Lab No. 3

Finding Trough and Ridge and Determining The Relative Vorticity at The 500 mb Level Maps

The aim:

Analysis of the map of 500 mb, and an attempt to determine the valleys, ridges, and vortices.

Tools:

Weather map for a level of 500 mb, colored pens (black, red, green, blue).

Methodology:

Counterclockwise rotation about a local vertical axis defines positive vorticity. One type of vorticity ζr , called relative vorticity, is measured relative to both the location of the object and to the surface of the Earth (also see the Forces & Winds chapter). Picture a flower blossom dropped onto a straight river, where the river current has shear (Fig. 1). As the floating blossom drifts (translates) downstream, it also spins due to the velocity shear of the current. Both Figs. 1. a & 1. b show counterclockwise rotation, giving positive relative vorticity as defined by:

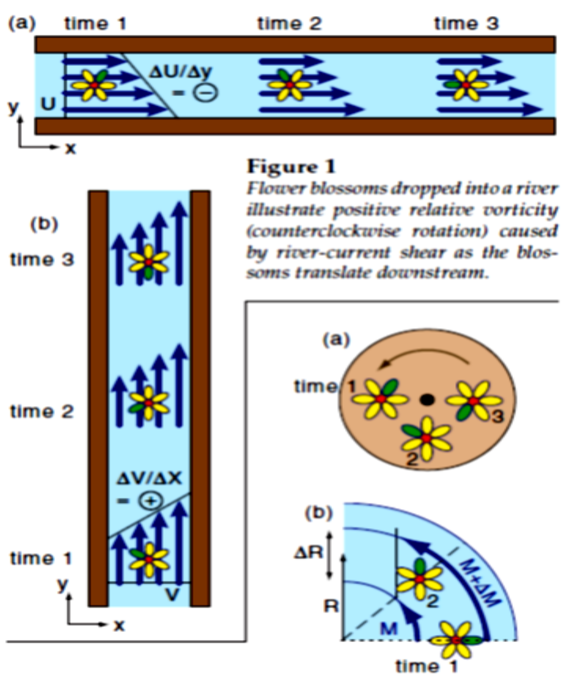


Figure 1
Flower blossoms dropped into a river illustrate positive relative vorticity (counterclockwise rotation) caused by river-current shear as the blossoms translate downstream.

$$\zeta_r = \frac{\Delta V}{\Delta x} - \frac{\Delta U}{\Delta y}$$ ……. [1]

for (U, V) positive in the local (x, y) directions. Next, consider a flower blossom glued to a solid turntable, as sketched in Fig. 1.a. As the table turns, so does the orientation of the flower petals relative to the center of the flower. This is shown in Fig. 1.b. Solid-body rotation requires vectors that start on the dotted line and end on the dashed line. But in a river (or atmosphere), currents can have additional radial shear of the tangential velocity. Thus, relative vorticity can also be defined as:

$$\zeta_r = \frac{\Delta M}{\Delta R} + \frac{M}{R}$$ ……..[2]

For pure solid-body rotation (where the tangential current- or wind-vectors do indeed start at the same dotted line and end at the same dashed line in Fig. 1.b), eq. 2 can be rewritten as:

$$\zeta_r = \frac{2M}{R}$$ ……….{3}

Relative vorticity has units of s–1. A quick way to determine the sign of the vorticity is to curl the fingers of your right hand in the direction of rotation.

If your thumb points up, then vorticity is positive. This is the **right-hand rule**. Fig. 2 shows the relative vorticity of various signs, where vorticity was created by both shear and curvature.

