EAS372 Assignment 2 (15%) Due: Fri. 14 Mar. 2014

Format: Please submit a tidy, organized report *in electronic format* (PDF), covering the exercises below. Text should be double spaced with font size 12 pt. No page limit. Answers added at back.

Create histogram and empirical PDF (6%)

Column-organized file YEG_Feb_81_2010.csv lists daily max, min and mean temperatures for YEG (Edmonton Int'l Airport) for every February day in the interval 1981-2010 inclusive ($N =$ 843 days; a few days are missing). Compute the mean $\overline{T}$ and standard deviation σ_T of the series of daily mean temperatures. Create a histogram of the daily mean temperatures, using a bin-width of 2^{o}C. For each bin (label "j", j=1...) compute the relative frequency n_j (total count of days falling in that bin, divided by N). Plot this histogram. Then divide each n_j by the bin width (2^{o}C) to obtain an empirical probability density function f_j. Plot f_j, and compare with a Normal distribution

$$f(T) = \frac{1}{\sqrt{2\pi}\,\sigma_T}\ \exp\left(-\frac{T-\overline{T}}{2\,\sigma_T^2}\right)$$

plotting using your computed mean $\overline{T}$ and standard deviation σ_T.

Compute eddy fluxes (6%)

Compute the 30-min average vertical flux densities of sensible heat Q_H, of latent heat Q_E, of water vapour E ($= Q_E/L_v$) and of carbon dioxide F_c from the raw data given in file "Timeseries13_20110816_tab.dat" (columns tab separated). The signals, recorded at 10Hz, span 13:30-14:00 MDT on 16 Aug. 2011, and were recorded over a wheat crop at St. Albert by a sonic anemometer at a height of 2.5 m. Column 1: vertical velocity $w\,[\mathrm{m\,s^{-1}}]$. Column 2: $T - 25\,[^o\mathrm{C}]$. Column 3: scaled carbon dioxide concentration "C" which can be converted to true concentration of CO2 $[\mathrm{g\,m^{-3}}]$ by the calculation $\rho_{CO2} = 0.001(C + 600)$. Column 4: absolute humidity $[\mathrm{g\,m^{-3}}]$. Assume the pressure $P = 91$ kPa, in order to compute a mean air density ρ. Compute the fluxes as (e.g.)

$$Q_H = \rho\, c_p\, \overline{w'T'}$$

where a prime designates the *deviation from the mean value.*

Plot daily surface energy budget (3%)

Plot the daily cycle in hourly-averaged energy balance components (file "flanagan.txt") over grassland in Alberta, 1 July 2003. File gives net radiation (labelled Q^*), sensible and latent heat flux densities (Q_H, Q_E) and the "ground" heat flux (Q_G). All fluxes are in $[\mathrm{W\,m^{-2}}]$; data courtesy of Dr. L. Flanagan (U. Lethbridge).

Statistics of February daily mean temperatures (T_m) at YEG

Average $\overline{T}_m = -9.8185\,^{\circ}\mathrm{C}$

Standard deviation $\sigma_{T_m} = 8.0538\,^{\circ}\mathrm{C}$

Minimum $-35.9\,^{\circ}\mathrm{C}$, Maximum $= 7.3\,^{\circ}\mathrm{C}$

Note that the Gaussian (normal) PDF will peak at $\frac{1}{\sqrt{2\pi}\,\sigma_T} = 0.0495$.

See last page for plot of histogram (nbins = 22) and PDFs

Calculations for fluxes over wheat canopy

Mean vertical velocity $\overline{w} = -0.0287\,\mathrm{m\,s^{-1}}$, mean temperature $\overline{T} = 20.0869\,^{\circ}\mathrm{C}$, mean carbon dioxide concentration $\overline{\rho}_c = 608.45\,\mu\mathrm{g\,m^{-3}}$, mean absolute humidity $\overline{\rho}_v = 0.0076\,\mathrm{kg\,m^{-3}}$.

Air density based on the above mean temperature, $\rho = 1.0813\,\mathrm{kg\,m^{-3}}$.

