MTEOR 605

Fall 2017

Homework: Analysis of time series

A one-hour time series of 20 Hz data from a site near Ames is linked from the course syllabus. The observations contained within the data file are the u, v, and w components of the wind, and the virtual temperature T_v. The measurement height was $z =$ 4.5 m, which we will assume is within the atmospheric surface layer. Also assume the atmospheric pressure during the measurement period was 10^5 Pa (1000 mb) so that T_v and θ_v are interchangeable.

With this time series we can calculate many of the boundary-layer scaling variables and other important quantities that we have covered in the course. As with all data analysis tasks first inspect the data to confirm the variable names, completeness of the data record, units of measurement, and other necessary information about the measurements. Then use the time series to find and report the following values at the height of these measurements. Include an annotated copy of the program that you used to compute these values when you submit your assignment.

1. Compute the mean values $\overline{u}$, $\overline{v}$, $\overline{w}$ and $\overline{\theta_v}$.

2. Compute the variances of these quantities, i.e., $\overline{u'^2}$, $\overline{v'^2}$, $\overline{w'^2}$ and $\overline{\theta_v'^2}$.

3. Compute the turbulence kinetic energy averaged over the period of record.

4. Find the magnitude of the surface stress, τ.

5. Find the friction velocity, u_*.

6. Find (a) the kinematic heat flux and (b) the sensible heat flux. For this question assume the virtual temperature effect is negligible so that $T = T_v$.

7. Find the buoyant production rate of turbulence kinetic energy.

8. Find the Obukhov length, L and the nondimensional height z/L.

9. Determine the convective scaling velocity, w_*, assuming a typical summertime mid-day value for z_i.

10. Find the values of the nondimensional wind shear $\phi_M(\frac{z}{L})$ and the nondimensional temperature gradient $\phi_H(\frac{z}{L})$. See section 9.7 of Stull for discussion of $\phi_M(\frac{z}{L})$, $\phi_H(\frac{z}{L})$ and their functional forms. There are two caveats: (i) The text immediately following eq. (9.7.5f) is slightly confusing. Replace this with "where (K_m/K_H) is the ratio of eddy diffusivities of momentum and heat for neutral conditions, and is equal to 0.74." (ii) The exponent in eq. (9.7.5f) should be -1/2, not -1/4.