

## PROBLEM SET

### **Problem 1: Logarithmic velocity profile (Part I.)**

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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 **2m**

Previously you were asked to computed 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  $u_*$ . 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 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.)

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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 ( $\tau$ ) (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  $\rho = 1.25 \text{ [kg/m}^3\text{]}$ .

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.