Basic turbulence data processing report, WFIP2 physics site 01 (PS01)

June 27, 2017, BWB

The met tower at PS01 has sonic wind and bulk T/RH measurements at two levels, 3m and 10m. Fast water vapor and CO2 (Licor 7500) is included at the 3m level. In addition, the site has SODAR (Vaisala Triton), up/down solar and IR radiometers, and soil temperature / moisture measurements.

This note describes basic processing of turbulence, soil and radiation data for the period 24-Jun-2016 to 01-May-2017. Soil and radiation data are as-supplied by PSD/HOP, averaged to 30 min. Soil measurements have passed QA/QC.

Summary met and spectra plots are in *~/Cruises/WFIP2_2016/PS01/images_final/*

Results are available in *~/Cruises/WFIP2_2016/PS01/processed_final/*
Three file formats are available: as 139 variables in *da_PS01_all_PF_rad_soil.mat*; as raw, headerless matlab ascii text output in *da_PS01_all_PF_rad_soil.txt*; and as tab-delimited ascii with a single variable name header line in *da_PS01_all_PF_rad_soil_hdr.txt*.

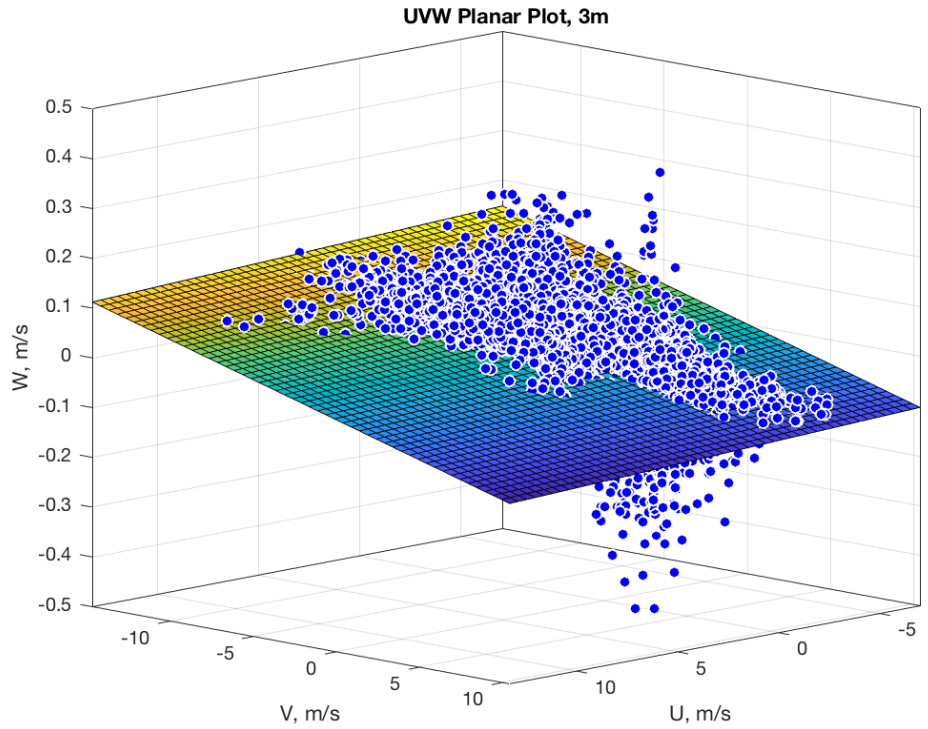
Variable descriptions are given in *da_PS01_all_PF_rad_soil.README.txt*

