Lab No ( )

Determining atmospheric stability based on calculating the Richardson number (Ri)

Aims: To determine the state of atmospheric stability (stable, neutral or unstable) by calculating the gradient Richardson number (Ri).

Tools:

1- Anemometer (2 devices), for measuring wind speed at two heights Z_1 and Z_2.
2- Thermometer (2 devices), for measuring temperature at the same two heights, Z_1 and Z_2.
3- stopwatch.

Theoretical part :

The Richardson number (Ri) is a dimensionless number that expresses the ratio of buoyancy to mechanical (wind shear) forces. It is used to assess the stability of the atmospheric boundary layer. Atmospheric stability is defined as the degree to which an air mass tends to move vertically. Atmospheric conditions are generally classified as stable, neutral, or unstable.

The Richardson number is calculated using the following formula:

$$Ri = \frac{g}{\bar{T}} \left[\frac{\left(\frac{\partial T}{\partial z}\right)}{\left(\frac{\partial u}{\partial z}\right)^2} \right] \dots\dots\dots\dots (1)$$

Where:
$\overline{T}$: Temperature rate in Kelvin.
g: Gravitational acceleration, which equals 10 m/sec^2
$\frac{\partial u}{\partial z}$: Vertical gradient of wind speed.
$\frac{\partial T}{\partial z}$: Vertical gradient of temperature.

When we have measurements at two discrete heights (Z_1 and Z_2), the formula can be approximated as:

$$R_i = \frac{g}{\left(\frac{T_1+T_2}{2}\right)} \left[\frac{\left(\frac{T_2-T_1}{z_2-z_1}\right)}{\left(\frac{u_2-u_1}{z_2-z_1}\right)^2} \right] \dots\dots\dots (2)$$

Where:
u_1,T_1 : Wind speed and temperature at height Z_1.
u_1,T_1: Wind speed and temperature at height Z_2.
$\bar{T} = \frac{T_1+T_2}{2}$: Average temperature.

- If Ri > 0 : The atmosphere is stable.
- If Ri = 0: The atmosphere is neutral.
- If Ri < 0 : The atmosphere is unstable.

Methodology

1- Record the information as in the following table:

Time	At height z_1		At height z_2	
	u_1	T_1	u_2	T_2
1				
2				
3				
4				
5				

2- Record this information every minute, continuing for a duration of (10) minutes.
3- Calculate the average temperature and average wind speed for each height, resulting in u_1 and T_1 at height Z_1 and u_2 and T_2 at height Z_2.
4- Calculate the mean temperature $\bar{T}$ for the two heights Z_1 and Z_2 using the relationship: $\bar{T} = \frac{T_1+T_2}{2}$

5- Calculate the value of Ri using Equation (2).
6- Repeat this process every 15 minutes and compare the values of Ri to determine the state of atmospheric stability based on the value of Ri.

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Z_1= 15 m		Z_2=20 m	
U_1 (m/s)	T_1(k)	U_2 (m/s)	T_2 (k)
2.2	308.4	1.8	307.6
2.2	308.3	2.2	307.6
2.5	308.1	1.7	308.1
3.2	307.9	1.7	308.1
0.9	308.8	1.7	308.1
2.2	308.7	0.4	308
1.5	309.5	2.8	308
1.5	309.8	2	307.1
1.5	309.5	1.4	307.1
2.2	308.6	1.8	307.4
$\overline{U_1}$=	$\overline{T_1}$=	$\overline{U_2}$ =	$\overline{T_2}$ =

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Z_1= 15 m		Z_2=20 m	
U_1 (m/s)	T_1(k)	U_2 (m/s)	T_2 (k)
1,5	307.6	1	305.4
1.5	307.3	2.2	303.6
1	307.2	2.8	303.6
0.7	306.9	2.7	304.1
0.9	307.0	0.2	304.3
0.9	308.1	2.7	304.2
0.9	308.1	5.5	304.1
1.2	307.5	1.7	304.6
0.5	307.8	0.4	304.6
0.9	307.4	0.7	304.6
$\overline{U_1}$=	$\overline{T_1}$=	$\overline{U_2}$ =	$\overline{T_2}$ =