チベット高原安多観測点で見られた
乱流変動よりちょっと長い変動について

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Amdo (Anduo) PBL site:

Longitude/Latitude/Altitude: 32° 14.468'N/91ḩar'27 37.507'E

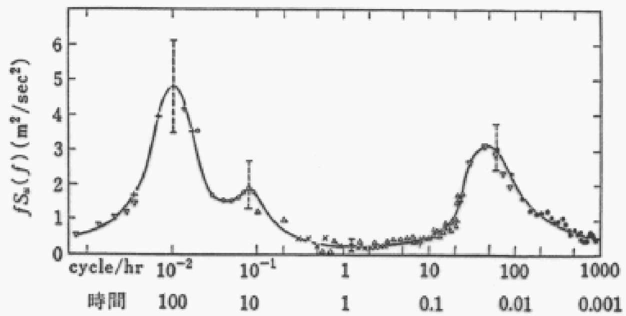
Surface: Flat grassland.

Sensors: Turbulence(2.85m)
/A,B,W,Ts/KAIJO DA-300
/q(variation)/KAIJO AH-300
/Temperature & Relative humidity(reference)/VAISALA HMP35
/Sensor inclination/

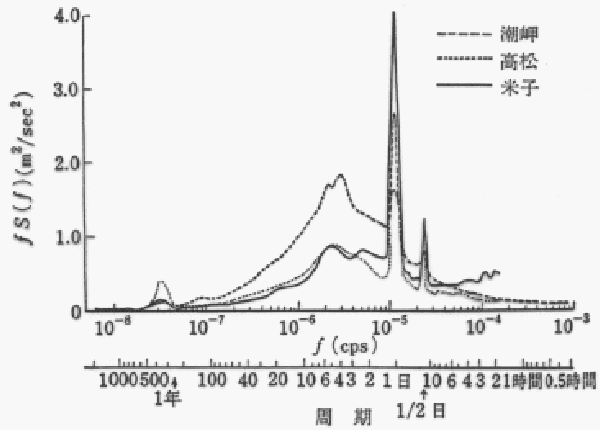
Data Processing and Storage: National Instruments DAQPad MIO
IBM-PC compatible computer
(HDD or 230MB MO disk)

Sampling: 10Hz, continuously, 30min stored in one file

Data amount: 4928 files, 3.8Gb.



(a) 地表付近の風速変動スペクトル (Van der Hoven, 1957)



(b) 風速変動の長周期成分 (光田 寧, 森 征洋, 1975)

図 11.11

長さの効果について示し，Smith (1962) はより一般的にこれらの関係を表わす式を導いた．

有限記録長さによる誤差：まず，最初にサンプリング長さの影響について考える．サンプリングを長さTで打ち切ると，平均値は

$$\{v(t)\}_T=\frac{1}{T}\int_{-T/2}^{T/2}v(t+\xi)\,d\xi \qquad (11.89)$$

と表わされる．ここに t は任意に選ばれた検査時間あるいは距離である．したがって，平均値からの変動分 v_T' は

$$v_T'(t+\xi)=v(t+\xi)-\frac{1}{T}\int_{-T/2}^{T/2}v(t+\eta)\,d\eta \qquad (11.90)$$

日野 1977 スペクトル解析

where ζ has been neglected compared with f in the right hand side of (8.36) (cf. problem 8.16). Integrating (9.19) between the top of the boundary layer ($z=d$) and the top of the atmosphere ($z=H$) we have

$$\frac{\partial \zeta_g}{\partial t}(H-d) = -fw_d$$

and on substituting from (9.18),

$$\frac{\partial \zeta_g}{\partial t} = -\frac{f}{2\gamma H}\zeta_g \qquad (9.20)$$

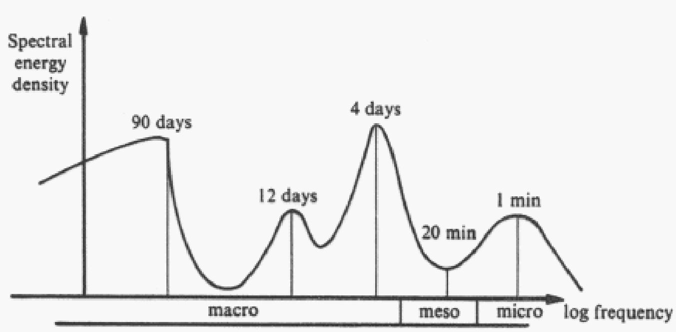
since $d \ll H$.

The result expressed by (9.20) is that the vorticity is reduced with a time constant of $2\gamma H/f$ – the *spin-down time* which is typically several days. The main circulation decays very much more rapidly through this means involving a *secondary circulation* than by other damping mechanisms (problem 9.5). This secondary circulation is driven by friction in the boundary layer, a mechanism known as *Ekman pumping*.

9.6 The spectrum of atmospheric turbulence

The discussion so far in this chapter has been concerned with turbulent motion on the rather small space and time scales associated with the boundary layer. Motion on much larger scales possesses random characteristics and may also be considered as turbulence which therefore occurs in the atmosphere on a very wide range of scales. Fig. 9.5 shows an estimate of the energy spectrum of atmospheric motions on different scales. The minimum in the mesoscale region corresponds to motions in size about 10 km, i.e. about 1 scale height. At smaller

Fig. 9.5. Spectral energy density of atmospheric motions having different time scales. (After Monin, 1973)



Houghton The physics of atmosphere 1986 2nd Ed

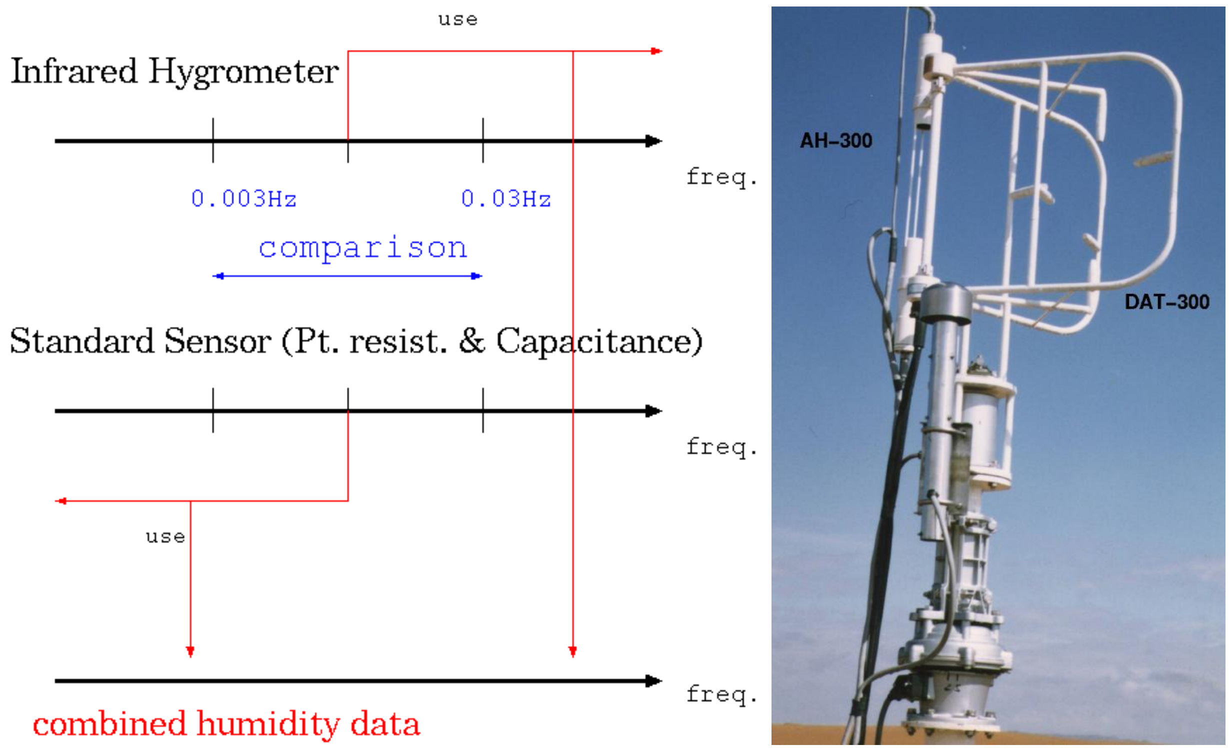
Data Processing

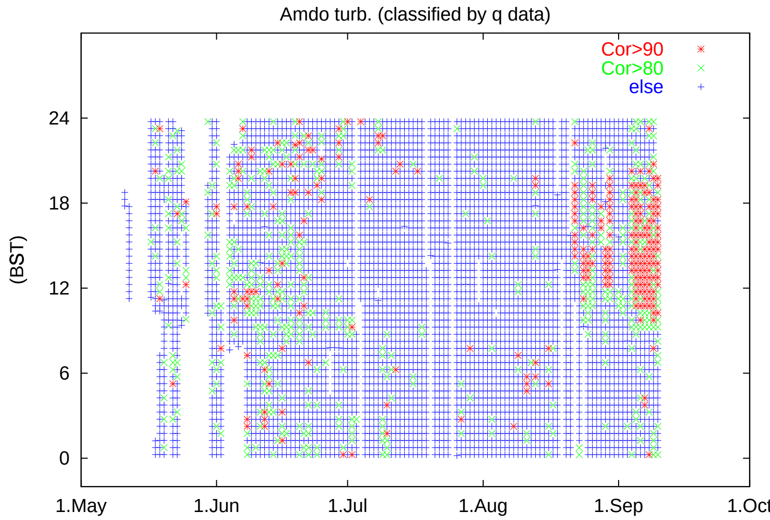
Sonic Anemometer: Coordination change with inclination data