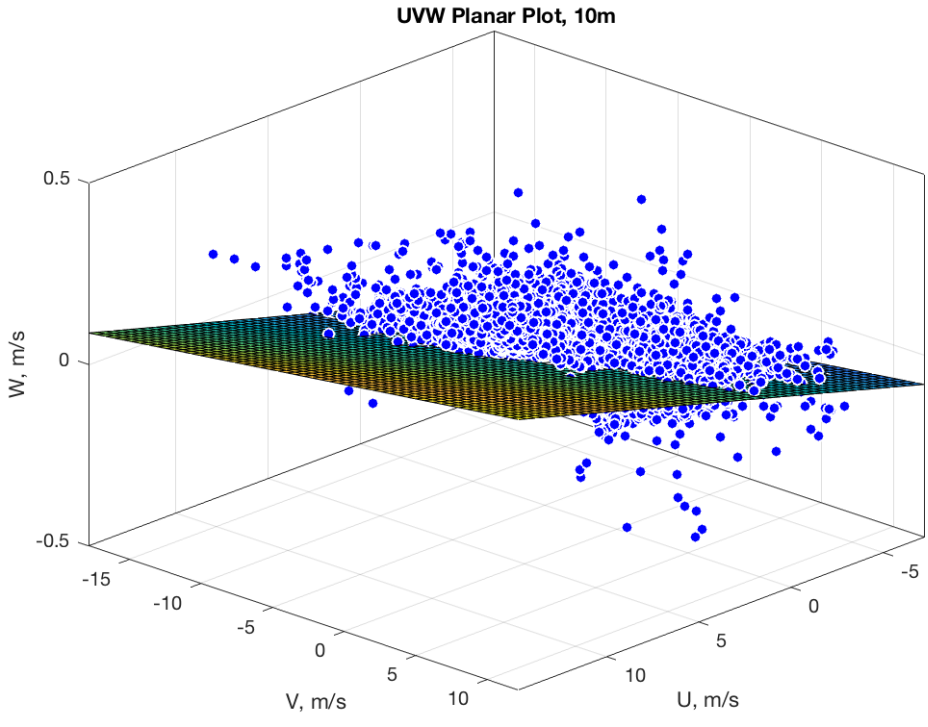
Turbulence parameters and derived quantities are presented 'as is', but three logical arrays provide a data selection mask to remove outliers: good03 (3m sonic), good10 (10m sonic) and good_licor (good_licor = good03 & agc<60;). Note, the Notre Dame group has done preliminary QA/QC on the sonic data, removing most periods where wind direction is in the 90-180° sector, when measurements are subject to interference from the met tower.

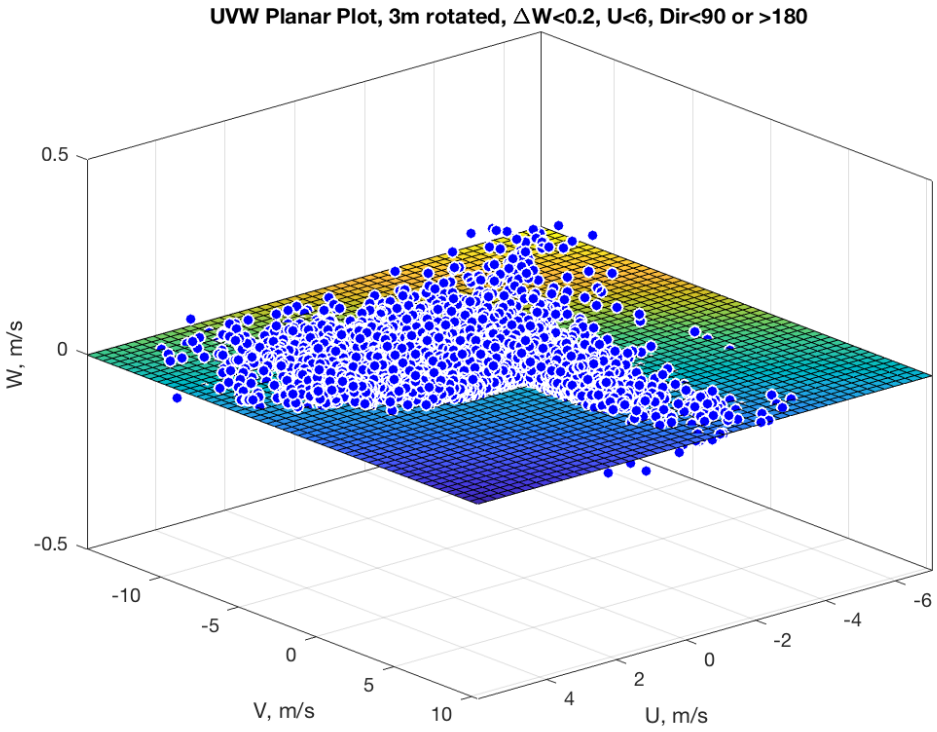
Planar fit coefficients were derived from an analysis of raw UVW data at each level. A planar plot of the 3m level (next page) shows the expected positive bias in W when wind is from the W (i.e. blowing up hill). Note, V is positive to the East, U is positive to the North. The mean plane slopes in a different direction at the 10m level, which may be due to anemometer tilt. There are apparent outlier values, especially when wind speeds are low. A filter was applied to clip some of the outliers, removing 30 min values where $\overline{W}$ is displaced by more than+/- 0.2 m/s from the mean plane, U > 6 m/s (strong southerly wind), or wdir is 90 – 180°.

