Divergence in Natural Coordinates

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. While this is mathematically beyond the level of ERTH 260, we can work with the concept.

B. Diffluence and Speed Divergence

General

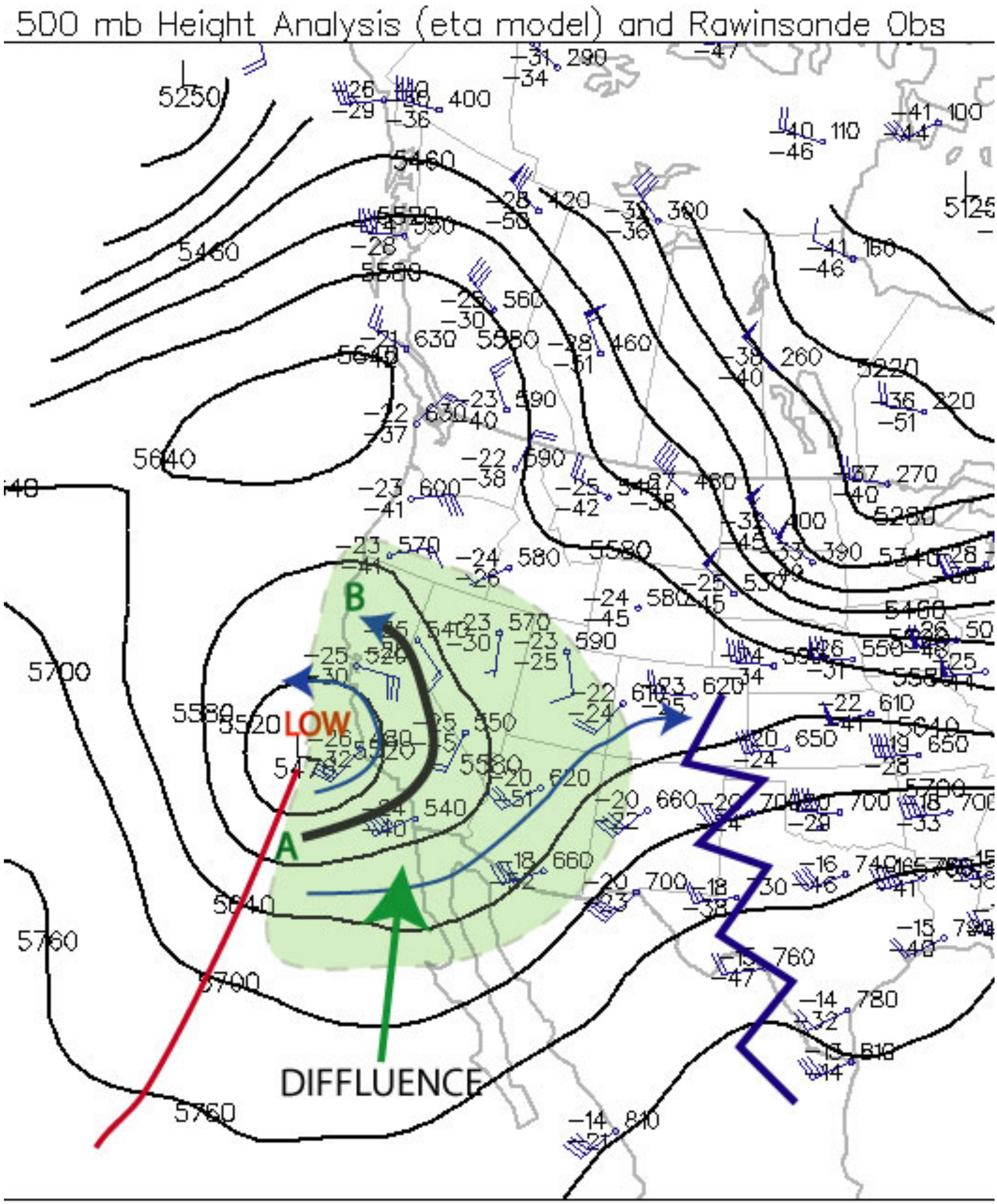
The concept equation for divergence in natural coordinates is as follows:

Horizontal Divergence = Diffluence (obvious lateral spreading) + 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.


500 mb Height Analysis (eta model) and Rawinsonde Obs
LOW
A
B
DIFFLUENCE


A
SPEED CONVERGENCE

Diffluence/Confluence

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 characteristic 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 occurring in the green region. But this is the 500 mb level, the level at which Non-divergence should be occurring.

Speed Divergence/Convergence

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.

Actually, the expression for speed divergence/convergence is easy to understand and calculate:

Speed Divergence = $\Delta V/\Delta s$

Algebraic Addition of Terms

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.

However, in the upper troposphere there is a tendency to speed convergence NOT to balance the diffluence east of troughs. Hence in the region between trough axis and downstream ridge axis, there is net divergence at that level. And in the region between ridge axis and downstream trough axis there is net convergence at that level.

Both the diffluence term and the speed divergence terms get smaller and smaller numerically the greater the distance between trough and ridge axes. Hence, for long waves, there is hardly any divergence or convergence at all in any region.

You will learn that the divergence and convergence patterns are partially responsible for the motion of these troughs and ridges in the upper troposphere. Thus, the fact that short waves move rapidly and long waves hardly at all will make more sense when we delve into these topics in ERTH 465.