to the 500 mb level.

You have enough experience with charts drawn for the middle and upper troposphere (700 mb to 200 mb) to realize that the height and wind patterns resemble sine waves, with ridges and troughs. Let's examine the trough that was associated with the storminess in Southern California on February 22, 2005.



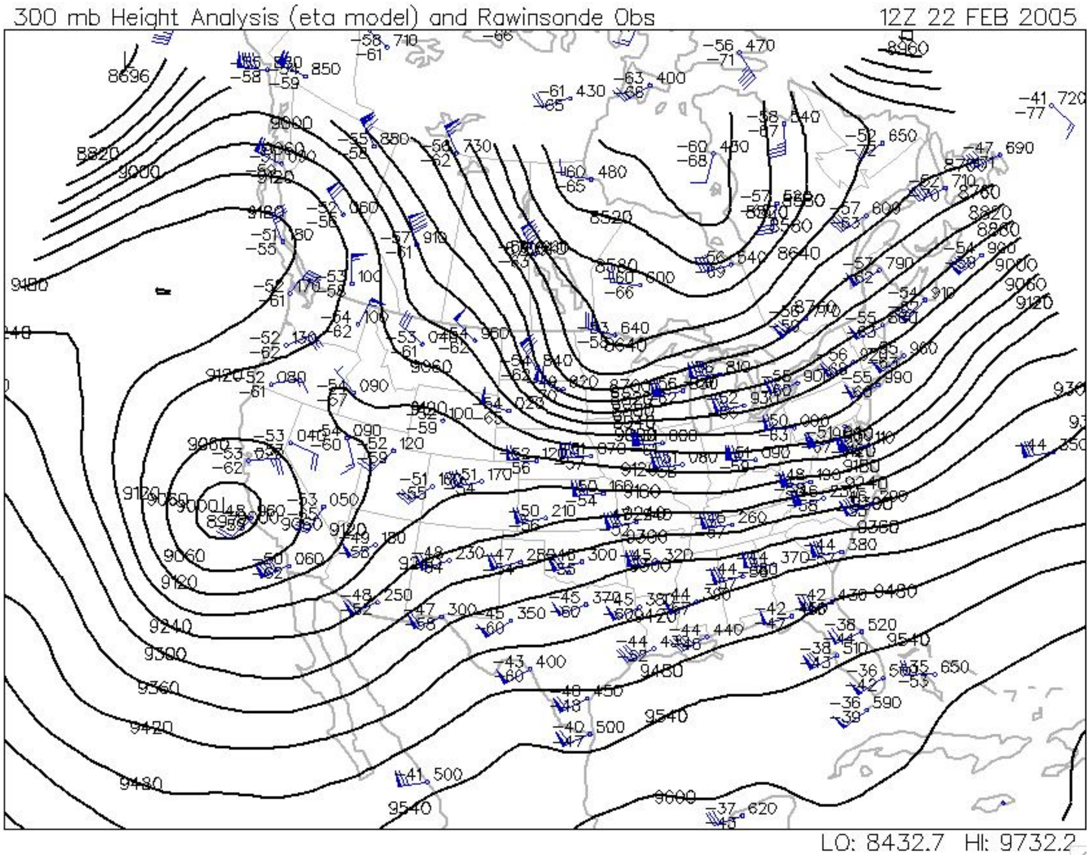
Note that in the green shaded area the wind streamlines are generally splitting apart from trough axis to ridge axis. This is called diffluence and it is very characteristis of trough/ridge systems in the jet stream that diffluence occurs east of troughs and confluence east of ridges.

That would suggest to the eye, at least, that divergence is occuring in the green region. But this is the 500 mb level, the level at which Non-divergence should be occuring.

Note that along each streamline, however, the wind speeds are stronger near the trough axis and weaker near the ridge axis. The inset shows the streamline that stretches from A to B on the chart. You will note that speed convergence is occurring along the streamline (meaning, that the air parcels on the west side of the streamline are "catching up" to the air parcels on the east side.

Thus in the concept equation above, diffluence would have a positive sign, but there would be a negative speed divergence. At the Level of Non-Divergence, these two terms are very nearly equal in opposite, producing non-divergence.

Let's take a look at a chart in the upper troposphere.



Note first that the chart has a very similar geometry, meaning the troughs and ridges are in basically the same location as they are on the 500 mb chart, as is the jet stream (this occurs in all cases, allowing you to infer positions of jet streams and troughs and ridges in the upper troposphere simply by looking at a 500 mb chart).

Note also that diffluence is occurring in the same region as it is on the 500 mb chart. But, to some extent, so is speed convergence. At this point, we must leave the quasi-quantative discussion aside, because it turns out that in the upper troposphere the two terms generally are not balanced...so that diffluence "wins" out, producing net divergence east of trough axes.