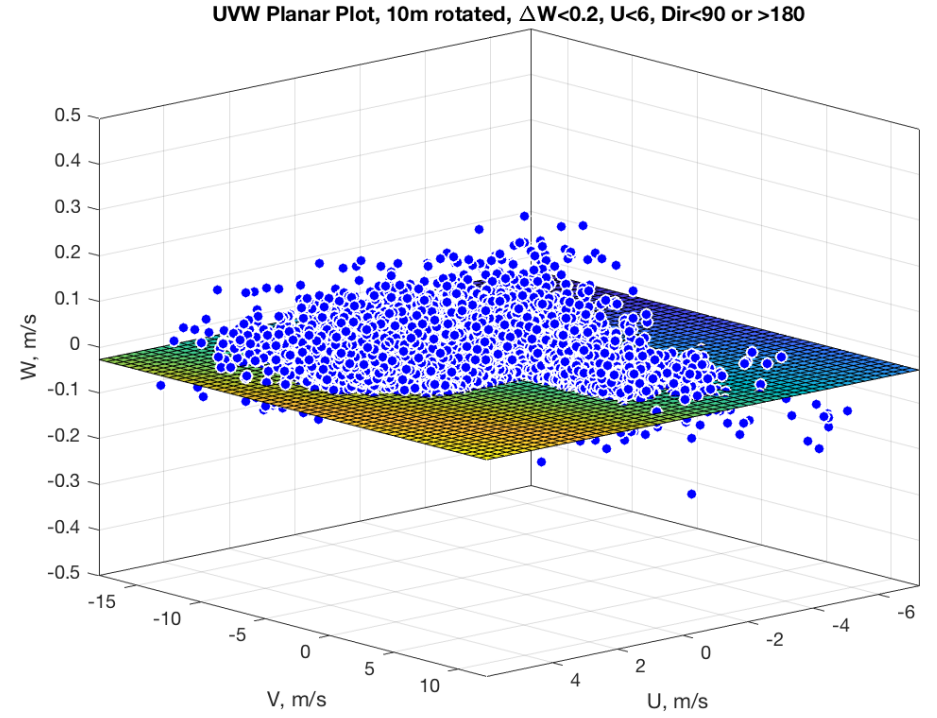
```
ff = isfinite(uvw03(:,1));
sf03 = fit([uvw03(ff,1),uvw03(ff,2)],uvw03(ff,3),'poly11');
DiffW03 = abs(uvw03(:,3) - (sf03.p00 + sf03.p10*uvw03(:,1) + sf03.p01*uvw03(:,2)));
good03 = (isfinite(uvw03(:,1)) & DiffW03<0.20 & uvw03(:,1)<6 & (dir03<90 | dir03>180));
```

Planar fit coefficients were determined from the filtered data at both levels and the subsequent rotation is shown in plots on p.3.


UVW Planar Plot, 3m
W, m/s
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-10
-5
0
5
10
V, m/s
-5
0
5
10
U, m/s