Sonic Thermometer: Cross wind correction and humudity correction

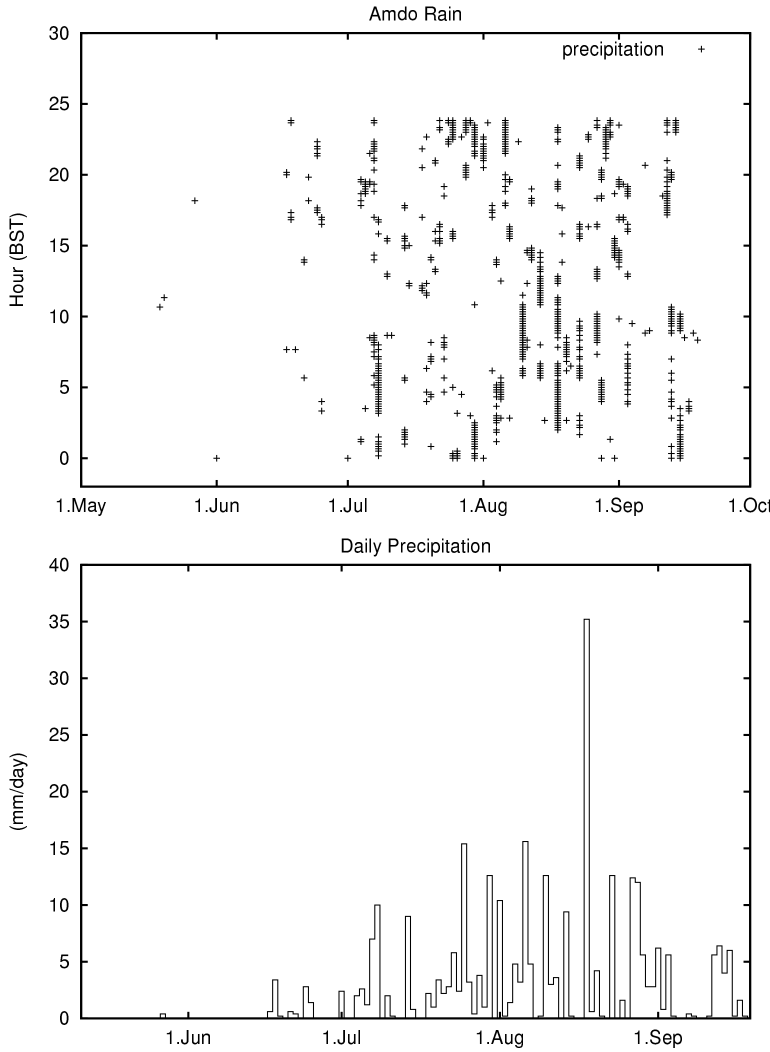
Infrared Hygrometer: Dynamic Calibration and combination with stable low response sensor, converting vapor densisty into mixing ratio.

Processing AH–300 Humidity Data

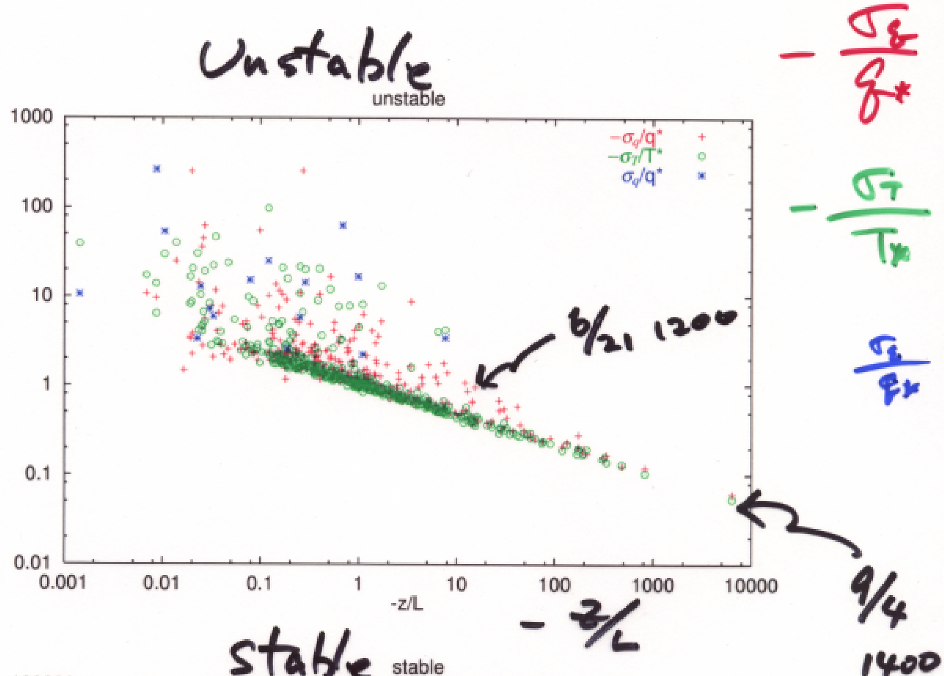


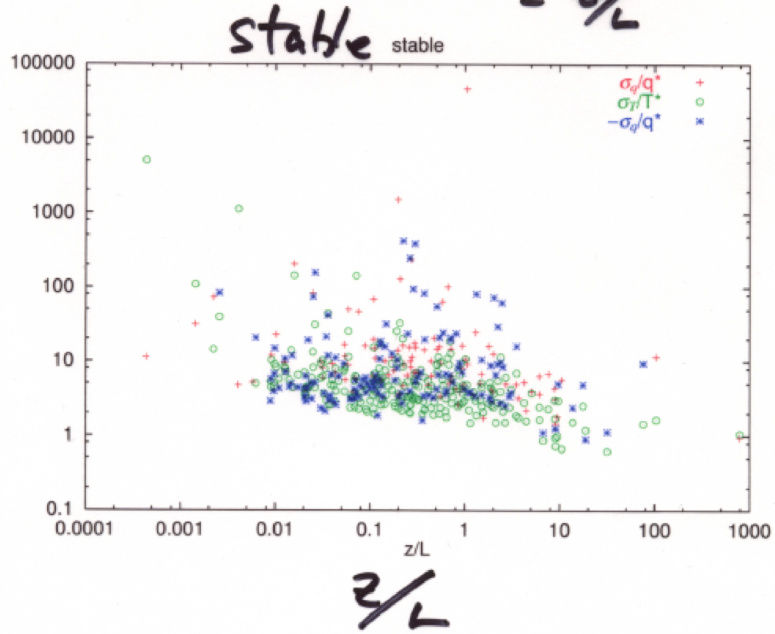


Classification of each run by "Wind Sensor Direction were not moving in the run", "The recieved intensity of the AH-300 are positive" which mean power was on, and "the class of the magnitude of correlation coefficient between q and standard sensor in comparison freq. range (qcov)".



