Problems on Chapter 15: Baroclinic Rossby Waves

Q 15.1: For latitude 60°N find the critical velocity u_c for baroclinic Rossby waves with phase lines oriented N-S for the cases of x-wavenumbers 1, 2 and 6 (i.e. that number of waves fit round the latitude circle, which has length 20,000 km).

You will need to know the pressure scale height H and the Brunt-Väisäla frequency N; calculate H on the basis of $T = 250\,\mathrm{K}$ and assume the Brunt-Väisäila period is 10 minutes.

Q 15.2: Consider the case where two waves with phase lines oriented N-S just fit round the latitude circle of 60°N. If the basic wind is 20% less than the critical velocity which you just calculated in question 1, calculate the wave amplitude and phase at a "height" of $z^* = 50\,\mathrm{km}$ in terms of the amplitude and phase at $z^* = 10\,\mathrm{km}$.

Q 15.3: Repeat question 2 for the case when the basic wind is 20% more than the critical velocity.

Q 15.4: For the propagating case, find an expression for the vertical group velocity (i.e. work out $-\frac{\partial \sigma}{\partial \nu}$ in terms of the other variables) and hence show that if the phase lines tilt towards the west with increasing height, energy is propagating upwards, and that if they tilt towards the east with increasing height, energy is propagating downwards.

(Hint: you will need to re-arrange equation 10 to make σ the subject of the formula, then differentiate it will respect to ν.)

Q 15.5: For the propagating case in the northern hemisphere show that if the phase lines tilt towards the west with increasing height then T' is positively correlated with v' (i.e. if they are multiplied together and averaged over a wavelength in the x-direction the answer comes out positive).