Mean value of $w\,T$ is $\overline{wT} = -0.4186\,\mathrm{K\,m\,s^{-1}}$

Mean value of the $w' \times T'$ product, $\overline{w'T'} = \overline{w\,T} - \overline{w}\;\overline{T} = 0.1587\,\mathrm{K\,m\,s^{-1}}$. Multiplying this by $\rho\,c_p$ (where $c_p \approx 1000\,\mathrm{J\,kg^{-1}\,K^{-1}}$) we get Q_H

Sensible heat flx density $Q_H = \rho c_p\,\overline{w'T'} = 171.6\,\mathrm{W\,m^{-2}}$

Vapour flux density $E = \overline{w'\rho_v'} = 1.239 \times 10^{-4}\,\mathrm{kg\,m^{-2}\,s^{-1}}$

Latent heat flux density $Q_E = L_v E = L_v\,\overline{w'\rho_v'} = 309.9\,\mathrm{W\,m^{-2}}$

Carbon dioxide flux density $F_c = \overline{w'\rho_c'} = -1.033\,\mathrm{mg\,m^{-2}\,s^{-1}}$

See last page for plot of energy fluxes versus time over grassland

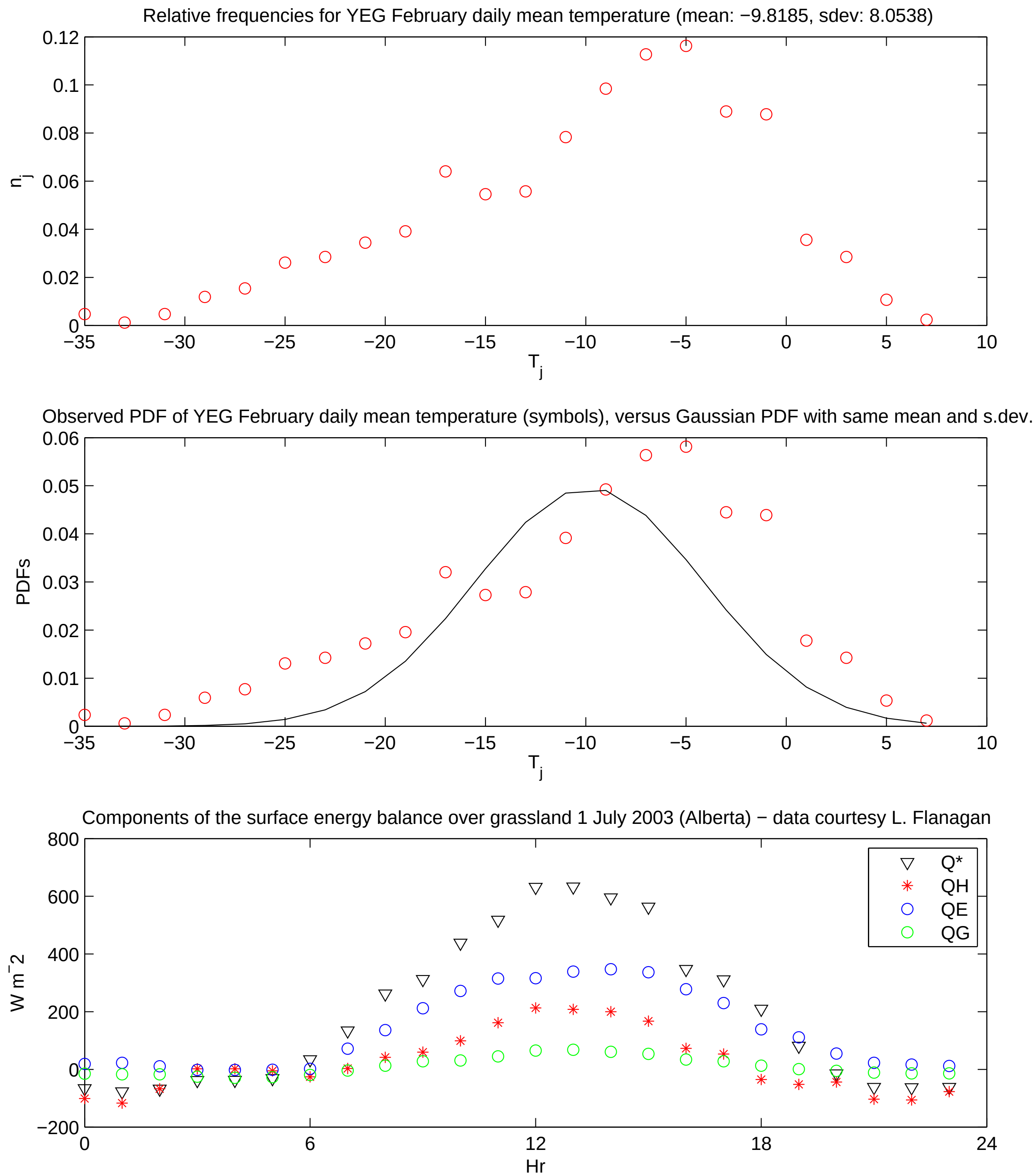

Figure 1: Figures plotted by instructor (JDW) using MATLAB.