Precipitation at Amdo observation site

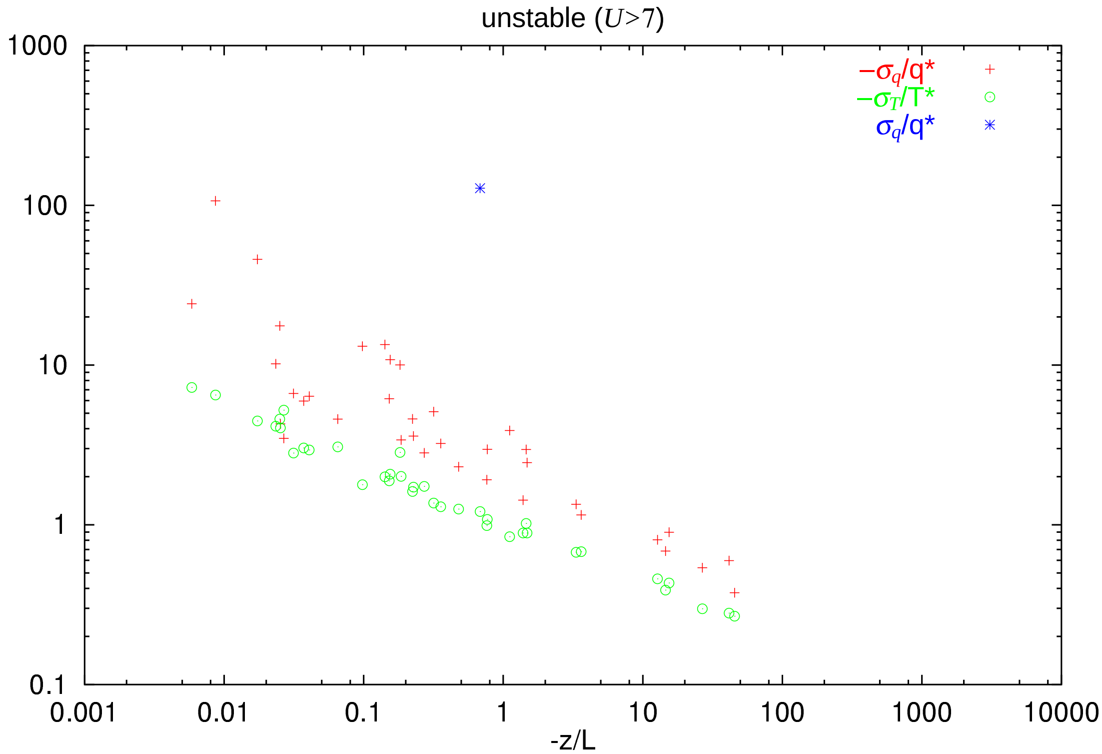




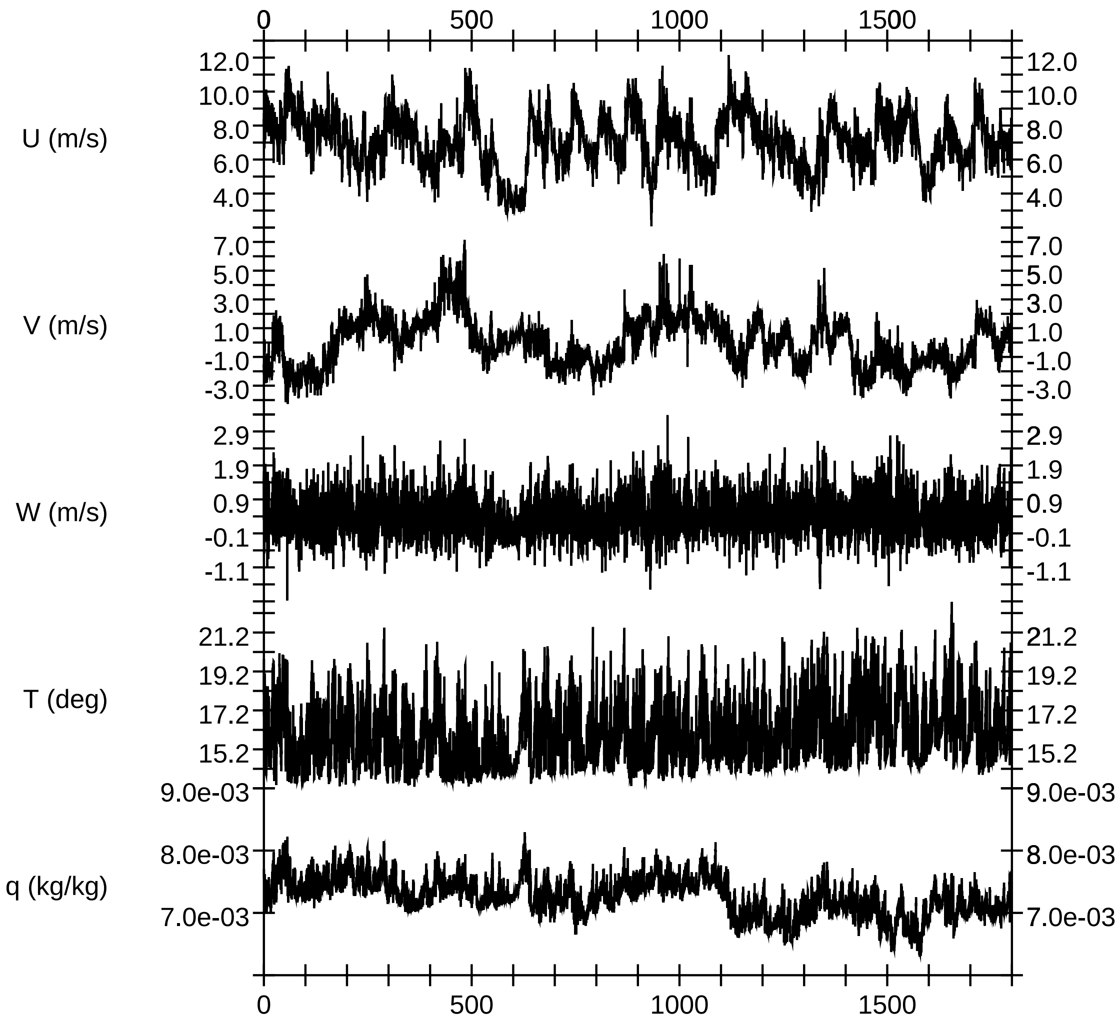
$-\overline{u'w'} = u_* u_*$

$-\overline{T'w'} = T_* u_*$

$-\overline{q'w'} = q_* u_*$


unstable (U>7)
−σq/q*
−σT/T*
σq/q*
1000
100
10
1
0.1
0.001
0.01
0.1
1
10
100
1000
10000
-z/L

../../TurbAmdo/980621/1200.dat Sun Jun 21 12:00:00 1998



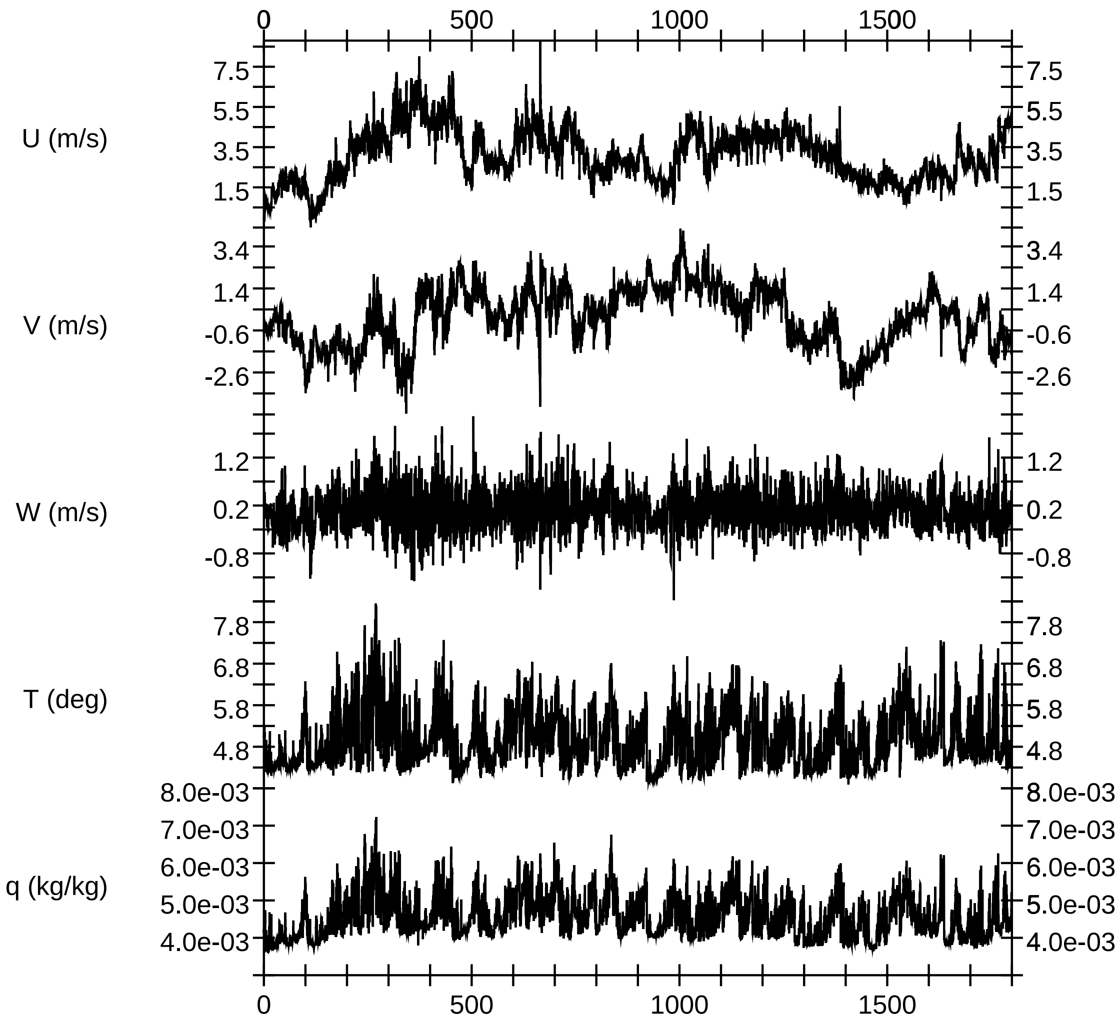
z/L (moist) -15.40 z/L (dry) -15.36
lmin 70.86 qcov 0.886 qcov(l) 0.616
Wind Dir 234.4 Sensor Dir -210.7 Dif.of them -85.1

