Mechanisms of pressure change

Pressure tendency equation: To derive pressure tendency equation, we shall start from the hydrostatic approximation

$$\frac{\partial p}{\partial z} = -g\,\rho \;\ldots\ldots.(1)$$

Integrating the above equation vertically from an arbitrary level $z = z_0$ to $z = \infty$, we obtain,

$$\int_{z=z_0}^{\infty} \frac{\partial p}{\partial z} dz = -\int_{z=z_0}^{\infty} g\rho\, dz$$

$\Rightarrow\ p(z_0) = \int_{z_0}^{\infty} g\,\rho dz$, since, at the top of the atmosphere there is no pressure.

Now, differentiating the both sides of the above partially with respect to time, we obtain,

$$\frac{\partial p}{\partial t} = \frac{\partial}{\partial t}\left(\int_{z_0}^{\infty} g\rho dz\right) = g\int_{z_0}^{\infty}\frac{\partial \rho}{\partial t}\,dz$$

Again from continuity equation we have, $\frac{\partial \rho}{\partial t} = -\vec{\nabla}.(\rho\vec{V})$

So, we have,

$$\frac{\partial p}{\partial t} = -g\int_{z_0}^{\infty}\vec{\nabla}.(\rho\vec{V})\,dz$$

$$= -g\int_{z_0}^{\infty}\rho(\vec{\nabla}_h.\vec{V}_h)dz + g\int_{z_0}^{\infty}\left(-\vec{V}_h.\vec{\nabla}_h\rho\right)dz + g\rho(z_0)w(z_0)$$

The above equation is known as pressure tendency equation. Left hand side of the above equation represents pressure tendency at a point at level $z = z_0$ and right hand side consists of three terms each of which representing some mechanisms for pressure change.

First term is known as divergence term. It represents net lateral divergence or convergence across the sidewall of an atmospheric column with base at $z = z_0$ and extending up to top of the atmosphere. We know that pressure at $z = z_0$ is nothing but the weight of air contained in an atmospheric column with base at $z = z_0$ having unit cross sectional area and extending up to top of the atmosphere. Now this weight will increase or decrease if mass of air inside this column increases or decreases. Again mass of air inside this column increases or decreases if there is net inflow (convergence) or out flow (divergence) of air. Hence, net lateral divergence leads to fall in pressure and net lateral convergence leads to a rise in pressure. For synoptic scale system, this term contributes significantly towards pressure change.

Second term expresses the net lateral advection of mass into the atmospheric column with base at $z = z_0$ having unit cross sectional area and extending up to top of the atmosphere. Clearly net positive advection leads to an increase in mass, which in tern leads to rise in pressure and net negative advection leads to a decrease in mass which in tern leads to fall in pressure.

Third term expresses flux of mass into the above atmospheric column across its base at $z = z_0$.

Movement of different pressure systems: Here we shall discuss the movement of pressure systems (lows/highs) for different isobaric patterns. Mainly we shall discuss Sinusoidal pattern, circular pattern and circular pattern beneath a Sinusoidal pattern above.

Sinusoidal isobaric pattern: Let us refer to the adjoining sinusoidal pressure pattern. Ahead of the trough there is divergence and ahead of the ridge there is convergence at the surface. Hence fall in pressure takes place ahead of trough and rise in pressure ahead of ridge. Due to this, after some time lowest pressure will be found ahead of trough, as a result trough will be shifted towards east of its present location. Hence, the pressure system will move in a westerly direction.

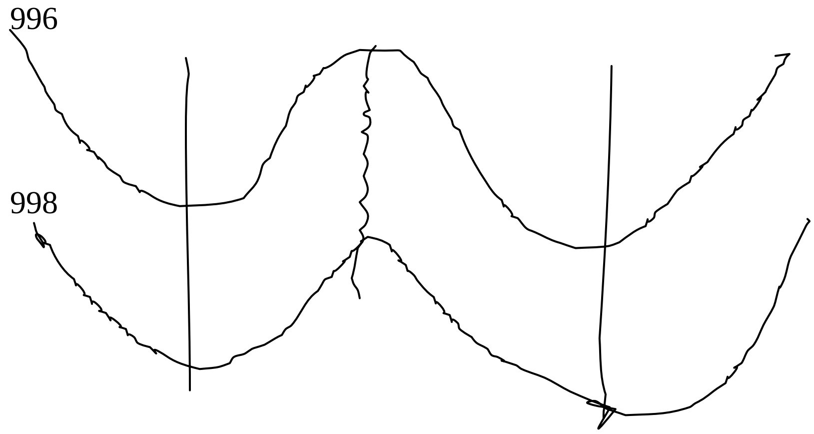

Fig.1

Circular low-pressure pattern: Let us consider the adjoining circular low-pressure pattern. Lowest pressure is at the center of the circular pattern. To the north of the center Coriolis force is higher than that to the south. As we know that Coriolis force makes flow anticyclonic, hence cyclonic wind will be more to the south than to the north of the center. Hence to the east of the center there is downstream decrease in wind speed and to the west there is down stream increase in wind speed. Hence divergence takes place to the west of the center as a result of which there will be fall in pressure to the west of the center. Due to this, center of low after some time will be shifted to the west of its present position. Hence net result is movement of the pressure system in an easterly direction.