EAS270, "The Atmosphere" <u>Assignment 1</u> Due 5 pm 14 Oct., 2009

<u>Professor</u>: J.D. Wilson <u>Value</u>: 10%

Instructions: All questions have equal value. Answers should be stated with two decimal point precision, and in identified SI units (e.g. 20.02°C , 278.16 K, 1.09 kg m^{-3}). Please document your working tidily — there is potentially a one mark penalty for illegible or unintelligible working. Please drop off your assignment (labelled with your name and ID number) in the drop-off box outside Tory 3-40. A two mark penalty will be applied for late assignments received before noon Thursday 15 Oct. After that time, the late penalty will be five marks.

Task: Add together the last five digits of your student I.D. number, to form what we shall interpret as a ground-level temperature T_1: e.g. I.D. number 1198765 $\rightarrow$ $T_1 = 35$°C. Then:

1. Assuming the emissivity of the ground surface is $\epsilon = 0.95$, compute the emitted longwave radiative flux density $L \uparrow$ corresponding to ground temperature T_1.
2. Assuming ground-level pressure is $P_1 = 930$ hPa, compute the air density ρ_1 implied by this combination (P_1, T_1).
3. Adopt the hydrostatic law, evaluating the right hand side as $-\rho_1 g$, to compute the vertical distance Δz between the ground and the 850 hPa surface (i.e. the altitude where pressure is $P_2 = 850$ hPa).
4. Assuming the temperature variation from ground to the P_2 level follows the dry adiabatic lapse rate (DALR), compute the temperature T_2 (in Celcius units) at this level.
5. Compute the density ρ_2 of air whose state is defined by (P_2, T_2).

Data

- 1 hPa = 100 Pa, $T\ [K] = T\ [^\circ\mathrm{C}] + 273.16$
- $\frac{\Delta P}{\Delta z} = -\rho g$

  The hydrostatic law. ΔP [Pascals], the change in pressure as one ascends a distance Δz [m]; ρ [kg m^{-3}] the air density; $g = 9.81$ [m s^{-2}] acceleration due to gravity.
- $P = \rho R T$

  The ideal gas law. P [Pascals], pressure; ρ, [kg m^{-3}] the density; T [Kelvin], the temperature; and $R = 287$ [J kg^{-1} K^{-1}], the specific gas constant for air.
- $L \uparrow = \epsilon \sigma T^4$

  Stefan-Boltzmann law. $L \uparrow$ [W m^{-2}], the emitted longwave energy flux density; ϵ, the emissivity of the surface (dimensionless); $\sigma = 5.67 \times 10^{-8}$ [W m^{-2} K^{-4}], the Stefan-Boltzmann constant; T [K], the surface temperature.
- $\frac{\Delta T}{\Delta z} = -0.01$ [K m^{-1}]

  The dry adiabatic lapse rate (DALR), i.e. for every one metre of ascent the temperature decreases by 0.01 degrees Kelvin. (Note that a *change* of one degree Kelvin is the same as a *change* of one degree Celcius).