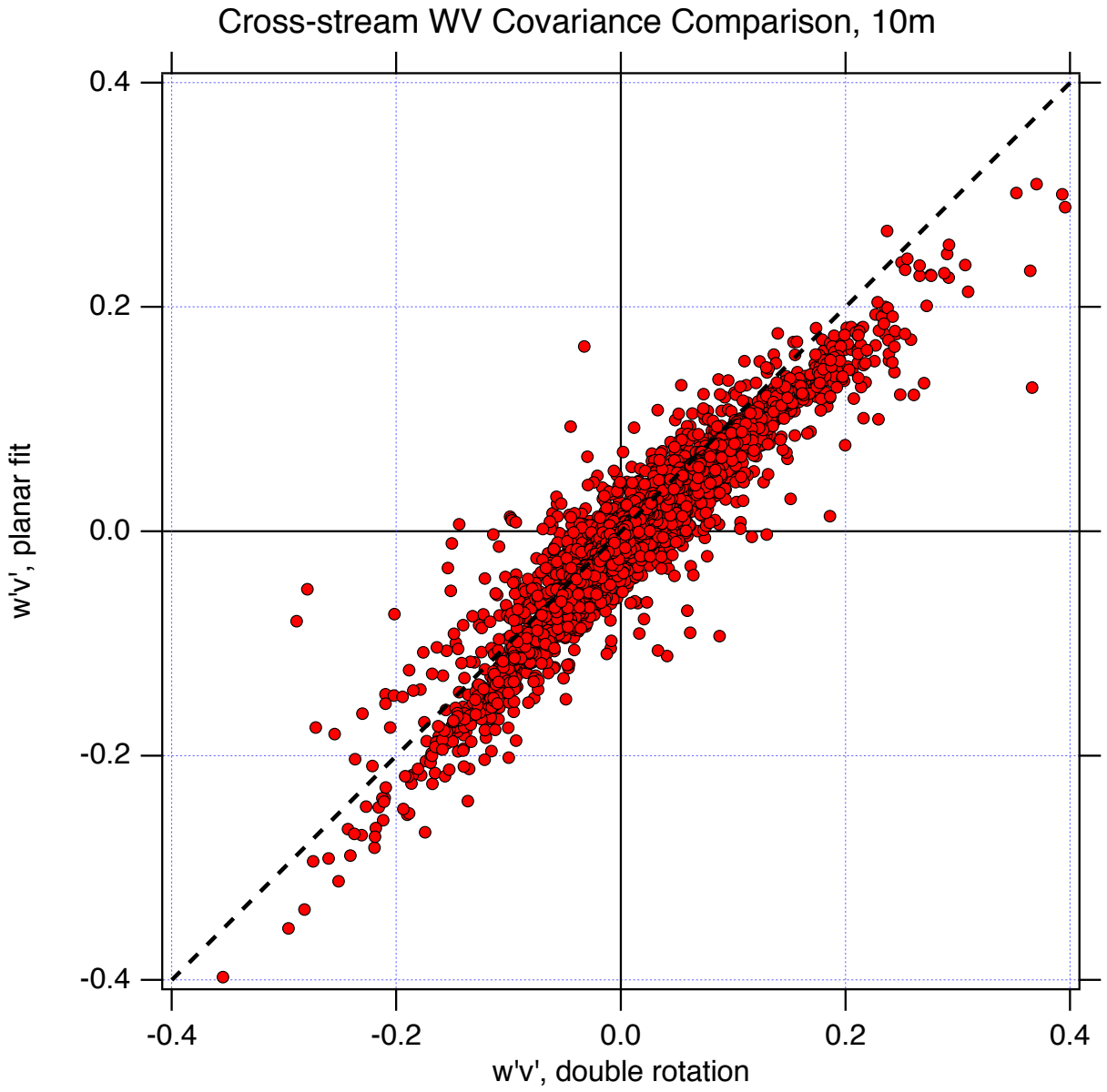

UVW Planar Plot, 10m
W, m/s
0.5
0
-0.5
-15
-10
-5
0
5
10
V, m/s
-5
0
5
10
U, m/s


UVW Planar Plot, 3m rotated, △W<0.2, U<6, Dir<90 or >180
W, m/s
0.5
0
-0.5
V, m/s
-10
-5
0
5
10
U, m/s
4
2
0
-2
-4
-6