Means:	U	W	T	q	RH
	7.094	0.402	15.97	0.00726	36.8

Tau(Pa)	H(W/m2)	LE(W/m2)
0.00632	239.0	52.2

sigma_w/u*	sigma_T/T*	sigma_q/q*
5.374	-0.433	-0.965

../../TurbAmdo/980904/1400.dat Fri Sep 4 14:00:00 1998

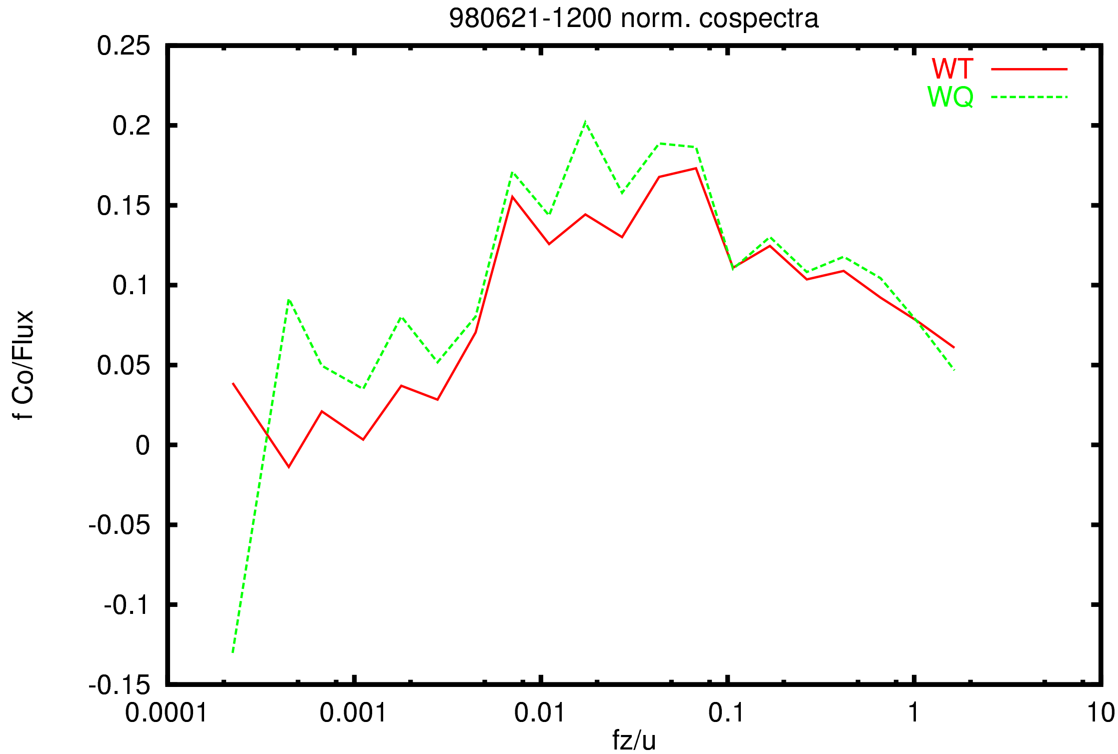


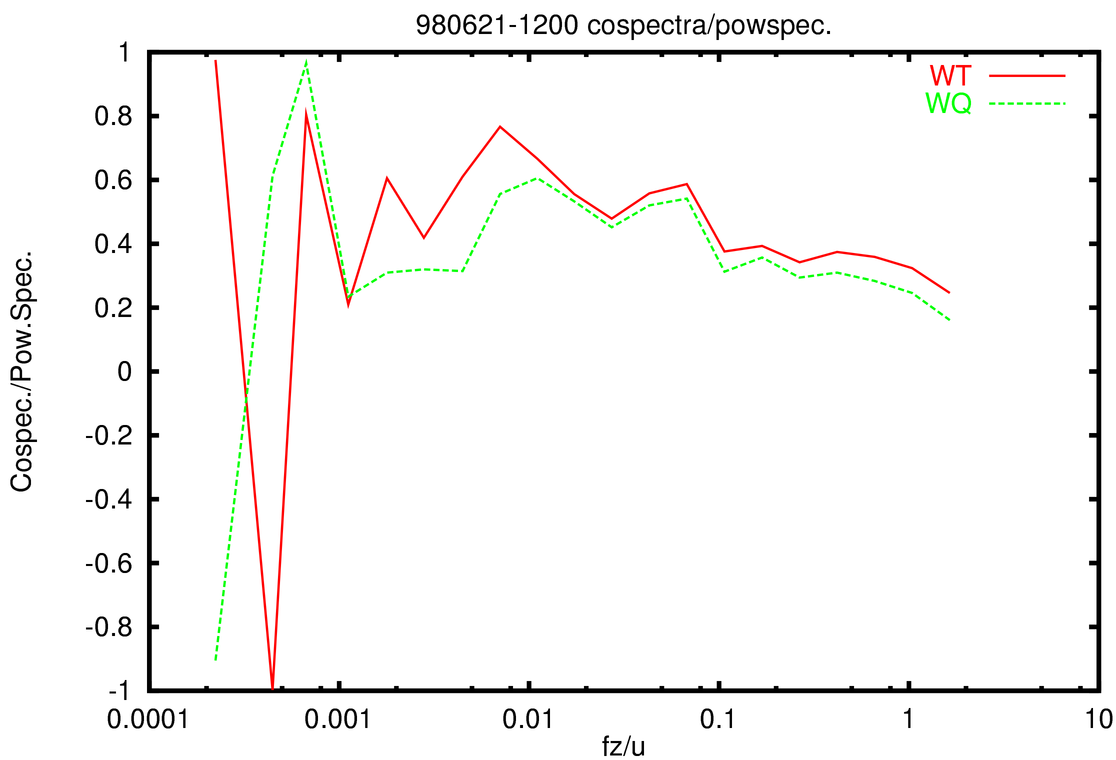
z/L (moist) -6343.62 z/L (dry) -6276.52
Imin 75.20 qcov 0.901 qcov(I) 0.892
Wind Dir 34.8 Sensor Dir 14.6 Dif.of them -20.2

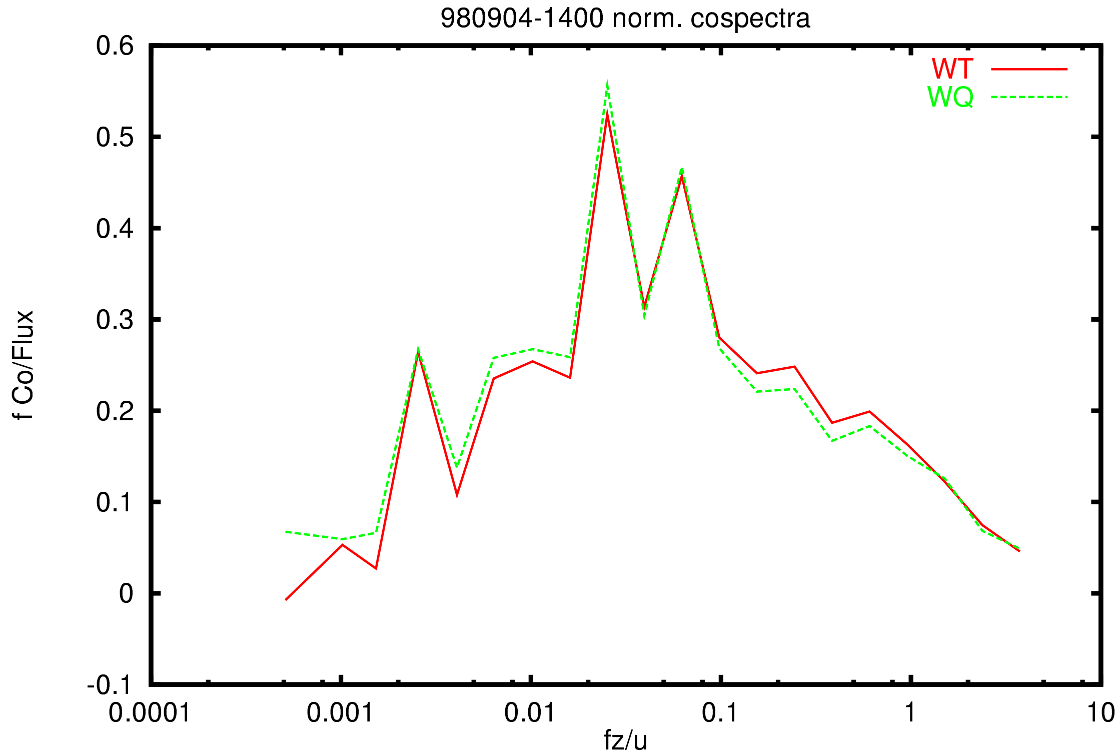
Means:	U	W	T	q	RH
	3.107	0.105	4.97	0.00457	49.0

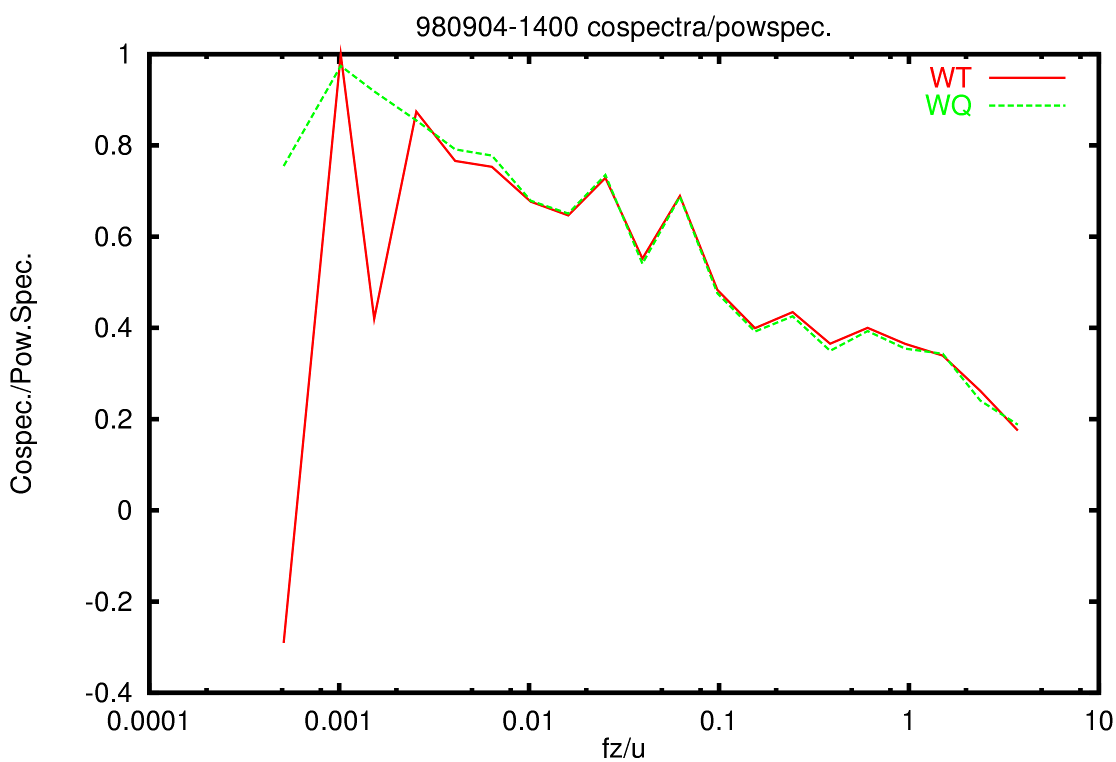
Tau(Pa)	H(W/m2)	LE(W/m2)
-0.00006	78.4	145.6

