ATM 500: Atmospheric Dynamics
Homework 3
Due Thursday September 20 2018

1. What amplitude of sound wave is required for the nonlinear terms in the momentum equation to become important? Is this achieved at a rock concert (120 dB), or near a jet aircraft that is taking off (160 dB)?

   To answer this, you may want to read section 1.11 on scaling the equations of motion. Here, choose velocity and length scales consistent with the dispersion relation for sound waves. The decibel unit (dB) is defined on page 40 (2nd ed.) or 37 (1st ed.) of the text.

   (Based on question 1.5 from Vallis, 1st edition)

2. a. Suppose that a sealed, insulated container consists of two compartments, and that one of them is filled with an ideal gas and the other is a vacuum. The partition separating the compartments is removed. How does the temperature of the gas change? (Answer: it stays the same. Explain.) Obtain an expression for the final potential temperature, in terms of the initial potential temperature of the gas and the volumes of the two compartments.

   b. A dry parcel that is ascending adiabatically through the atmosphere will generally cool as it moves to lower pressure and expands, and its potential temperature stays the same. How can this be consistent with your answer to part (a)?

   (Based on question 1.9 from Vallis, 1st edition)

3. a. Read Section 1.10 in Vallis on the energy budget of a fluid. Give a more detailed derivation of equation (1.200) – the total energy equation for a compressible fluid. Make sure to explain your reasoning at each step. In particular, provide details of how you get from (1.198) to (1.199).

   b. Why can we conclude from (1.200) that total energy is conserved for a closed domain with rigid boundaries? What is the role of the boundaries in this conclusion?

   Note the equation numbers here correspond to the 2nd edition of Vallis. For the first edition, replace (1.198 – 1.200) with (1.185 – 1.187).