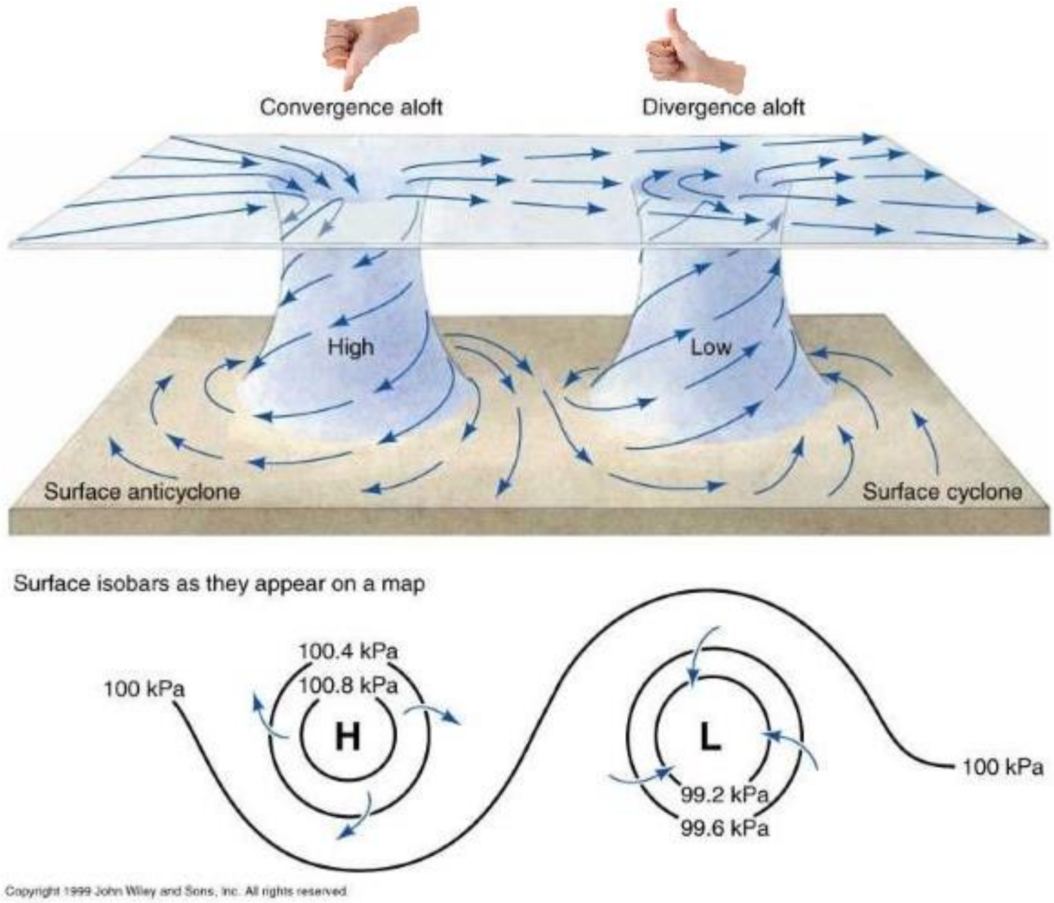


Fig 2

Troughs:

It is the meandering of cold polar air (low thickness) towards tropical regions with warmer air (high thickness). Troughs are usually associated with bad weather and weather manifestations such as rain and others.

Troughs can be determined on the map, by drawing a dashed line passing through the center of the Trough and the direction of its extension to the south.

Ridge:

It is the meandering of warm tropical air (high Thickness) towards the polar regions with cold air (Low Thickness) and is usually associated with an improvement in the weather condition. The Ridge can determine on a map of 500 mb, by drawing a zigzag line passing through the center of the convexity and toward Stretch it north.