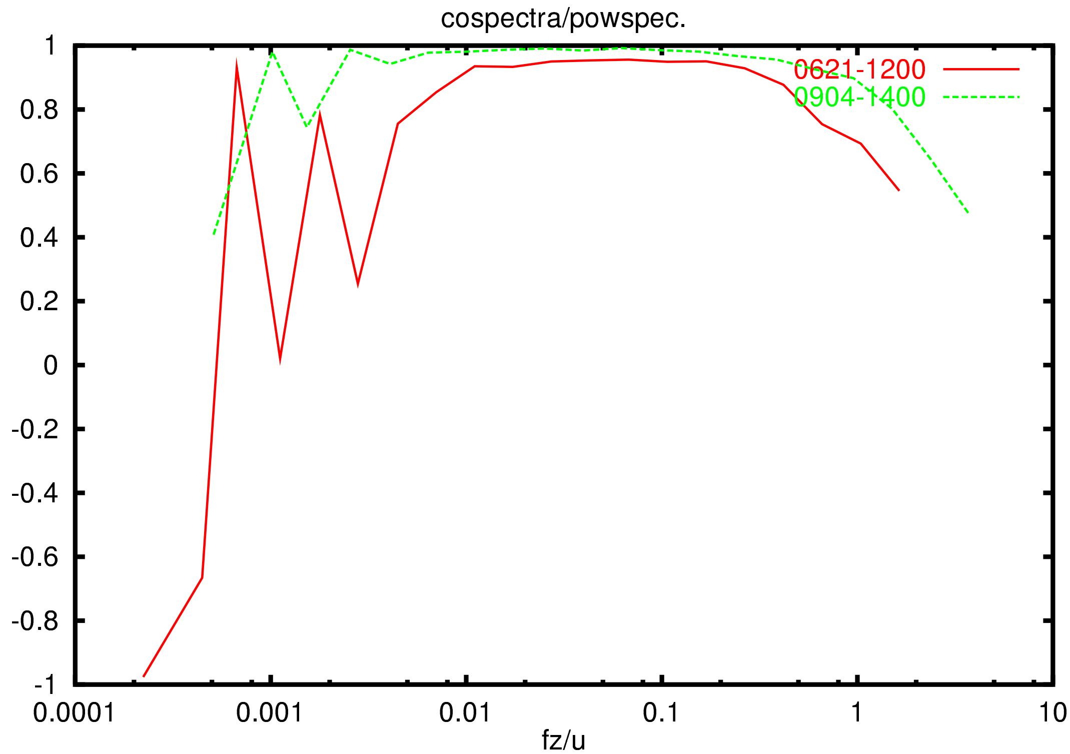
sigma_w/u*	sigma_T/T*	sigma_q/q*
38.804	-0.054	-0.062


980621-1200 norm. cospectra
WT
WQ
f Co/Flux
fz/u
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
0.0001
0.001
0.01
0.1
1
10


980621-1200 cospectra/powspec.
WT
WQ
Cospec./Pow.Spec.
fz/u
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0.0001
0.001
0.01
0.1
1
10

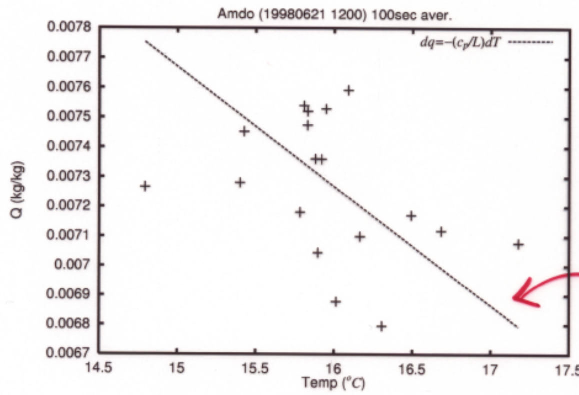

980904-1400 norm. cospectra
f Co/Flux
fz/u
WT
WQ
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0.0001
0.001
0.01
0.1
1
10


980904-1400 cospectra/powspec.
Cospec./Pow.Spec.
fz/u
WT
WQ
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0.0001
0.001
0.01
0.1
1
10



cospectra/powspec.
0621-1200
0904-1400
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0.0001
0.001
0.01
0.1
1
10
fz/u

T-Q plot (100sec. averaged)



6/21 1200~1230

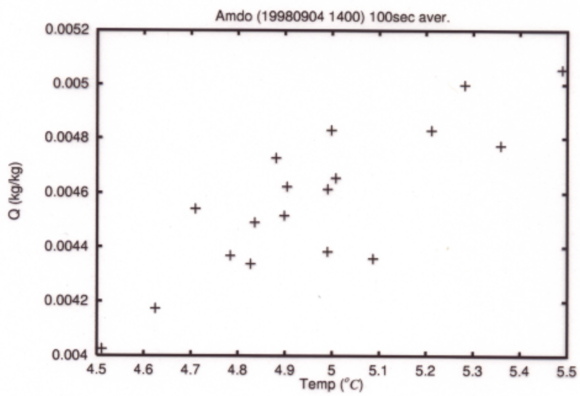
$\frac{\sigma_q}{q_*} \sim 2 \frac{\sigma_T}{T_*}$

$dq = -\frac{c_p}{L} dT$

$\sigma_q/q* = -0.965$, $\sigma_T/T* = -0.433$

U = 7.094m/s, z/L = -15.4

H=239W/m^2, LE=52.2W/m^2



9/4 1400~1430

$\frac{\sigma_q}{q_*} \sim \frac{\sigma_T}{T_*}$

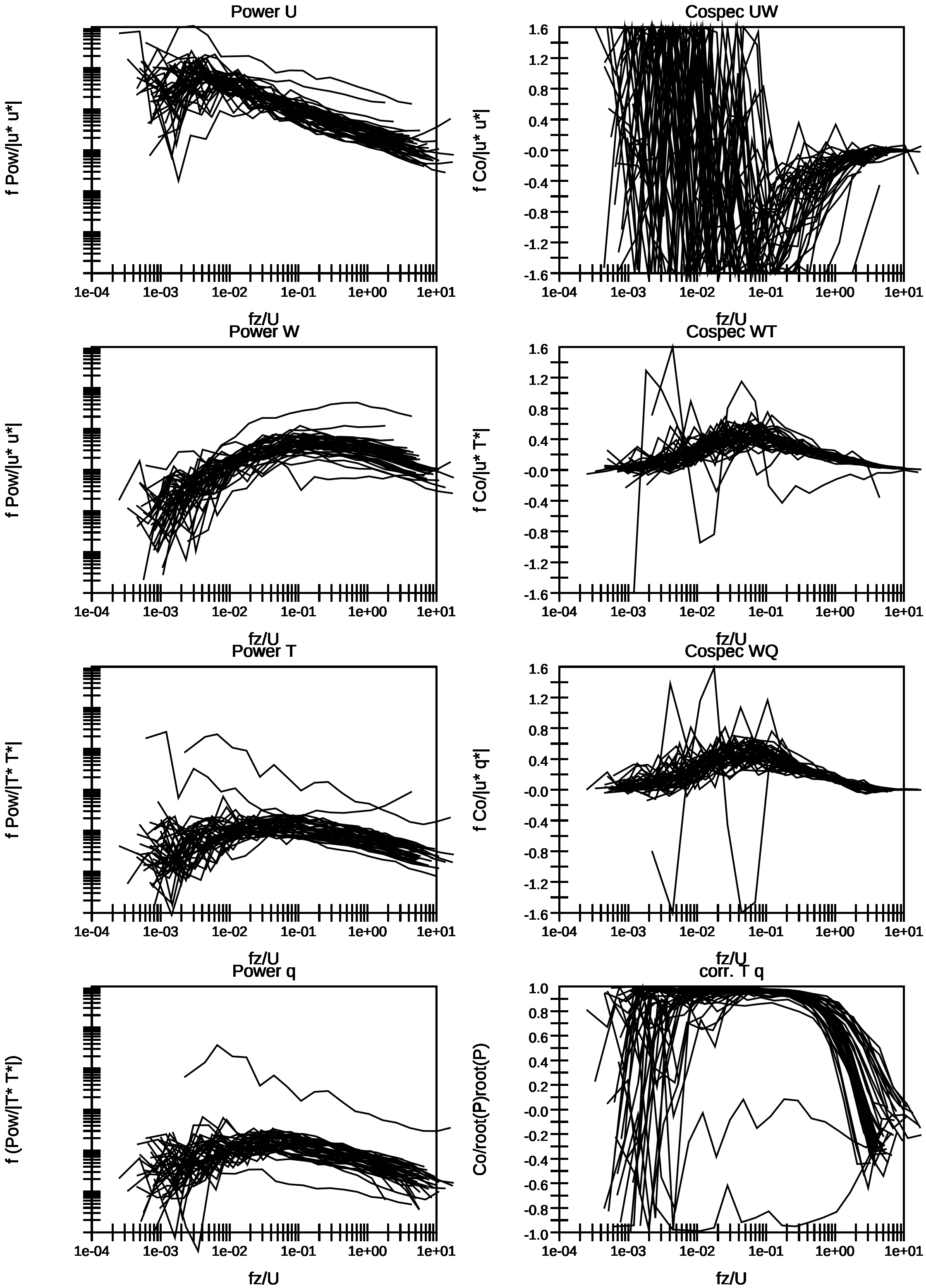
$\sigma_q/q* = -0.062$, $\sigma_T/T* = -0.054$

