By: Thomas Galarneau, Research Physical Scientist
NOAA/OAR National Severe Storms Laboratory

Nondivergent wind QG diagnostics

Nondivergent wind QG diagnostics are computed following the methods described by Nielsen-Gammon and Gold (2008, p. 184–191). Definitions are as follows:

$\boldsymbol{v_{nd}} = \boldsymbol{v} - \boldsymbol{v_\chi}$, where $\boldsymbol{v_{nd}}$ is the nondivergent wind, $\boldsymbol{v}$ is the total wind, and $\boldsymbol{v_\chi} = \boldsymbol{\nabla}\chi$ is the divergent wind where χ is the velocity potential.

Temperature, T, is defined as the vertical gradient of streamfunction, ψ, as $T = \frac{p}{R} f_0 \left(-\frac{\partial \psi}{\partial p}\right)$.

Potential temperature: $\theta = \left[\frac{p}{R} f_0 \left(-\frac{\partial \psi}{\partial p}\right)\right] \left(\frac{p_0}{p}\right)^{R/c_p}$.

Temperature advection: $-\boldsymbol{v_{nd}} \cdot \boldsymbol{\nabla_p} \left[\frac{p}{R} f_0 \left(-\frac{\partial \psi}{\partial p}\right)\right]$

Resultant deformation: $E = \sqrt{(E_{st}^2 + E_{sh}^2)}$, $E_{st} = \frac{\partial u_{nd}}{\partial x} - \frac{\partial v_{nd}}{\partial y}$, $E_{sh} = \frac{\partial v_{nd}}{\partial x} + \frac{\partial u_{nd}}{\partial y}$

2D Frontogenesis: $F = \frac{1}{|\nabla \theta|} \left[-\frac{\partial \theta}{\partial x}\left(\frac{\partial u_{nd}}{\partial x}\frac{\partial \theta}{\partial x} + \frac{\partial v_{nd}}{\partial x}\frac{\partial \theta}{\partial y}\right) - \frac{\partial \theta}{\partial y}\left(\frac{\partial u_{nd}}{\partial y}\frac{\partial \theta}{\partial x} + \frac{\partial v_{nd}}{\partial y}\frac{\partial \theta}{\partial y}\right)\right]$

Vector frontogenesis (**Q**): $\boldsymbol{Q} = \left(-\frac{\partial \boldsymbol{v_{nd}}}{\partial x} \cdot \boldsymbol{\nabla_p}\theta, -\frac{\partial \boldsymbol{v_{nd}}}{\partial y} \cdot \boldsymbol{\nabla_p}\theta\right) = (Q_1, Q_2)$

The across- (*Qn*) and along-isentrope (*Qs*) components of the **Q** vector are computed as described in the Omega Equation Users' Guide. The Miller (1948) 2D frontogenesis function, evaluated here using the nondivergent wind, is equivalent to $-Q_n$ and the Petterssen (1936) frontogenesis function.