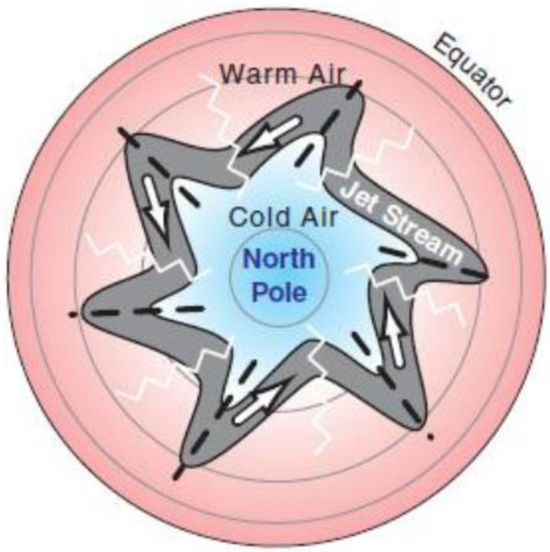
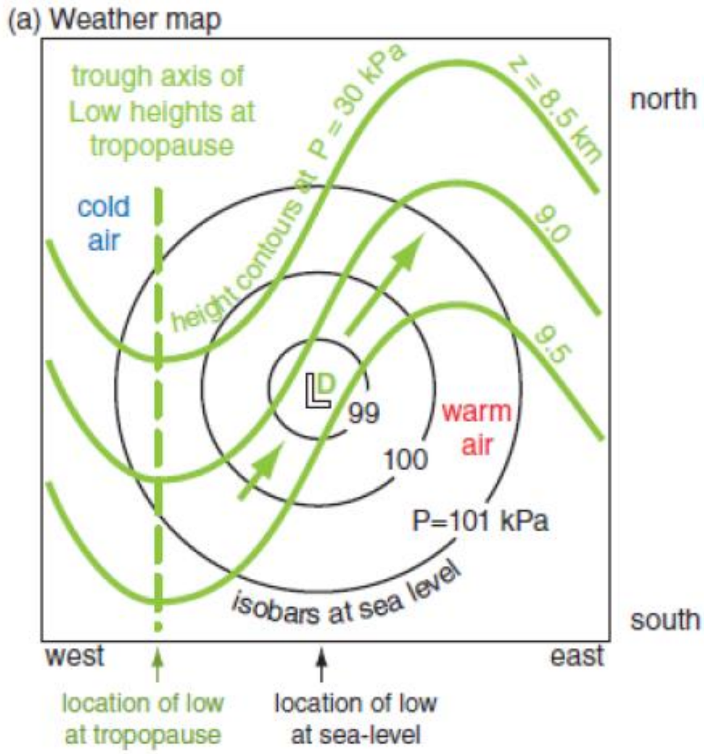


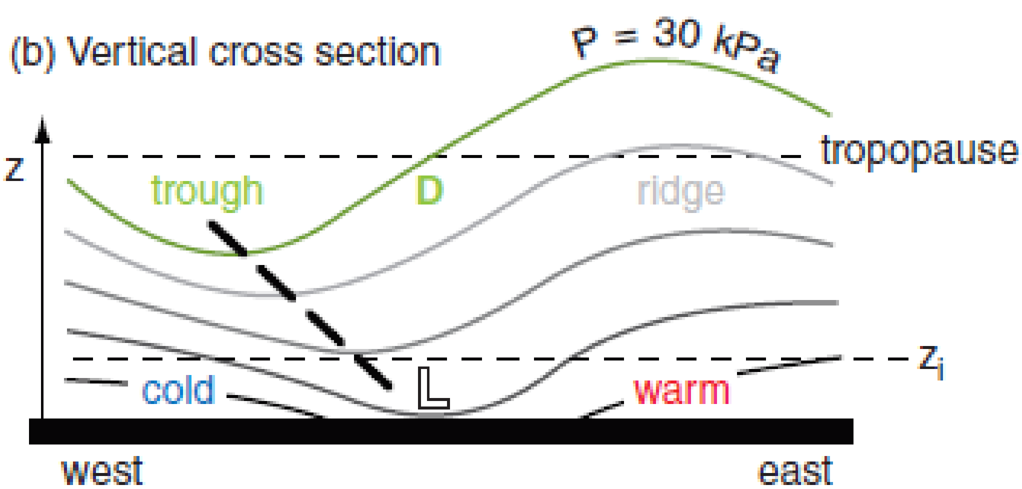
Fig. 3

The region of instability is always located at the center of low pressure, which formed in the transitional region between the Trough and the ridge, as shown in Figure (4) for the horizontal and vertical sections of the depressions of the middle widths.

The area marked with the letter D is the area where winds approach the surface and ascend upwards.



(a) Weather map
trough axis of Low heights at tropopause
cold air
height contours at P = 30 kPa
z = 8.5 km
9.0
9.5
north
D
L
99
100
warm air
P=101 kPa
isobars at sea level
south
west
east
location of low at tropopause
location of low at sea-level



(b) Vertical cross section
P = 30 kPa
z
tropopause
trough
D
ridge
L
cold
warm
z_i
west
east

Fig. 4

the procedure:

1 - Draw the contour lines for the potential height on the 500 mb map.

2 - Determine the troughs by drawing a dashed line, passing from the center of the Trough towards the south.

3 - Determine the ridge by drawing a zigzag line passing from the center of the Ridge towards the north.

4 - Using equation No. 3, calculate the relative vorticity at selected points.

5 - Determine the regions of instability according to the value of relative vorticity