EART164 Homework #5 Due Monday 13th May 2012

Show all your working for full credit

1a) Does an object exactly at the equator travelling in a northerly direction experience any Coriolis acceleration? If so, in what direction? What about the same object travelling in an easterly direction? (3)

b) You're standing in the middle of a low-pressure region and the winds are travelling clockwise. Which hemisphere are you in? (2)

c) Explain how the characteristic length-scale of circulation features would be expected to change with latitude (2)

d) If the strength of zonal winds decreases with increasing altitude, what is this telling you about the latitudinal temperature gradient? (1) [8 total]

2. Here we're going to consider thermal winds on Titan.

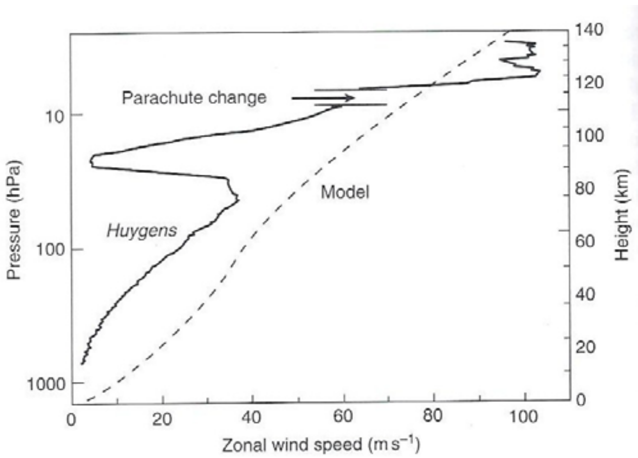
a) Titan has a rotation angular frequency Ω of 4.5×10^{-6} s^{-1}, a radius R of 2575 km and wind speeds u of up to 50 ms^{-1}. What is the Rossby number, and what does this tell us about the role of the Coriolis acceleration? (2)

b) Write down an expression which gives the steady-state balance between the pressure gradient in the y-direction and the centrifugal acceleration u^2/R (R is the planetary radius) (1)

c) By differentiating both sides with respect to z and assuming that u=0 at z=0, show that we can derive the following expression for u:

$$u^2 = \frac{gR}{T}\frac{\partial T}{\partial y}z$$

Here g is the acceleration due to gravity, T is the atmospheric temperature, and you can assume that the temperature gradient in the y-direction is constant. You can also assume that density only varies slowly in the z-direction. (5)



d) The figure above (from Taylor) shows that wind speeds measured by *Huygens* increase from zero at the surface to about 40 m/s at 80 km altitude. Use this information and your answer to c) to determine $\frac{\partial T}{\partial y}$ for Titan (in K/m). Take g=1.3 ms^{-2} and T=90 K. (1)

e) Hence determine the predicted temperature difference between the pole and the equator. (1)

f) We simplified things by using u^2/R, so that the centrifugal acceleration was constant. How would the centrifugal acceleration actually change with latitude, and what effect would this have on the calculated temperature gradient? (2) [12 total]

3. a) Cyclostrophic wind speeds at mid-latitudes on Venus are about 100 m/s at 0.1 bar pressure. Taking R_g/μ to be 200 J/kg K, what is the rate of change of temperature with latitude (in K/radian)? [2]

b) At 0.1 bar, the atmosphere at 30^{o}N is about 25 K warmer than at 60^{o}N (Taylor Fig 5.5). How does this compare with your prediction? [1]

c) The mean temperature at this height is about 200 K. What is the rate of change of pressure with latitude (in bar/radian)? [1]

d) At higher elevations in Venus' atmosphere, the poles are *warmer* than the equator. What effect will this have on the cyclostrophic winds? [1]

e) Suggest one possible reason for this reversal in the latitudinal temperature gradient [1] [6 total]