PROBLEM SET

Problem 1: Logarithmic velocity profile (Part I.)

In exercise set 7 you were provided with atmospheric turbulence data measured with a sonic anemometer and a hygrometer during a field campaign at the Seedorf Lake (FR) to investigate turbulent fluxes over water bodies. All measurements were taken at a height of $\mathbf{2m}$

Previously you were asked to compute some statistical properties of the flow, such as the standard deviations of the various time-series, as well as the turbulent fluxes of momentum, $(\overline{u'w'})$, and water vapor, $(\overline{u'q'})$.

Now we want to examine the data set to learn more about the boundary layer.

i. Using the results of the statistical analysis performed in the previous exercise set, find the value of $\boldsymbol{u_*}$. Assume that the measurements are taken in the surface layer.
ii. Based on the value of u_* determine the aerodynamic roughness length z_0. What can we tell about the surrounding environment? Is it more likely to be a coastal area? Farmland? A forest?
iii. Predict the velocity at a height of 10m. Can we predict the velocity of the wind for any height? Why or why not?
iv. Plot the velocity as a function of height up to 100m

Note: It is interesting to observe that a lot of information can be determined regarding the boundary layer using only a time-series of data recorded at a single point in space.

Problem 2: Logarithmic velocity profile (Part II.)

Given the following wind speeds measured at various heights in a neutral boundary layer, find the

i. Boundary layer depth (H)
ii. Aerodynamic roughness (z_0)
iii. Friction velocity (u_*)
iv. Shear stress at the ground (τ) (in units of N/m^2).

What would you estimate the wind speeds to be at 2m and at 10m above the ground? Assume that the von Karman constant is 0.4 and density $\rho = 1.25$ [kg/m^3].

z	(m)	1	4	10	20	50	100	200	300	500	800	1000	2000
U	(m/s)	3.7	5	5.8	6.5	7.4	8	8.9	9.5	10.5	10.8	11	11

Assuming that the friction velocity measured at the same location on the next day is 0.6 [m/s], what would you estimate the wind speeds to be at 2m and at 10m above the ground?

On which day (first day or second day) is the wind velocity at 2 m above the ground larger? Comment on the relation between the friction velocity and the wind speed.