12.811

Tropical Meteorology

Problem Set 2

1. Suppose that the latitudinal boundary layer entropy distribution in a zonally symmetric world is given by

$$S_b = S_e - (S_e - S_p)\sin^3\theta,$$

where S_e and S_p are the equilibrium boundary layer entropies of the equator and pole, respectively. Approximating the absolute surface temperature, T_b, and tropopause temperature, T_t, as constants, and given values for the earth's radius, a, and angular rotation rate, Ω, find an expression for the latitude below which the radiative-convective equilibrium solution is not attainable. (This may be a transcendental relation.) Estimate a value for this critical latitude given

$$S_e - S_p = 400 \text{ m}^2 \text{ s}^{-2} \text{ K}^{-1},$$
$$\Omega = 7.3 \times 10^{-5} \text{ s}^{-1},$$
$$a = 6.38 \times 10^6 \text{ m},$$
$$T_b = 300 \text{ K},$$
$$T_t = 200 \text{ K},$$

2. Let us hypothesize that, below the critical latitude found as a solution to problem 1 above, the actual atmosphere is close to the radiative-convective equilibrium state, but has a non-zero surface zonal wind. Find an expression for the surface zonal wind, under the assumption that the angular momentum along the tropopause is constant and equal to its resting value at the equator. Using the parameter values given in problem 1, calculate the surface zonal wind at increments of $2°$ latitude up to the critical latitude. In the presence of surface friction, how would you expect this solution to be modified?