12.818: INTRODUCTION TO ATMOSPHERIC DATA AND LARGE-SCALE DYNAMICS

# PROJECT SEVEN: THE QUASI-GEOSTROPHIC VORTICITY EQUATION

ALI RAMADHAN

In this project we will study synoptic systems by employing the *quasi-geostrophic vorticity equation*, which can be expressed mathematically in pressure coordinates as

$$\frac{D_g}{Dt}(\zeta_g + f) = -f(\nabla \cdot \boldsymbol{v}) = f\frac{\partial \omega}{\partial p} = \frac{f}{\varrho}\frac{\partial(\varrho w)}{\partial z}$$

where

$$\frac{D_g}{Dt} = \frac{\partial}{\partial t} + \boldsymbol{v}_g \cdot \nabla$$

is the geostrophic derivative operator, $\zeta_g + f$ is the absolute vorticity, $f$ is the planetary vorticity, $\zeta_g$ is the geostrophic relative vorticity evaluated on an isobaric surface, $\omega$ is the vertical velocity in pressure coordinates, $w$ is the vertical velocity in height coordinates, $\boldsymbol{v}$ is the wind velocity field, and $\boldsymbol{v}_g$ is the geostrophic wind velocity field.

Note that positive vorticity is associated with low pressure systems, while negative vorticity is associated with high pressure systems.

Also note that the local rate of change of geostrophic vorticity is determined by the sum of two terms; the advection of the absolute vorticity by the geostrophic wind, and the the stretching or shrinking of fluid columns via a divergence.

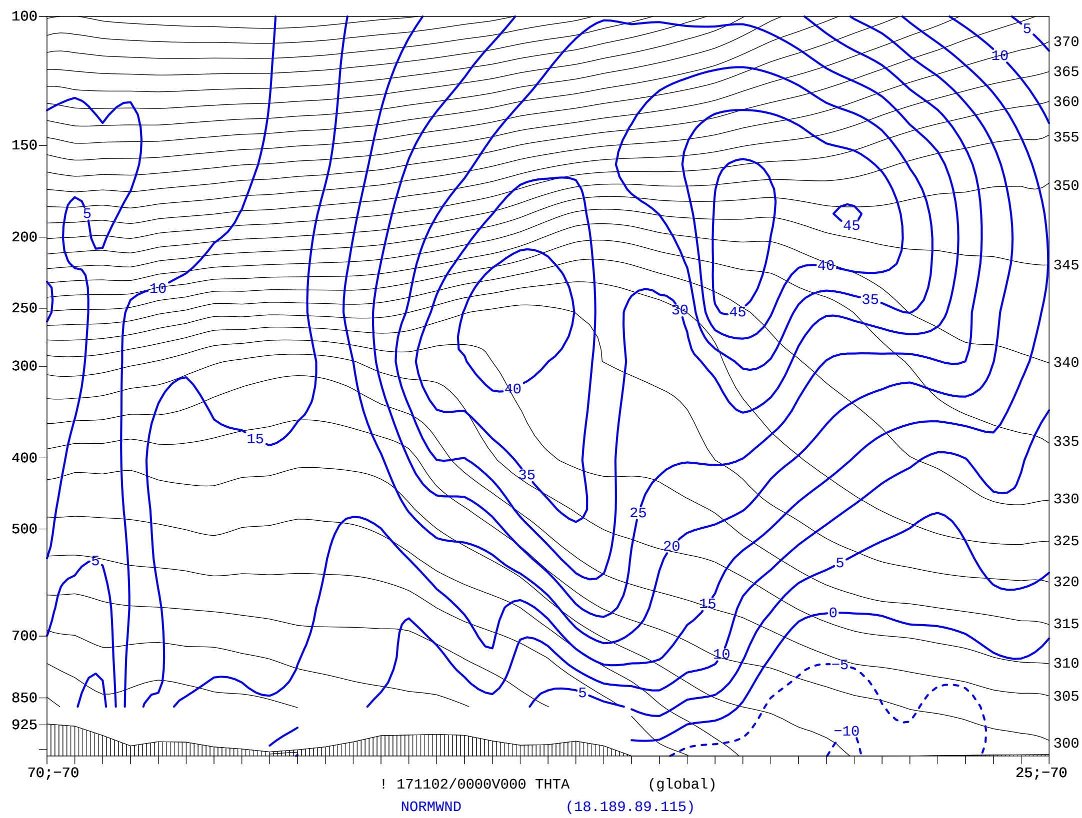


Figure 1: Potential temperature field at 500 hPa over the Northern Hemisphere on February 14, 2016 (0Z) showcasing a particularly cold front as it is about to pass through the Northeastern United States.