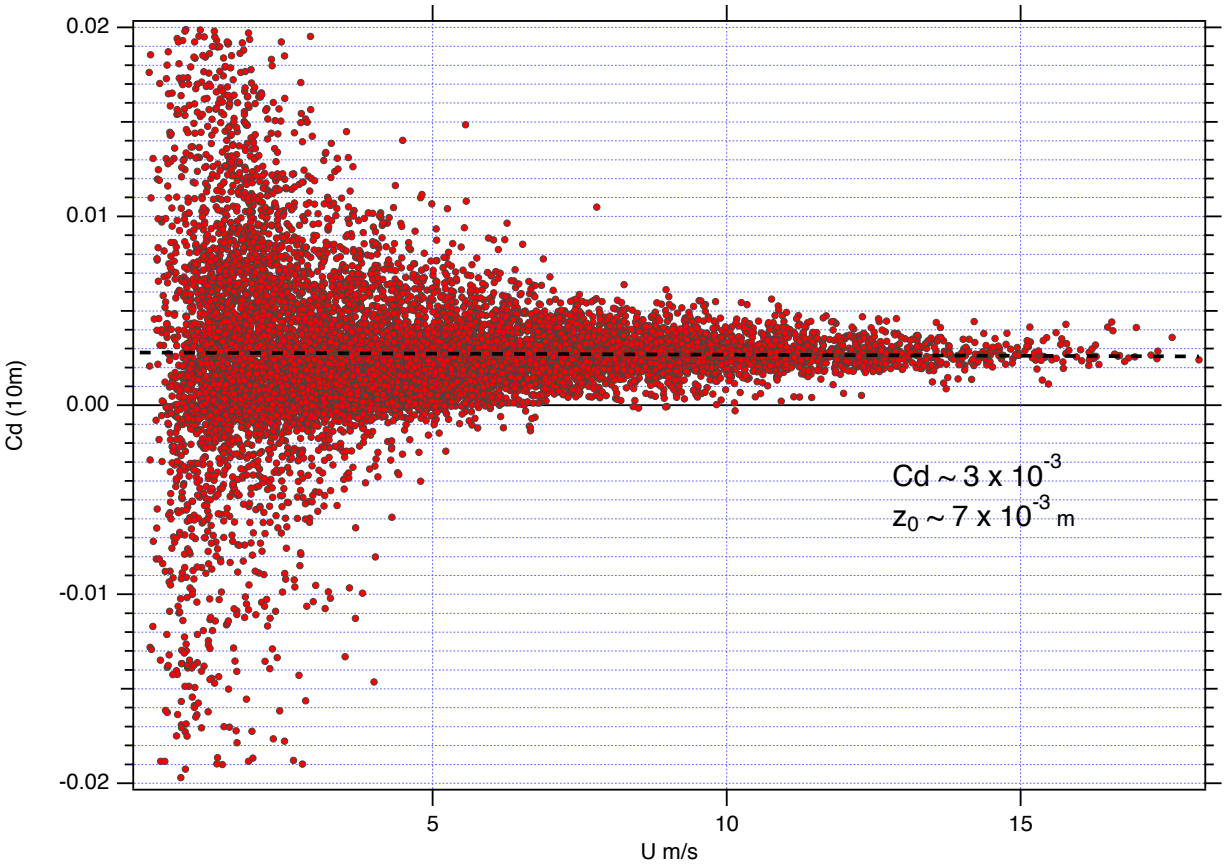

UVW Planar Plot, 10m rotated, △W<0.2, U<6, Dir<90 or >180
W, m/s
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
V, m/s
-15
-10
-5
0
5
10
U, m/s
4
2
0
-2
-4
-6

Following rotation into the plane, an azimuth rotation into the streamline was applied in 30 min segments for computing covariances.

Comparison plots for the double rotation and planar fit runs are in *~/cruises/WFIP2_2016/PS01/processed_final/PF/*. Most comparisons show little difference except for increasing scatter at lower wind speeds. Cross-stream stress at the 10m level is the exception, where the double rotation method seems to give a more positive result.



For all data, the 10m drag coefficient is ~ 3 x 10^{-3}, giving z_0 ~ 7 x 10^{-3} m, which seems reasonable.



Smoothed 30-min spectra and cospectra data are in the files *sp_PS01_all_PF.mat* or *sp_PS01_all_PF.txt*. The first column is a julian day-of-year timestamp but corresponds exactly to the dnum timestamp in *da_PS01_all_PF_rad_soil.mat*. See *specreader_WFIP2.m* for how to read, filter and plot spectra data from this file.

Structure function parameters are computed 2 ways:
1) "Method a", from the spectrum mean between Fx ~0.8 and 1.2 Hz (*Px(fmin:fmax)),*

```
Cx2 = mean(4*((2*pi/rwspd)^(2/3))*Px(fmin:fmax).*Fx(fmin:fmax).^(5/3));
```

2) "Method b", from a polynomial fit to the spectrum over Fx ~0.8 to 3 Hz, choosing a value where the slope is close to zero (<0.25),

```
logF = log(Fx(fmin:fmax));
logP = log(4*((2*pi/rwspd).^(2/3)).*Px(fmin:fmax).*(Fx(fmin:fmax).^(5/3)));
Zpoly = polyfit(logF,logP,4);  % Then find point where Zpoly(4)<0.25
```

These could be recomputed from the spectra with different criteria if desired.

