12.811

Tropical Meteorology

Problem Set 6

In deriving an expression for the maximum wind speed in tropical cyclones, we began with an expression derived from local conservation principles:

$$\frac{1}{r_b^2} = \frac{1}{r_o^2} - 2\left(T_b - T_o\right)\frac{ds^*}{f^2 R^3 dR},$$

where here I have expressed the relation in terms of potential radius rather than angular momentum.

1. Derive the above from the thermal wind equation for axisymmetric flow, using also Maxwell's relation and assuming that s^* is invariant on surfaces of constant M (or R).

2. In the subsequent development (see powerpoint presentation from class), we neglected $\frac{1}{r_0^2}$ in comparison to $\frac{1}{r_b^2}$, which is equivalent to assuming zero absolute vorticity at the storm top. Here, let's assume, instead that

$$\frac{1}{r_0^2} = \frac{\eta}{R^2},$$

where η is some constant. Note that taking $\eta = 1$ is equivalent to assuming no motion at the storm top, while $\eta > 1$ would indicate a cyclonic circulation at the storm top.

Using this expression, and otherwise following the development undertaken in class, derive a new expression for the maximum wind speed. For reasonable values of the parameters, how large does η have to be to have a noticeable effect on V_{max}? From the definition of R, roughly what azimuthal velocities at the tropopause would this correspond to?