Synoptic Meteorology I: Divergence and Vertical Motion Application

Let us consider several examples in which we can use the relationship between divergence and vertical motion to infer the vertical profile of the latter from the vertical profile of the former.

First, consider the case of lower-tropospheric convergence and upper-tropospheric divergence with a level of non-divergence in the midtroposphere. If we integrate (13) from the accompanying notes upward from the surface, we obtain increasingly negative ω (indicating increasingly large ascent) up to the level of non-divergence. Further upward, ω becomes less negative as upper-tropospheric divergence begins to offset the lower-tropospheric convergence in the integration, with ω reaching zero at the tropopause. The corresponding vertical profiles of divergence and vertical velocity for this example are provided in Fig. 1.

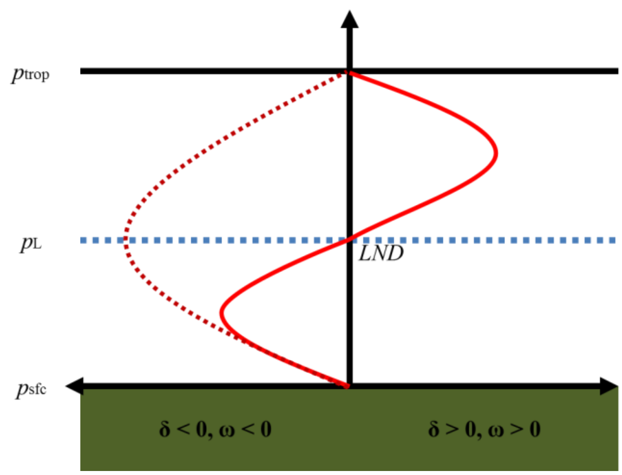

Figure 1. Vertical profiles of divergence (solid red line) and vertical motion (dashed red line) corresponding to the case of convergence in the lower layer, divergence in the upper layer, and the level of non-divergence at the interface between the two layers. Note how ascent ($\omega < 0$) is maximized at the level of non-divergence (*LND*).

Next, consider the case of lower-tropospheric divergence and upper-tropospheric convergence with a level of non-divergence in the midtroposphere. If we integrate (13) upward from the surface, we obtain an increasingly positive ω (indicating increasingly large descent) up to the level of non-divergence. Further upward, ω becomes less positive as upper-tropospheric convergence begins to offset the lower-tropospheric divergence in the integration, with ω reaching zero at the tropopause. The corresponding vertical profiles of divergence and vertical velocity are provided in Fig. 2.

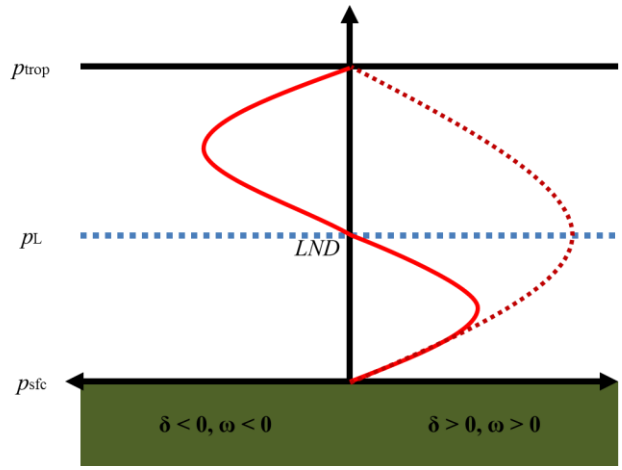

Figure 2. Vertical profiles of divergence (solid red line) and vertical motion (dashed red line) corresponding to the case of divergence in the lower layer, convergence in the upper layer, and the level of non-divergence at the interface between the two layers. Note how descent ($\omega > 0$) is maximized at the level of non-divergence (*LND*).

We can consider even more complex examples than in Figs. 1 and 2. In Fig. 3, we are presented with an example like in Fig. 1, except with two wavelengths in the vertical profile of divergence rather than just one. Integrating upward from the surface, lower-tropospheric convergence results in ascent. This makes sense: converging air at ground level must go somewhere, and if it cannot go down into the ground, it must go up.

When the vertical integral of divergence reaches its maximum negative value – where the vertical profile of divergence switches from convergence to divergence, or the first level of non-divergence – ascent is maximized. Ascent decreases to zero when the vertical integral of divergence becomes zero at p_L, whereupon the area of convergence near the surface becomes exactly balanced by the area of divergence above it. The pattern repeats as you continue upward from p_L.

In Fig. 4, we are presented with an even more complex – but also more realistic, representing the vertical profile of divergence within a stratiform precipitation region (such as those associated with mesoscale convective systems) – example. This example is characterized by weak convergence in the near-surface layer, midtropospheric divergence, and near-tropopause convergence. Integrating upward from the surface results in ascent maximized at the lower level of non-divergence, zero at the dotted green line where the vertically integrated divergence is zero, descent over a deep vertical layer in the mid- to upper troposphere that is maximized at the upper level of non-divergence, and zero vertical motion at the tropopause.

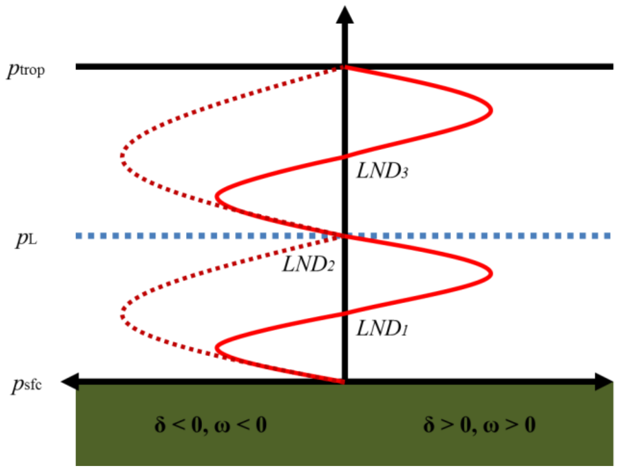

Figure 3. Vertical profiles of divergence (solid red line) and vertical motion (dashed red line) corresponding to the case of equal areas of convergence-divergence-convergence-divergence from the surface to the tropopause. Note how ascent is either maximized or is zero at a level of non-divergence, depending upon the vertical integral of δ from the surface to that altitude.

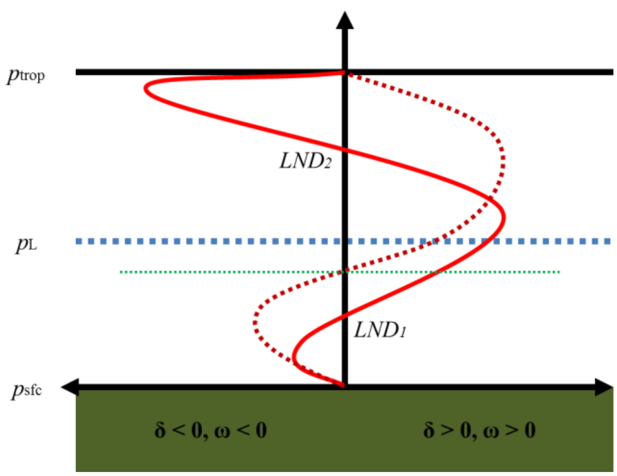

Figure 4. Vertical profiles of divergence (solid red line) and vertical motion (dashed red line) corresponding to the case of unequal areas of convergence-divergence-convergence from the surface to the tropopause. The dashed green line indicates the first altitude above the ground where the vertically integrated divergence is zero; the only other such altitude is p_{trop}.