This is a list of parameters and computed quantities in the *da_PS01_all_PF_rad_soil* files.

30-min result array, 14976 rows x 139 columns
3m and 10m heights on tower PS01 - licor only at 3m

column	variable	description
1	dnum	matlab datenum at start of 30 min interval
2	U03_m_s	NS wind speed vector, m/s (positive fromS), 3m
3	V03_m_s	EW wind speed vector, m/s (positive from E), 3m
4	W03_m_s	Vertical wind speed vector, m/s (positive upward), 3m
5	T_sonic03_C	sonic air temperature, C, 3m
6	wspd03_m_s	wind speed, m/s, 3m
7	wspd03_m_s_std	std dev wind speed, m/s, 3m
8	wdir03	wind direction, deg, 3m
9	wdir03_std	std dev wind direction, deg, 3m
10	Ta03_C	air temp, C, 3m
11	rh03	relative humidity, %, 3m
12	Ta03_C_std	std dev air temp, C, 3m
13	rh03_std	std dev rh, %, 3m
14	Ta03_C_min	minimum air temp, C, 3m
15	rh03_min	minimum rh, %, 3m
16	Ta03_C_max	maximum air temp, C, 3m
17	rh03_max	maximum rh, %, 3m
18	co2_mmol_m3	licor co2 conc, mmol/m3, 3m
19	h2o_mmol_m3	licor h2o conc, mmol/m3, 3m
20	P_mb	licor pressure, mb
21	T_licor_C	licor box temperature, C
22	agc	licor AGC QA parameter
23	co2_ppm	licor co2 conc, ppm or umol/mol, 3m
24	co2_mmol_m3_std	std dev licor co2 conc, mmol/m3, 3m
25	h2o_mmol_m3_std	std dev licor h2o conc, mmol/m3, 3m
26	P_mb_std	std dev pressure, mb
27	T_licor_C_std	std dev licor box temperature, C
28	agc_std	std dev AGC
29	co2_ppm_std	std dev licor co2 conc, ppm or umol/mol, 3m
30	co2_mmol_m3_min	minimum licor co2 conc, mmol/m3, 3m
31	h2o_mmol_m3_min	minimum licor h2o conc, mmol/m3, 3m
32	P_mb_min	minimum licor pressure, mb
33	T_licor_C_min	minimum licor box temperature, C
34	agc_min	minimum licor AGC QA parameter
35	co2_ppm_min	minimum licor co2 conc, ppm or umol/mol
36	co2_mmol_m3_max	maximum licor co2 conc, mmol/m3
37	h2o_mmol_m3_max	maximum licor h2o conc, mmol/m3
38	P_mb_max	maximum pressure
39	T_licor_C_max	maximum licor box temperature, C
40	agc_max	maximum AGC
41	co2_ppm_max	maximum licor co2 conc, ppm or umol/mol
42	q_g_kg	specific humidity, g/kg, 3m
43	q_lic_g_kg	licor specific humidity, g/kg, 3m
44	q_lic_g_kg_std	std dev licor specific humidity, g/kg, 3m
45	rho_air03	moist air density, kg/m3, 3m
46	wu03	streamwise WU covariance, m2/s2
47	wv03	cross-stream WV covariance, m2/s2
48	wt03	Tsonic:W covariance, degC m/s
49	wq03	q:W covariance, g m/kg s
50	hs03	sensible heat flux, moisture corrected, W/m2
51	hl03	latent heat flux, W/m2, NOT WEBB CORRECTED
52	lag03	lag points in W:q correlation
53	tauc03	wind stress by covariance, N/m2, 3m
54	usr03	u_star by covariance, m/s, 3m
55	uvar03	U stream variance, 3m
56	vvar03	V stream variance, 3m
57	wvar03	W stream variance, 3m
58	tsvar03	Sonic temperature variance, 3m

