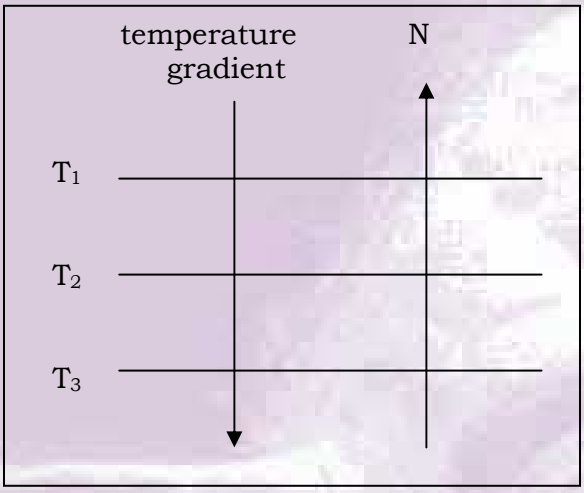
Gradient and Advection



The change of a scalar quantity, such as temperature or pressure, with distance is called the **gradient** of that quantity. A scalar gradient has magnitude and direction; therefore, it is a vector quantity. The direction of a temperature gradient is perpendicular to the isotherms and from low values towards high values.

In general, a scalar gradient is three dimensional; it has a vertical part and a horizontal part. The magnitude of a scalar gradient is computed using vector algebra, by squaring each component, adding the results, then taking the square root. The magnitude of the horizontal part of the temperature gradient, ∇T, is

$$|\nabla T| = \sqrt{\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial y}\right)^2} .$$

A component of a scalar gradient is positive when the scalar quantity increases in a positive direction. For example, consider the common situation of temperature increasing to the south. The meridional temperature gradient is,

$$\frac{\partial T}{\partial y} = \frac{T_2 - T_1}{y_2 - y_1} ,$$

which is negative.

Advection

A very important quantity in meteorology is advection, which occurs when the wind crosses isolines of some scalar, such as temperature. The definition of horizontal temperature advection is

$$-\vec{V}\cdot\nabla T = -u\frac{\partial T}{\partial x} - v\frac{\partial T}{\partial y} = -\left|\vec{V}\right|\left|\nabla T\right|\cos\theta ,$$

where θ is the angle between the wind and temperature gradient vectors. The strength of the horizontal temperature advection depends on three quantities: the wind speed, the horizontal temperature gradient, and the angle between the horizontal wind and temperature gradient vectors. The maximum positive horizontal temperature advection occurs when the horizontal wind and

horizontal temperature gradient are in opposite directions. With this arrangement wind is blowing from warm towards cold, and is often called warm air advection, WAA.

Also note that the formula for advection does not require movement of the isotherms, just that the moving air parcels (wind) cross the isotherms.