Below is excerpt from following web page:
http://www.propilotmag.com/archives/2013/April%2013/A4_Wx%20Brief_p1.html

Although air is in constant movement through all parts of the troposphere, the layer itself can be divided, meteorologically, in half. The lower half is the layer that provides the heat and moisture needed to support convection, while the upper half is the layer that promotes or suppresses the vertical motion of the air from below. The halfway point—around 500 mb or roughly FL180—is known by meteorologists as the level of nondivergence.

The level of nondivergence (LND) is so called because it rests beneath the upper levels of the troposphere, where a great deal of convergence or divergence of air flow takes place. This convergence and divergence is what helps to enhance or suppress the pressure systems moving along the surface.

For example, an area of diverging air in the upper troposphere will lower the air density aloft, encouraging the uplift of lower-level air and enhancing a surface low beneath it.

Conversely, upper troposphere convergence will increase density there, resulting in increased surface pressure. The strength of convergence or divergence aloft can best be captured by evaluating conditions at the LND. One of the most important measures of the potential of the upper levels to support convergence or divergence is **vorticity**.

Divergence Versus Diffluence

METEOROLOGIST JEFF HABY

Divergence occurs when a stronger wind moves away from a weaker wind or when air streams move in opposite directions. When divergence occurs in the upper levels of the atmosphere it leads to rising air. The rate the air rises depends on the magnitude of the divergence and other lifting or sinking mechanisms in the atmosphere. The 1st diagram below shows two examples of divergence.

Diffluence is the spreading of wind vectors. In a diffluent pattern the height contours become further spaced from each other over distance. Does this spreading out of the wind vectors and height contours cause the air to rise? The 2nd diagram below is an example of 300-mb diffluence.

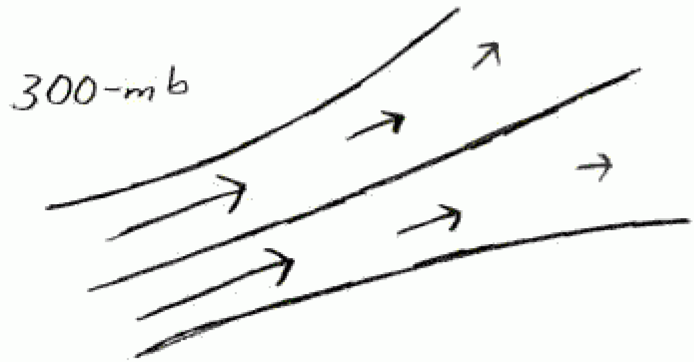
In a diffluent pattern, two distinct phenomena occur at the same time. First, strong wind is moving into weaker wind. Where the height contours are closer spaced, the wind velocity is higher. As you know, a strong wind moving into a weak wind is convergence. Second, as height contours spread apart, a divergence of air occurs. The convergence due to stronger wind moving into weaker wind replenishes the mass lost due to the divergence in the diffluent flow. In the bottom diagram below, notice in the diffluent pattern that strong wind is moving into weaker wind and the air streams are diverging over distance also.

The effect of convergence and divergence occurring at the same time is no vertical motion. The air is merely being deformed into a new shape. The air is spreading out, but it is not rising or sinking. It is upper level divergence that causes rising air. The two best examples of upper level divergence are PVA and divergence associated with the right rear and left front quadrants of a jet streak. Upper level diffluence by itself does not cause rising air.

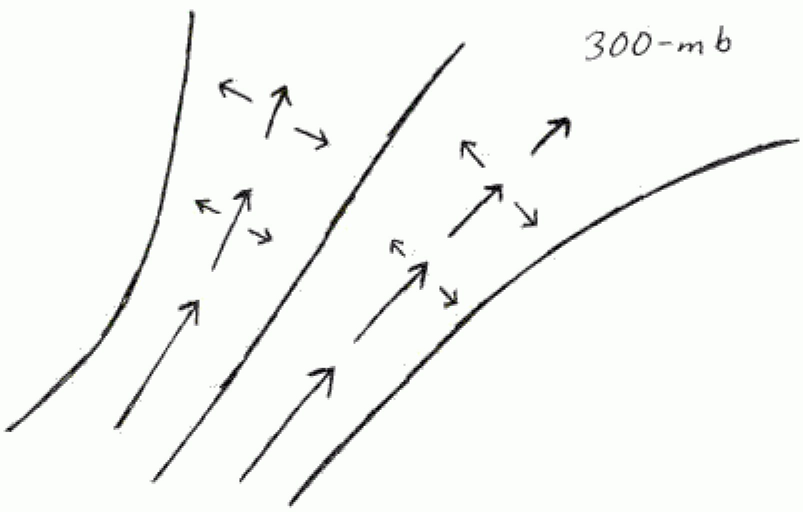
An upper level diffluence pattern by itself does not cause rising air. It is upper level divergence that causes rising air.

DIVERGENCE 1

DIVERGENCE 2



DIFFLUENCE



CONVERGENCE AND DIVERGENCE AT THE SAME TIME