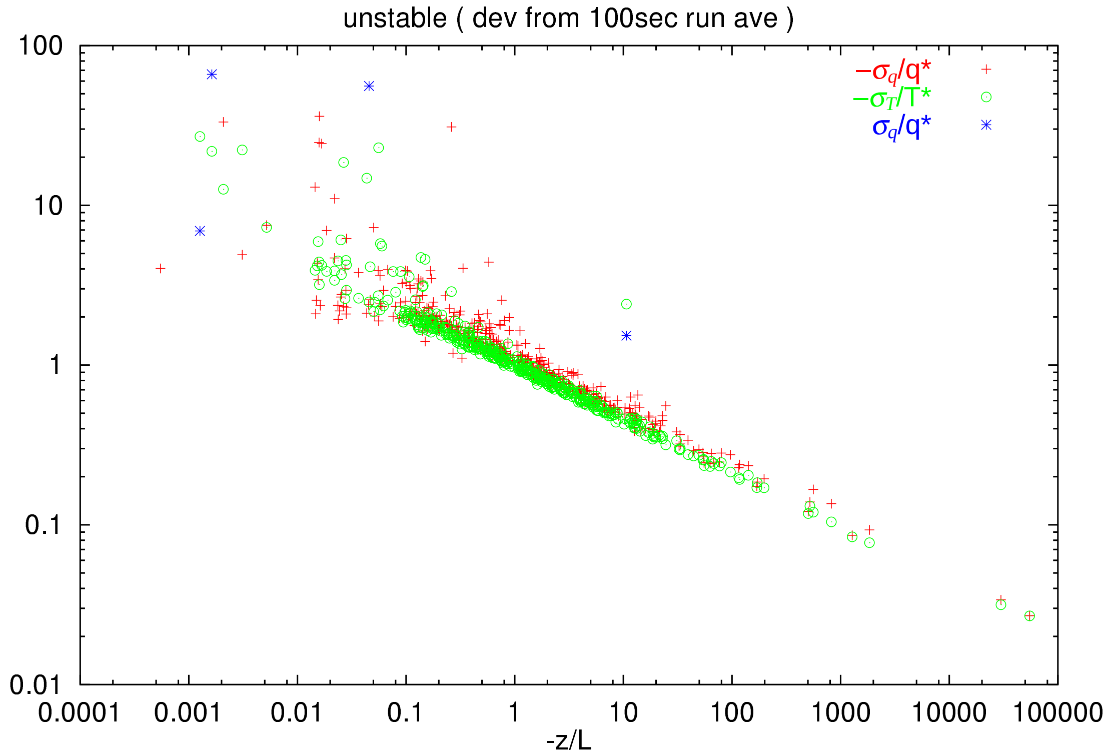
U = 3.107m/s, z/L = -6343.6,

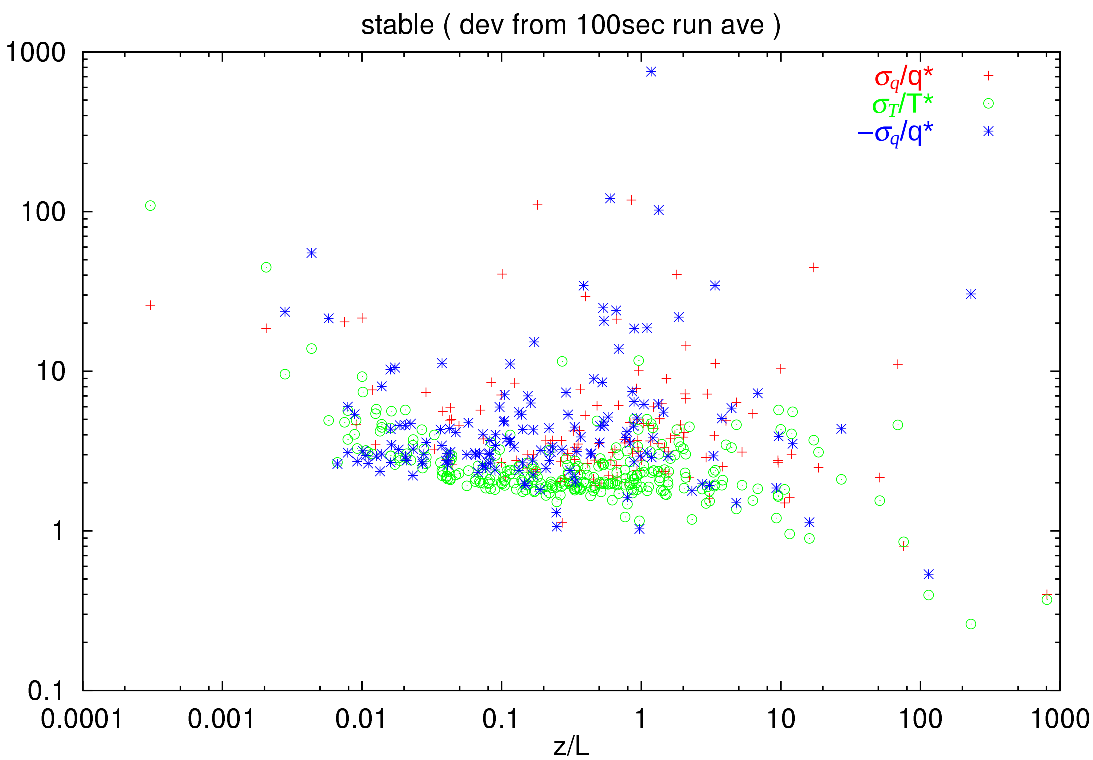
H=78.4W/m^2, LE=145.6W/m^2

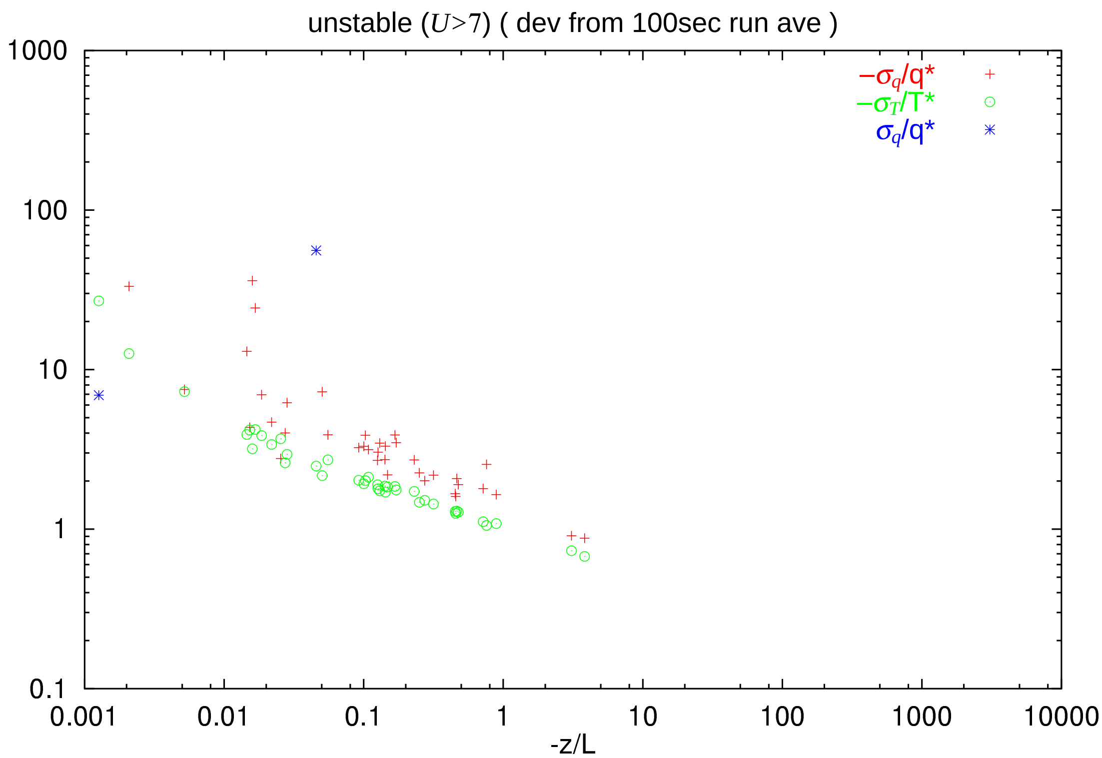
z/L -1.0e+01 <-> -2.0e+00

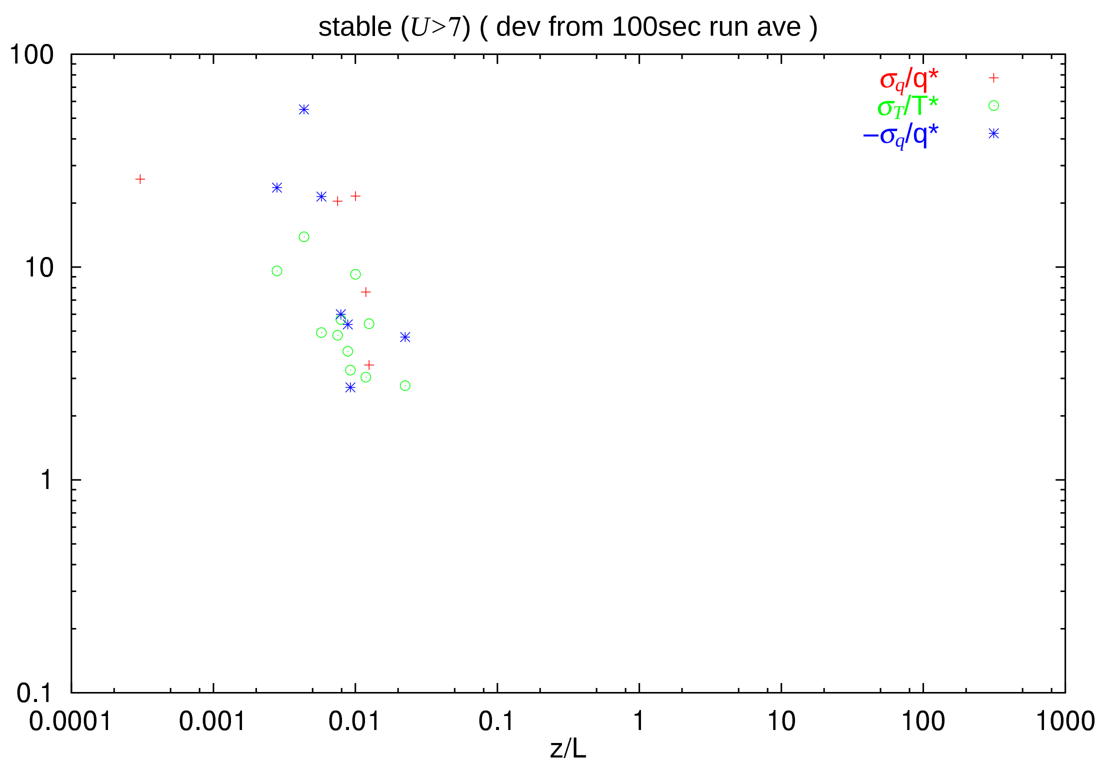
rotated in mean wind plane, detrended

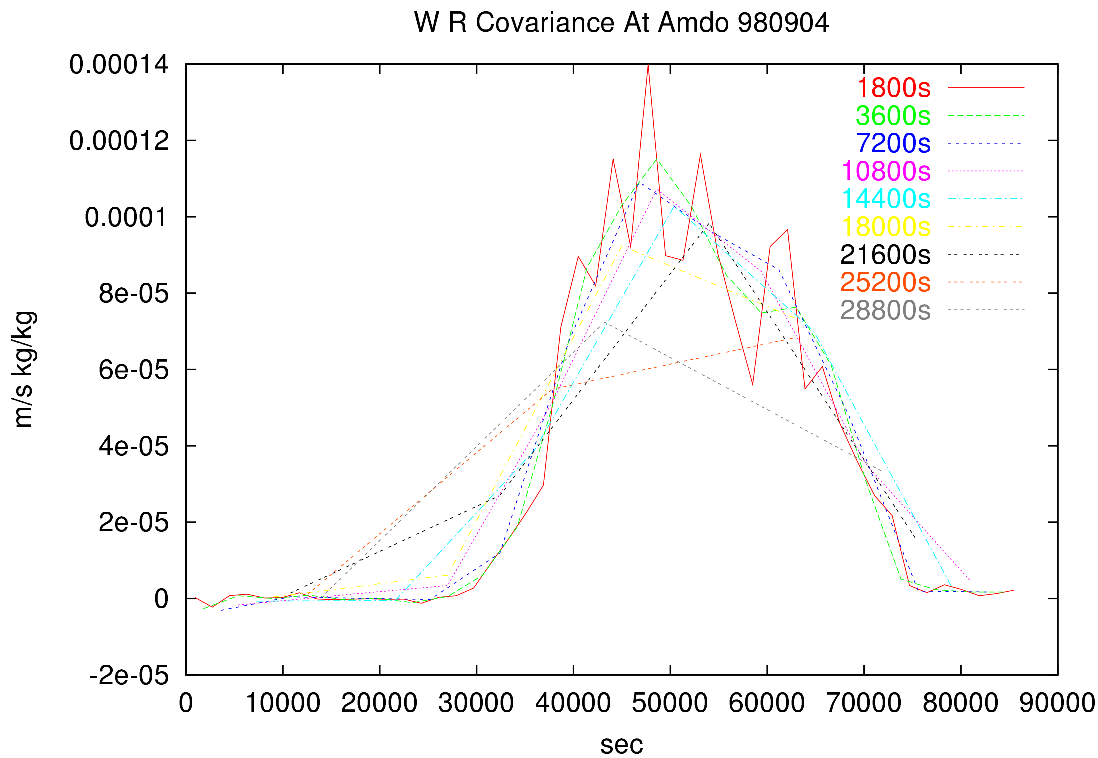


