ATOC 5060: Atmospheric dynamics

Homework exercise 3

Solution in class Thursday

Sound waves are variations in the pressure field associated with oscillating motions in the direction of propagation. Since they are fast, they can be considered adiabatic, and for simplicity assume they are only in one dimension (x).

1) For adiabatic conditions, the momentum and continuity equations can be written as:

$$\frac{du}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial x}$$

$$\frac{c_p}{c_v}\frac{dp}{dt} + p\frac{\partial u}{\partial x} = 0$$

Linearize these about the basic state $p = \overline{p} + p'$, $\rho = \overline{\rho} + \rho'$ and $u = \overline{u} + u'$.

2) From your linearized equation, derive a single wave equation for perturbations in pressure.

3) Assume a solution $p' = \hat{p}\exp\{i(kx - \upsilon t)\}$ to derive a dispersion relation, and thus show that speed of these waves is proportional to the quantity RT.

4) Given what you now know about acoustic waves, and the temperature structure of the atmosphere. Estimate the speed of sound a) near the surface, and b) near the tropopause?