**Atmos 6220**
**Exercise on Spectral Analysis**
**Due Monday, Nov. 25, 2013**

The dataset **rf18L1.txt** downloadable from the class WWW page contains 1819 seconds (30 mins) of data from a horizontal aircraft leg flown in a large circle S of Australia 30 meters above the ocean surface, sampled 25 times per second. The aircraft was flying at roughly 100 m $s^{-1}$. The columns are labeled; $u$, $v$, $w$ are the three velocity components, $T$ is temperature and $q$ is water vapor mixing ratio, while the last column, $p$ (which we wont use) is the measured air pressure. In this problem, we will analyze this dataset using Matlab. Please write a script or scripts (to hand in as part of your solutions) that implements the following

(a) Plot $u$, $v$, $w$ vs. time, and note that all of them show mesoscale variability (on scales of 10 km, or 100 s of sampling time) as well as turbulent variability.

(b) Now perform a spectral analysis of vertical velocity $w$ and E-W velocity component $u$ using the Matlab signal-processing toolbox function **psd** called according to the script **psduw.m** given in the class WWW page. This uses a Hanning window for data tapering and averages the tapered periodograms over overlapping intervals of 4096 samples (160 s, corresponding to 16 km, so variability in $w$ on wavelengths longer than 16 km is not accounted for). Plot the analyzed power spectral densities $P_{ww}$ and $P_{uu}$ vs. frequency $f$ using log-log axes. Over what range in frequencies does $P_{ww}$ exhibit a power law behavior, and with what power?

(c) Based on the above analysis, we decide to isolate the turbulent component of the signal from the mesoscale component by high-pass filtering to remove frequencies of less than 0.05 $s^{-1}$ (wavelengths longer than 2 km). To do this, we use a Butterworth filter. Download the script **highpassw.m** and use it to perform this filtering on $w$. What is the standard deviation of `whi`, the high-pass-filtered $w$ (Matlab function **std**)?

(d) The Matlab function **[whi_lag,lags] = xcov(whi,maxlag,'coeff)** calculates the autocorrelation sequence of the `whi` time series. If $w$ includes `ns` samples, then `whi_lag(ns + lag)` will be the autocorrelation with lag time = lags/rate = lags/25 s. Plot the autocorrelation of $w$ vs. lag time for lag times between 0 and 2 s, and calculate the integral timescale for $w$ based on this range of lag times. To what characteristicupdraft width does it correspond?

(e) After high-pass filtering $u$, $v$, $T$, and $q$ similarly, calculate their variances, their correlations with $w$, and the corresponding horizontal momentum, sensible and latent heat fluxes. Use a nominal air density of $\rho_0 = 1.21$ kg $m^{-3}$, and $L = 2.5\times10^6$ J $kg^{-1}$ and $c_p = 10^3$ J $kg^{-1}$ $K^{-1}$) to compute the fluxes. Is the buoyancy flux upward or downward? Calculate the friction velocity $u_*$ and the Obuhkov length $L$. At the measurement height of 30 m, is $z/L$ in the stable ($z/L > 0.2$), neutral ($-0.2 < z/L < 0.2$) or unstable ($z/L < -0.2$) regime?