Problems - 2 Due: 18 Oct. 2018

You are welcome (in fact, encouraged) to discuss problem sets with your classmates. However, each of you must turn in your own problem-set answers.

1. In z* coordinates, the change of geopotential Φ with height is proportional to temperature T following

$$\frac{\partial \Phi}{\partial z^*} = RT/H$$

Using this and the definition of z* = - H ln(p/p$_o$), transform the pressure-coordinate thermodynamic equation

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} - S_p\omega = \frac{J}{C_p},$$

where

$$S_p \equiv \frac{RT}{C_p} - \frac{\partial T}{\partial p} = -\frac{T}{\theta}\frac{\partial \theta}{\partial p} \quad .$$

into the thermodynamic equation in z* coordinates:

$$\left(\frac{\partial}{\partial t} + \vec{V}\cdot\nabla\right)\frac{\partial \Phi}{\partial z^*} + w^*N^2 = {}^{\kappa J}\!/_{H},$$

where $N^2 = \frac{R}{H}\left(\frac{\partial T}{\partial z^*} + \frac{\kappa T}{H}\right)$.

Here R is the gas constant, H a scale height, w* is the vertical motion in z* coordinates, J is diabatic heating, κ = R/C$_p$ and C$_p$ is the heat capacity of air at constant pressure.

2. (Holton's problem 12.1)
Suppse that temperature increases linearly with height in the layer between 20 and 50 km at a rate of 2 K/km. If the temperature is 200K at 20 km, find the value of the scale height H for which the log-pressure height z* coincides with the actual height z at 50 km. You should assume that z* coincides with the actual height at 20 km and that g = 9.81 m/s^2 at all levels (i.e.,, it is a constant).