UCF Physics: AST 6165 Planetary Atmospheres

Spring 2020 Homework 8
DUE Thursday, 19 Mar 2020

Reading for this assignment: Andrews, 4 – 5.3.
Problems:

State answers in SI units. Many values are US units from the media. Get used to converting!

1. (10 points) Andrews 4.1.
2. (10 points) Andrews 4.4.
3. (a) (5 points) Find an image of a hurricane on the web, identify its extent, and find a report of the wind speed. From these numbers, estimate the Rossby number of the weather pattern. What do you conclude about the importance of the Coriolis force?
   Do the same analysis for:
   (b) (5 points) Jupiter's Great Red Spot
   (c) (2 points) a tornado in the American Midwest, with wind speed about 300 mi/h and a horizontal length scale about 100 m
   (d) (2 points) a supercell storm in the American Midwest, with wind speed about 50 mi/h and a horizontal length scale of about 3 mi
   (e) (3 points) flow in a bathtub vortex
4. Recall Bernoulli's principle and equation:

$$\rho\frac{v^2}{2} + p = \text{constant}$$

   (a) (5 points) A hurricane blowing at 130 mph encounters a 1500 sq ft. house. What is the pressure difference between the inside and the outside of the house? What would the lifting force be on the roof?
   (b) (5 points) Shortly after repairs, a tornado with winds of 300 mph encounters the same house. What is the pressure difference between the inside and the outside of the house? What would the lifting force be on the roof? Comment on any differences you might expect.
5. A simple model of a hurricane represents the eye as a cylindrical, rotating, "rigid" (i.e., shearless) mass and ignores updrafts, downdrafts and turbulence. The fastest winds are on the outer edge of the eye wall. Wind speeds then decay as you move outward. An inverse square-root power law can describe the outer region as follows:

$$v(r) = v_{\max}\left(\frac{r}{r_{\text{eye}}}\right) \qquad 0 \le r < r_{\text{eye}} \tag{1}$$

$$v(r) = v_{\max}\left(\frac{r_{\text{eye}}}{r}\right)^{1/2} \qquad r \ge r_{\text{eye}}, \tag{2}$$

   where $v(r)$ is the tangential wind speed, $v_{\max}$ is the maximum wind speed, r is the distance from the center of the hurricane, and r_{eye} is the radius of the eye wall.

   (a) (5 points) Plot the tangential wind speed as a function of radius for a hurricane with a 30-mile-diameter eye and a maximum wind speed of 130 mph.
   (b) (5 points) Derive an expression for the total kinetic energy of a hurricane modeled as described above. Consider the density constant with height.
   (c) (5 points) Using the expression derived above, determine the total kinetic energy of a 350 mile wide hurricane that is 10 km high, has a 30-mile-diameter eye, and has maximum winds of 130 mph.