

ATM 500: Atmospheric Dynamics Homework 7

Due Thursday November 3 2016 by 10:15 am

1. Suppose that in a hydrostatic atmosphere in the southern hemisphere, temperatures increase northward on every pressure level between the surface and the tropopause. Also suppose that the pressure gradient force is zero on the 500 hPa surface (about halfway between the surface and tropopause). Make a sketch that shows how the slope of pressure surfaces and the geostrophic winds must vary with height. Make sure to explain your reasoning. What is the direction of the geostrophic wind near the surface? What about near the tropopause? (Use the meteorological convention: “westerly” = from the west, “northerly” = from the north, etc.)
2. In meteorological terminology, “veering” winds turn clockwise with increasing height, while “backing” winds turn anti-clockwise with increasing height. Show that for an atmosphere in thermal wind balance, veering winds must be associated with warm air advection. Also show that backing winds must be associated with cold air advection.
3. Consider a compressible ideal gas atmosphere. The environment is characterized by vertical profiles of density and potential temperature $\tilde{\rho}(z), \tilde{\theta}(z)$. A small parcel of fluid is adiabatically displaced upward a small distance δz .

- a. Show that the density difference $\delta\rho$ between the parcel and its new environment is given by

$$\delta\rho = \frac{\tilde{\rho}}{\tilde{\theta}} \frac{d\tilde{\theta}}{dz} \delta z$$

- b. If the parcel obeys a linearized vertical momentum equation

$$\frac{Dw}{Dt} = -g \frac{\delta\rho}{\tilde{\rho}}$$

show that the resulting motion will be vertical oscillations at frequency N where

$$N^2 = \frac{g}{\tilde{\theta}} \frac{d\tilde{\theta}}{dz}$$

so long as $\frac{d\tilde{\theta}}{dz} > 0$

4. *Based on Question 2.18 from Vallis*

Using approximate but realistic for the observed stratification, what is the *buoyancy period* for (a) the midlatitude troposphere, and (b) the stratosphere. Make sure to cite your data sources and state any assumptions you make.