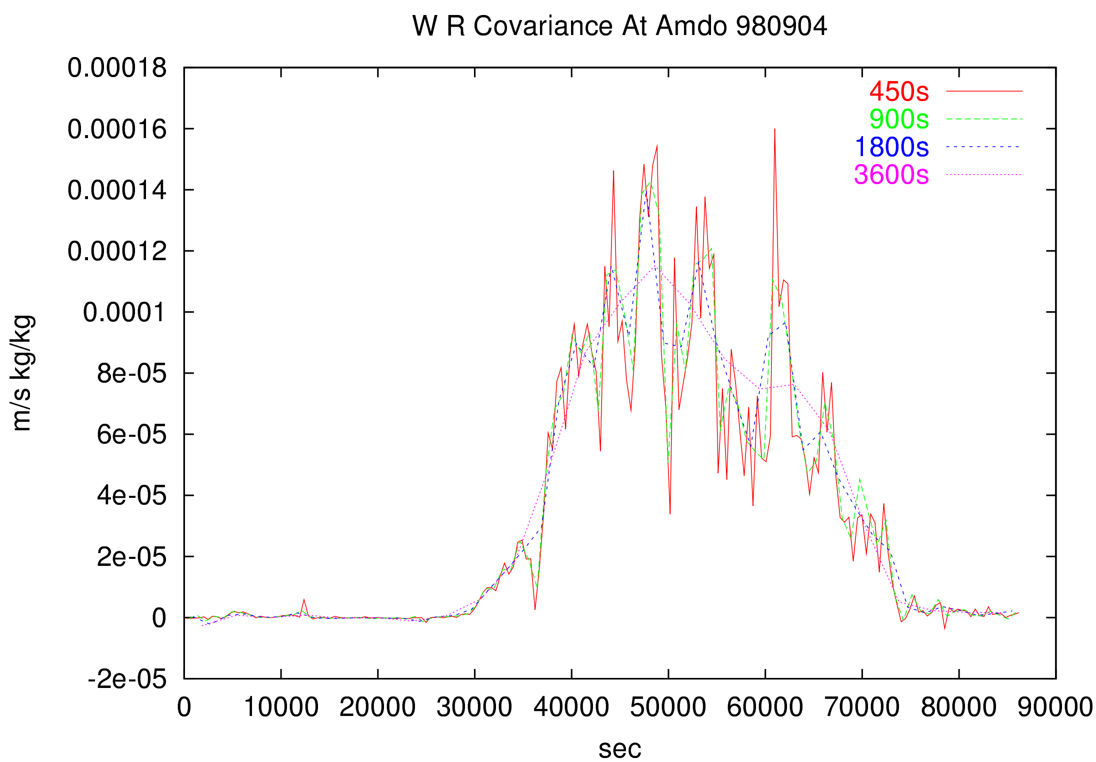

unstable (dev from 100sec run ave)
$-\sigma_q/q*$
$-\sigma_T/T*$
$\sigma_q/q*$
100
10
1
0.1
0.01
0.0001
0.001
0.01
0.1
1
10
100
1000
10000
100000
-z/L

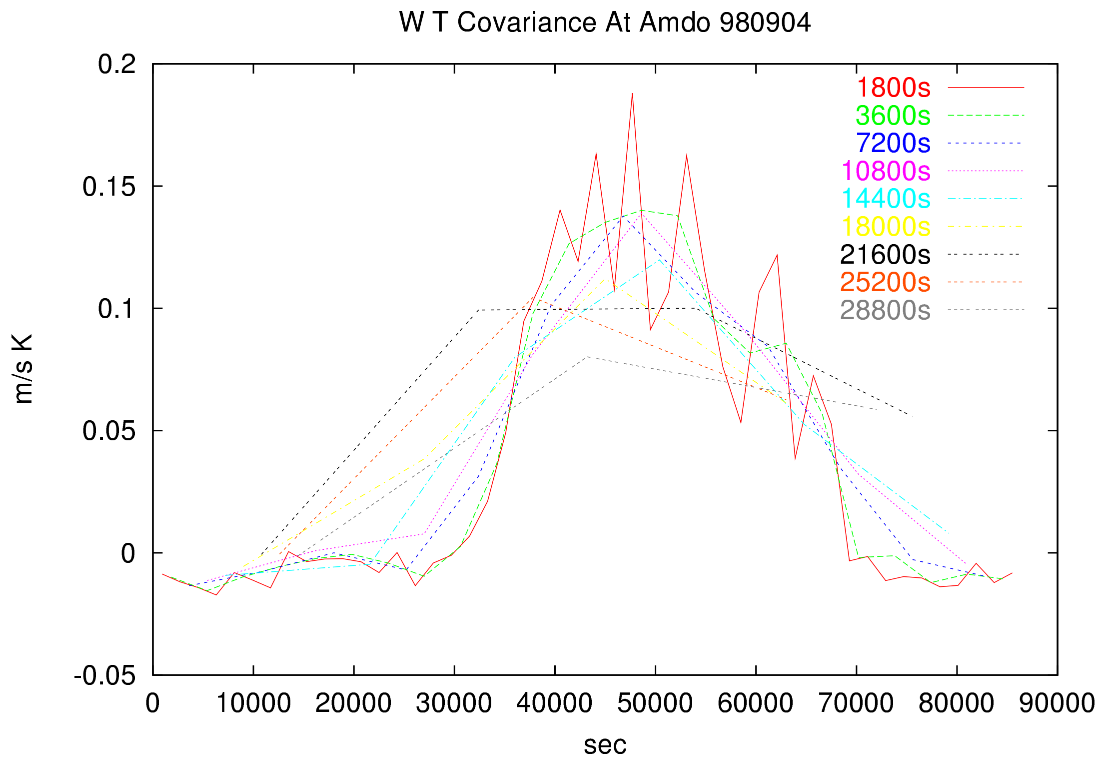

stable (dev from 100sec run ave)
$\sigma_q/q*$
$\sigma_T/T*$
$-\sigma_q/q*$
1000
100
10
1
0.1
0.0001
0.001
0.01
0.1
1
10
100
1000
z/L

