Problems for the course Fluid Dynamics II (turbulence) SS 2016

to be done until end of Sept 2016.

Given are two data sets,
1) *AtmosphericData July fs10Hz Kurz.txt*, for atmospheric data 2) *Data Centerline FractalGrid fs60kHz.txt* OR *jfm data block1.txt*, for laboratory data
3) some of you measured their own data and may replace one data set of 1) or 2) but your own data,
analyze the two sets (from 1) and 2) or alternatively replace one by your measured data) and compare the results. One set is from homogeneous isotropic turbulence the other are measured wind data. Always give a short explanation what you did and what the results shows.

the points marked by ++ are extra points. I want that you go in some details in the data analysis, thus two of the ++ points should be chosen and worked out. If you have some special own idea, you may also chose one other extra point by yourself.
the common notation is $u = u' + < u >$

1.) basic characteristic:
determine for the given data sets:

- mean value
- magnitude of fluctuations $< u'^2 > := \sigma_u^2$
- degree of turbulence $< u'^2 > / < u >^2$
- statistics $p(u)$; $p(u')$ and $p(u'/\sigma_u)$

++ Problem - show how these quantities change with different sizes of averaging intervals. Discuss the results- Discuss the statistics

2.) two-point quantities:
determine for the given data set:

- power spectrum $E(f)$ or $E(k)$
  - Problems - show the $k^{-5/3}$ scaling of the power spectrum,
    pay attention to smoothing of power spectra, to the inertia range, using u or u'
- autocorrelation
  - ++ show numerically that the power spectrum is the Fourier transform of the autocorrelation
- joint probability distribution $p(u'(t), u'(t + \tau))$, show a correlated an uncorrelated case

- integral length
- ++ Komogorov length (necessary to estimate from data also the dissipated energy)
- determine the velocity increments u_r for $r = 2^m, m = 0, 1, 2, ...$
- determine the structure function $< u_r^2 >= \sigma_r^2$
- determine the structure function $< u_r^n >$
be careful with the sign
- estimate the scaling exponents $< u_r^n > \propto r^{\xi_n}$
  - compare with K62 scaling,
- estimate the scaling exponents after ESS: $< u_r^n > \propto < |u_r|^3 >^{\xi'_n}$
  - compare with K62 scaling,
  - ++ comment on the ESS (Benzi publication) $< |u_r|^3 >$and $< u_r^3 >$
- determine the probabilities $p(u_r)$, $p(u_r/\sigma_r)$
- discuss intermittency effects on different quantities

3.) n-point quantities:
determine for the given data set:

- conditioned probabilities $p(u_r|u_{r'})$
- ++ $p(u_r|u_{r'}, u_{r''})$, use for $u_{r'}, u_{r''}$ sufficient large bins ($a < u_{r'} < b$) so that probabilities can be obtained
- ++ show evidence for the validity of Markow properties $p(u_r|u_{r'}) = p(u_r|u_{r'}, u_{r''})$?