

## ATOC 5050: Atmospheric dynamics

### Homework assignment 2

Due: 5pm, Tuesday 13 October 2009 (in class, or deliver to David's office)

- 1.** Balanced flow can be found everywhere. For instance, flushing toilets, dust devils, tornados, hurricanes, and synoptic cyclones might all be described as balanced.
  - a.** Estimate the velocity and length scales, and then estimate the Rossby number for the 5 different motions listed above. (It may be useful/convenient to present this in a table)
  - b.** Calculate the pressure difference from the center to the edge of circulation for each 5 types of flow under the assumptions of each i) cyclostrophic, ii) geostrophic, and iii) gradient wind balance. (You will end up with 15 numbers, which again may be placed in a table)
  - c.** Provide a physical explanation of why the pressure differences calculated above differ between the cyclostrophic and geostrophic wind calculations.
  - d.** Which balanced flow approximation is most accurate for each type of flow? Explain your reasoning.
  
- 2.** Tornadic flow can be approximated as balanced flow.
  - a.** If tornado rotates with angular velocity  $\omega$ , construct an expression for the surface pressure at the center. State any assumptions in a list.
  - b.** Assuming a temperature of 288K, a background pressure of 1000hPa, and the wind speed 100 meters from the center is 100 m/s, what is the central pressure?
  
- 3.** Consider a model of the atmosphere with two layers. The first between 900-700 hPa and the second between 700 and 500 hPa. The geostrophic flow is 10 m/s from the south at 900 hPa, 10 m/s from the west at 700 hPa and 20 m/s from the west at 500 hPa.
  - a)** Draw a diagram that depicts the configuration
  - b)** Estimate the thickness (in meters) between layer midpoints of 800 and 600 hPa.  
(*You will need to make an assumption about temperature*)
  - c)** Calculate the mean horizontal temperature gradient in each layer
  - d)** Compute the temperature advection in each layer
  - e)** If the entire profile is initially isothermal, how long would it take for the lapse rate to become (dry) adiabatically unstable?