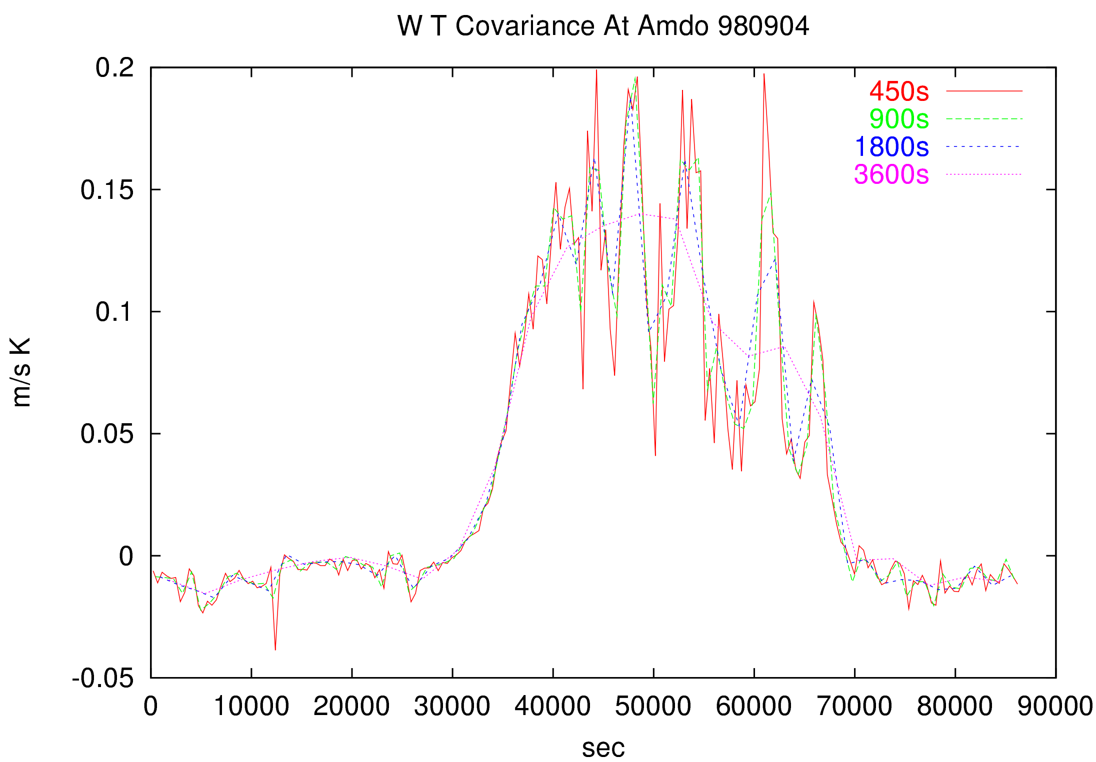

unstable (U>7) (dev from 100sec run ave)
−σq/q*
−σT/T*
σq/q*
1000
100
10
1
0.1
0.001
0.01
0.1
1
10
100
1000
10000
-z/L

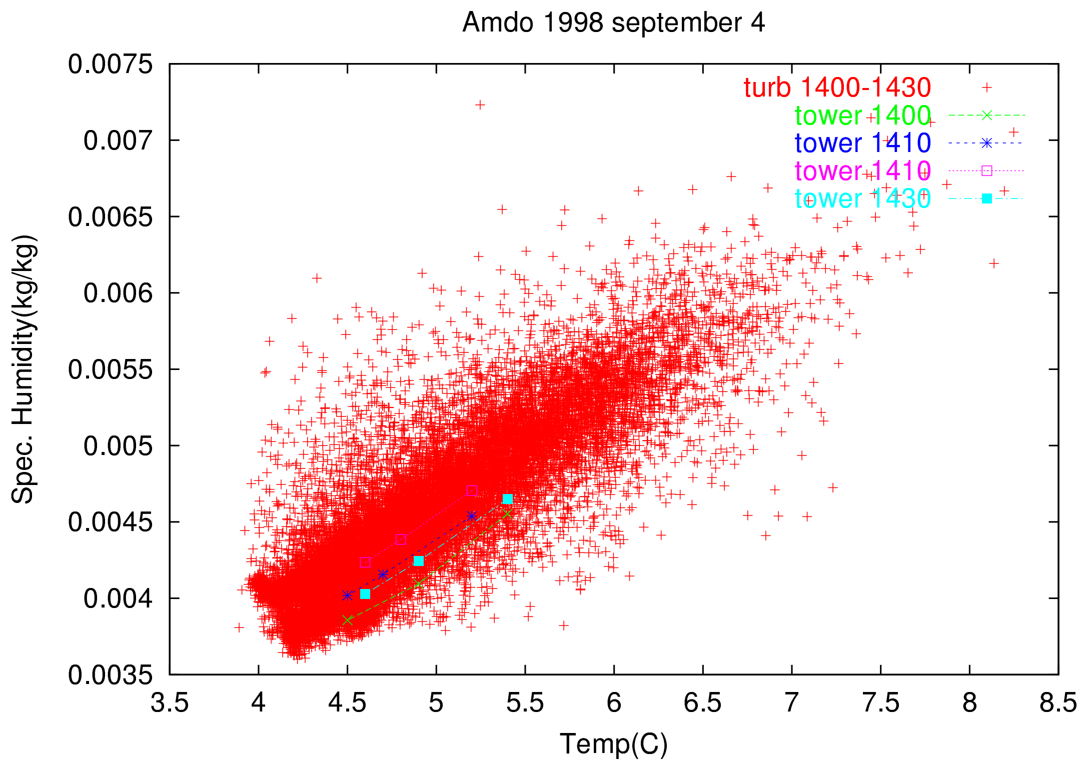

stable (U>7) (dev from 100sec run ave)
σq/q*
σT/T*
−σq/q*
100
10
1
0.1
0.0001
0.001
0.01
0.1
1
10
100
1000
z/L

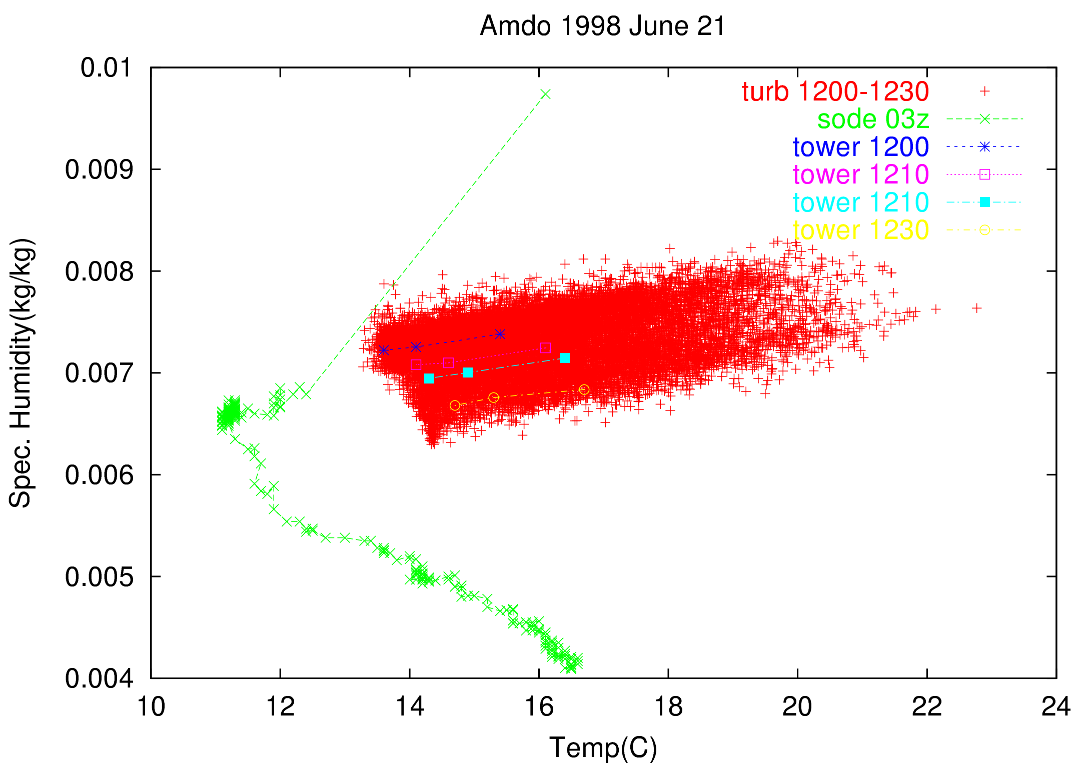

W R Covariance At Amdo 980904
m/s kg/kg
sec
1800s
3600s
7200s
10800s
14400s
18000s
21600s
25200s
28800s
0.00014
0.00012
0.0001
8e-05
6e-05
4e-05
2e-05
0
-2e-05
0
10000
20000
30000
40000
50000
60000
70000
80000
90000


W R Covariance At Amdo 980904
m/s kg/kg
sec
450s
900s
1800s
3600s
0.00018
0.00016
0.00014
0.00012
0.0001
8e-05
6e-05
4e-05
2e-05
0
-2e-05
0
10000
20000
30000
40000
50000
60000
70000
80000
90000


W T Covariance At Amdo 980904
1800s
3600s
7200s
10800s
14400s
18000s
21600s
25200s
28800s
m/s K
sec
0.2
0.15
0.1
0.05
0
-0.05
0
10000
20000
30000
40000
50000
60000
70000
80000
90000


W T Covariance At Amdo 980904
450s
900s
1800s
3600s
m/s K
sec
0.2
0.15
0.1
0.05
0
-0.05
0
10000
20000
30000
40000
50000
60000
70000
80000
90000


Amdo 1998 september 4
turb 1400-1430
tower 1400
tower 1410
tower 1410
tower 1430
Spec. Humidity(kg/kg)
Temp(C)
0.0075
0.007
0.0065
0.006
0.0055
0.005
0.0045
0.004
0.0035
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5


Amdo 1998 June 21
turb 1200-1230
sode 03z
tower 1200
tower 1210
tower 1210
tower 1230
Spec. Humidity(kg/kg)
Temp(C)
0.01
0.009
0.008
0.007
0.006
0.005
0.004
10
12
14
16
18
20
22
24