Lab. No.1

Describe the vertical structure of the boundary layer, using the potential temperature profile.

Aim:

Identify the diurnal structure of the atmospheric boundary layer and indicate its height (upper inversion) by drawing the vertical distribution of the potential temperature.

methodology:

The boundary layer is that part of the troposphere that is directly affected by the Earth's surface and responds to the effects of that surface within a time scale of about an hour or less. The height of the troposphere may extend from the earth's surface to a height of (11 km) in some areas, but the direct effect of the earth's surface does not extend vertically, except to hundreds of meters, which may reach (2-3 km).

The effects of the surface on the boundary layer include:

1- Frictional drag

2- Evaporation and condensation.

3- Heat transfer.

4- Emission of pollutants.

5- The terrain and ground obstacles that affect and change the shape of the flow.

The thickness and height of the boundary layer are not constant values. It changes over time and location, the height of the boundary layer ranges from hundreds of meters to a few kilometers. The height of the boundary layer and its vertical structure is determined by studying the vertical change of some atmospheric parameters such as temperature T, horizontal wind speed, and potential temperature θ.

potential temperature θ is the temperature of the air parcel if its height changes adiabatically from pressure level P to standard pressure level P0 which is usually equal to 1000 mb.

It is given by the following equation:

$$\theta = T\left(\frac{P_0}{P}\right)^{\frac{R}{C_P}} \dots\dots\dots (1)$$

whereas :

θ: potential temperature.

T: air parcel temperature, measured in Kelvin

R: gas constant for air

C_P: the specific heat capacity of air at constant pressure.

The behavior of the vertical change of potential temperature through the boundary layer differs from one region to another. For example, in areas where mixing takes place, the potential temperatures are approximately equal, ($\partial\theta/\partial z \approx 0$). While in the surface layer, there is a sharp change in the potential temperature with altitude. The behavior of the change depends on the time of day and the season of the year. Sometimes it is an inversion (the temperature rises with the rise to the top) or the lapse rate at other times. It is possible to diagnose specific regions by studying the behavior of the vertical change of the atmospheric parameters, as they are considered secondary layers within the boundary layer, the most important of these layers are:

1 - Surface Layer (SL).

It represents approximately 10% of the boundary layer. This layer is considered the most affected by the Earth's surface. The winds in this layer are affected by the shape of the surface, and the change in the behavior of the potential temperature is also affected. This layer is affected by the surface temperature, so it records laps rite during the day and a thermal inversion during the night. It may reach a height between (100-200m).

2 - Mixing Layer (ML) or Mixed Layer:

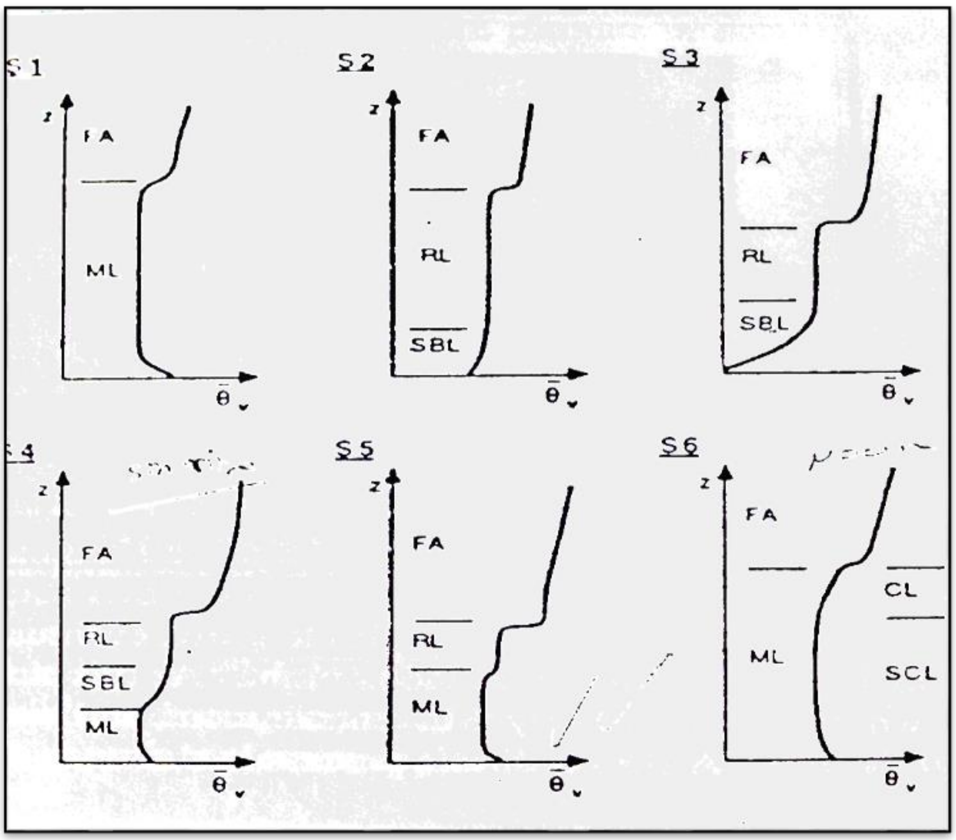
Most of the turbulence occurring in this layer is from thermal convection, where convective currents are generated from the heat of the Earth's surface. These currents reflect their direction when they reach the cloudy layer (at the top of ML,) due to the radiative cooling resulting from the Top of the cloudy layer. The mixed layer is a day-appearing layer, and it needs unstable weather conditions to form, it is usually generated about half an hour after sunrise and reaches its maximum height in the late afternoon, its height is about 1000 meters, it is located above the surface layer. The wind shear generated as a result of changes in the vertical wind profile is considered an additional reason for generating turbulence in the mixed layer. The most important function that the mixed layer does, is to spread the accumulated pollutants in the surface layer, as well as restore homogeneity for the distribution of atmospheric elements within the boundary layer such as humidity and temperature.

3- Entrainment Zone (EZ):

It is an upper thermal inversion region located above the Mixed Layer. In this layer, the temperature increases with rising.

There are other layers, some of which are night-appearing, such as **Stable Boundary Layer(SBL),** and some of them are permanent, such as the **micro-layer.**

The figure below is a diagram of the actual average potential temperature, which shows the development of the Boundary layer during the daily cycle.



Where: ML: Mixed layer. FA: Free Atmospher. SBL: stable boundary layer. RL: the Residual layer. $(\overline{\theta_v})$: the actual average potential temperature. CL: Cloudy layer. SCL: subcloud layer

The procedures

1- from equation (1) Calculate the potential temperature using the radiosonde data as in the table below:

Height(m)	P (mb)	T(c)	θ (k)	Type of layer
0				
50				
.				
.				
.				
1800				

2- Plot the vertical potential temperature profile.

3- identify the layers that appear within the boundary layer.