59	Ts_noise03	Sonic temp variance @ 10 Hz, 3m
60	Cu2a03	U structure function parameter, method a, 3m
61	Cu2b03	U structure function parameter, method b, 3m
62	Cw2a03	W structure function parameter, method a, 3m
63	Cw2b03	W structure function parameter, method b, 3m
64	Ct2a03	Ts structure function parameter, method a, 3m
65	Ct2b03	Ts structure function parameter, method b, 3m
66	Cq2a03	q structure function parameter, method a, 3m
67	Cq2b03	q structure function parameter, method b, 3m
68	U10_m_s	NS wind speed vector, m/s (positive from S), 10m
69	V10_m_s	EW wind speed vector, m/s (positive from E), 10m
70	W10_m_s	Vertical wind speed vector, m/s (positive upward), 10m
71	T_sonic10_C	sonic air temperature, C, 10m
72	wspd10_m_s	wind speed, m/s, 10m
73	wspd10_m_s_std	std dev wind speed, m/s, 10m
74	wdir10	wind direction, deg, 10m
75	wdir10_std	std dev wind direction, deg, 10m
76	Ta10_C	air temp, C, 10m
77	rh10	relative humidity, %, 10m
78	Ta10_C_std	std dev air temp, C, 10m
79	rh10_std	std dev rh, %, 10m
80	Ta10_C_min	minimum air temp, C, 10m
81	rh10_min	minimum rh, %, 10m
82	Ta10_C_max	maximum air temp, C, 10m
83	rh10_max	maximum rh, %, 10m
84	wu10	streamwise WU covariance, m2/s2, 10m
85	wv10	cross-stream WV covariance, m2/s2, 10m
86	wt10	Tsonic:W covariance, degC m/s, 10m
87	hs10	sensible heat flux, moisture corrected, W/m2, 10m
88	tauc10	wind stress by covariance, N/m2, 10m
89	usr10	u_star by covariance, m/s, 10m
90	uvar10	U stream variance, 10m
91	vvar10	V stream variance, 10m
92	wvar10	W stream variance, 10m
93	tsvar10	Sonic temperature variance, 10m
94	Ts_noise10	Sonic temp variance @ 10 Hz, 10m
95	Cu2a10	U structure function parameter, method a, 10m
96	Cu2b10	U structure function parameter, method b, 10m
97	Cw2a10	W structure function parameter, method a, 10m
98	Cw2b10	W structure function parameter, method b, 10m
99	Ct2a10	Ts structure function parameter, method a, 10m
100	Ct2b10	Ts structure function parameter, method b, 10m
101	U03_str	Mean U into streamline, 3m
102	V03_str	Mean V into streamline, 3m
103	W03_str	Mean W into streamline, 3m
104	Ts03_str	Mean Ts, 3m
105	U10_str	Mean U into streamline, 10m
106	V10_str	Mean V into streamline, 10m
107	W10_str	Mean W into streamline, 10m
108	Ts10_str	Mean Ts, 10m
109	U03_pl	Mean U PF rotation, 3m
110	V03_pl	Mean V PF rotation, 3m
111	W03_pl	Mean W PF rotation, 3m
112	U10_pl	Mean U PF rotation, 10m
113	V10_pl	Mean V PF rotation, 10m
114	W10_pl	Mean W PF rotation, 10m
115	wco203	CO2:W covariance, mmol/m2 s, 3m, NOT WEBB CORRECTED
116	good03	Logical mask for good turbulence data at 3m
117	good10	Logical mask for good turbulence data at 10m
118	good_licor	Logical mask for good Licor data at 3m
119	rl_dn	Downward Longwave Radiation (W/m^2)
120	rs_dn	Downward Short Wave Radiation (W/m^2)
121	rl_up	Upward Longwave Radiation (W/m^2)
122	rs_up	Upward Short Wave Radiation (W/m^2)
123	rnet	Net Radiation (W/m^2)

124	rl_dn_std	std deviations for radiation
125	rs_dn_std	
126	rl_up_std	
127	rs_up_std	
128	rnet_std	
129	Ts5	Soil Temperature (C) 5cm
130	Ts10	Soil Temperature (C) 10cm
131	Ts20	Soil Temperature (C) 20cm
132	Ts50	Soil Temperature (C) 50cm
133	Ts100	Soil Temperature (C) 100cm
134	Sm5	Soil Moisture (vol/vol) 5cm
135	Sm10	Soil Moisture (vol/vol) 10cm
136	Sm20	Soil Moisture (vol/vol) 20cm
137	Sm50	Soil Moisture (vol/vol) 50cm
138	Sm100	Soil Moisture (vol/vol) 100cm
139	rain_mm_hr	rain rate at wasco airport station (wco), mm/hr