EAS 572: Assignment 2

Table 1 gives the mean wind (U), temperature (T), and equivalent temperature (T_{eq}) profiles observed on a tower at Ellerslie, Alberta, in the middle of a flat field of alfalfa (height approx. 25 cm) during a fifteen minute period beginning 1425 MDT on October $12, 1986$. These data[1] define the state of the undisturbed ASL. Windspeed was measured with cup anemometers, and wet- and dry-bulb temperatures with individually-calibrated, shielded, ventilated diode thermometers (characteristic uncertainties $0.05 m/s$ and $0.1^o C$, respectively). The equivalent temperature $T_{eq} = T + e/\gamma$ where e is the vapour pressure and γ is the psychrometric constant. T_{eq} measures the total thermodynamic energy content of the air, and is the temperature that would result if all the water vapour in the air was condensed to release the latent heat.

Aim: From the given data, estimate for this period: the friction velocity u_*, the temperature and equivalent temperature scales T_*, T_{eq*}, the Monin-Obukhov length L, the sensible heat flux density Q_H, and the total convective heat flux density $Q_H + Q_E$. Plot the given mean profiles, along with the theoretical profiles implied by your derived u_*, T_*, T_{eq*}.

Method: Create the 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 $z = 0.61 m$. To each of these differences there correspond (for any guess of

[1] collected by Ph.D. student J. Argete (run "teq12o3"), who was studying the modified microclimate within small square plots sheltered by artificial windbreaks.

the scales u_*, T_*, T_{eq*}) 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:

$$\begin{aligned} R &= W_U \frac{\sum_1^{N_u} (\Delta U^m - \Delta U^t)^2}{\delta u^2} \\ &+ W_T \frac{\sum_1^{N_T} (\Delta T^m - \Delta T^t)^2}{\delta T^2} \\ &+ W_{T_{eq}} \frac{\sum_1^{N_T} \left(\Delta {T_{eq}}^m - \Delta {T_{eq}}^t\right)^2}{\delta T^2} \end{aligned} \tag{1}$$

Here $\delta u, \delta T$ are estimated instrument inaccuracy. In the present case the number of velocity differences is $N_u = 4$. The switches W_U (etc.) control whether information from a given profile is used in the fitting procedure (eg. we could possible optimise just u_*, T_* by setting $W_{T_{eq}} = 0$.

Table 1: Mean ASL state, Ellerslie (AB), 1425-1440 hrs, 12 Oct, 1986.

$z[m]$	$U(z)[m/s]$	$T(z)[^oC]$	$T_{eq}(z)[^oC]$
5.5	3.29	17.49	27.81
3.55	3.23	-	-
2.1	2.95	17.79	28.58
1.1	2.72	18.04	29.18
0.61	2.37	18.31	29.54