Tutorial 1

A. Vertical structure of the atmosphere

In the *hydrostaticly balanced* atmosphere the vertical pressure gradient is in balance with the gravitational force.

$$-\frac{1}{\rho}\frac{\partial p}{\partial z} = g$$

where g is the acceleration due to the Earth's gravity. The *hydrostatic balance* is applicable to most situations in the atmosphere, exceptions arising in the presence of large vertical accelerations such as are associated with thunderstorms.

Assume that the temperature varies linearly with height i.e. $T = T_0 - \Gamma z$, where Γ is the lapse rate.

1. Show how pressure and density vary with height.

   Assume different values of temperature at the ground level i.e. T_o =30^oC, 10^oC and -10^oC that could correspond roughly to eqautorial, mid-latitude and polar regions respectively.

   In each case assume that temperature changes linearly with height and the constant lapse rate, Γ, is equal to $0.01K/m$, $0.006K/m$, $0.004K/m$.

   Assume that the pressure at the ground is $1000hPa$.

2. Estimate the altitude of the tropopause for different values of ground temperatures and lapse rates.

   Assume that the tropopause is at $p_t = 200hPa$.

B. Potential temperature

Show that isolines of potential temperature are quasi-horizontal.

Assume that:

- the temperature at the surface, T_0, is varying like a cosinus of latitude, as shown in Figure 1
- the temperature is varying linearly with height, i.e. $T = T_0 - \Gamma z$
- take the following values of Γ: [0.6, 0.5] K/100m; assume that Γ is the same for all latitudes.

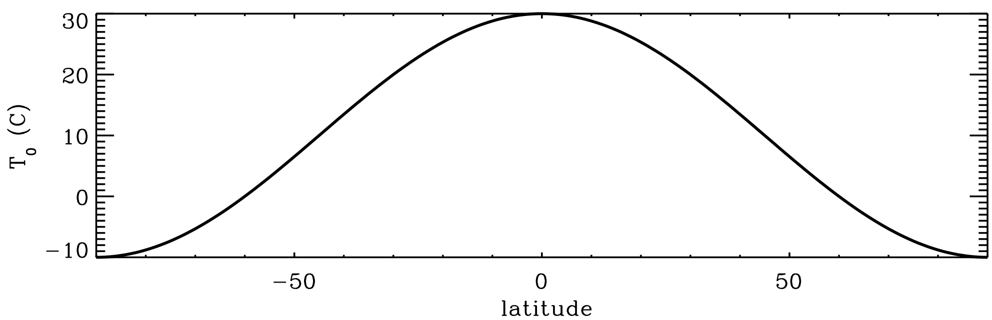

Figure 1: Variation of surface temperature with latitude.

1. Plot isolines of pressure in latitude-height coordinates
2. Plot isolines of temperature in latitude-height coordinates
3. Plot isolines of potential temperature: θ_i=[300,320,340,360,380,400]K