EAS 572 Assignment 2 2004

Tables (1, 2) give the mean wind (U) and temperature (T) profiles observed on a tower at Ellerslie, Alberta, in the middle of a flat field of sparse stubble during a fifteen minute period beginning 1615 MDT on May 11, 2001. Windspeed was measured with cup anemometers, which should be assumed to have overestimated the mean speed by 8%. Mean temperature *differences* relative to a reference level ($z = 0.29$ m) were measured by shielded, ventilated thermocouples. One may assume the characteristic uncertainties in windspeed and temperature difference are 0.05 m s^{-1} and 0.1 °C.

A wind vane determined that the mean wind direction $\beta_v = 234^o$. A sonic anemometer at $z = 2$ m determined the data given in Table (3).

Aim: The mean profiles define the state of the undisturbed ASL. From the given data, estimate for this period: the friction velocity u_*, the temperature scale T_*, the Monin-Obukhov length L, the sensible heat flux density[1] Q_H. Plot the given mean profiles, along with the theoretical profiles implied by your derived u_*, T_*.

From the sonic data compute alternative estimates u_*^S, T_*^S, L^S and mean wind direction $\beta_S = \arctan(V/U)$. Comment on the measured values of $\sigma_u/u_*, \sigma_v/u_*, \sigma_w/u_*$ in the context of MO similarity theory (MOST).

[1] The mean temperature T_0 during this period was about 17^o C, and for the purpose of calculating the density ρ_0 you may assume the atmospheric pressure $p = 93$ kPa.

Profile Fitting Method

Correct the cup anemometers for overspeeding. Create the set of measured differences ${\Delta U_z}^m = U_z - U_{ref}$, ${\Delta T_z}^m = T_z - T_{ref}$ (etc.) where U_{ref} is the windspeed at a reference height, such as $z = 0.65m$. To each of these differences there correspond (for any guess of the scales u_*, T_*) theoretical differences ${\Delta U_z}^t = (U_z - U_{ref})^t$ (etc.) that may be calculated from the Monin-Obukhov similarity profiles. Your scales should be optimal in the sense that they minimise the dimensionless residual:

$$\begin{aligned} R &= \frac{\sum_1^{N_U} (\Delta U^m - \Delta U^t)^2}{\delta u^2} \\ &+ \frac{\sum_1^{N_T} (\Delta T^m - \Delta T^t)^2}{\delta T^2} \end{aligned} \tag{1}$$

Here $\delta u, \delta T$ are estimated instrument inaccuracy. In the present case the number of velocity differences is $N_U = 4$ and $N_T = 2$.

Data

Table 1: Profile of mean cup windspeed, Ellerslie (AB), 1615-1630 hrs, 11 May, 2001.

z [m]	$U(z)$[m s^{-}1]
6.05	4.70
3.6	4.44
2.12	4.20
1.12	3.86
0.65	3.56

Table 2: Profile of mean temperature difference from reference temperature, Ellerslie (AB), 1615-1630 hrs, 11 May, 2001.

z [m]	$T(z) - T(0.29\text{m})$ [°C]
5.75	-2.79
1.35	-1.83
0.29	0.00

Table 3: Sonic anemometer data for the same interval.

Property	Value [MKS units]
U	3.06
V	1.88
W	-0.00004
T	16.8
$\overline{u'^2}$	1.426
$\overline{v'^2}$	2.0266
$\overline{w'^2}$	0.13216
$\overline{u'w'}$	-0.01994
$\overline{v'w'}$	-0.10775
$\overline{w'T'}$	0.17411