BERKELEY LAB
Earth Sciences Division

AMERIFLUX
MANAGEMENT PROJECT

6 December 2013

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Dear Dennis and Joe,

Thank you very much for hosting the inaugural LBNL AmeriFlux QA/QC site visit at Sherman Island, CA (US-Snd) from 8-18 April 2013 (DOY 98-118). The Sherman Island intercomparison served as a test run for the two new AmeriFlux portable eddy covariance systems (PECS1 and PECS2). Additionally, Chad Hanson from Oregon State University deployed the former PECS so that we could confirm consistency in the reference flux systems. This report summarizes the findings and key recommendations from the comparison between the AmeriFlux PECS2 and the in-situ system for the eddy covariance, radiation, and meteorological observations collected at the site (Sherman Island). PECS2 was chosen for the intercomparison because it faced into the prevailing winds (located along the western fence) and was on direct AC power.

The AmeriFlux PECS sensors were deployed to minimize separation (both horizontal and vertical) from the in-situ sensors (Appendix 1), to avoid interfering with existing infrastructure, and to prevent shadowing or wake effects. The AmeriFlux PECS included two infrared gas analyzers (a closed-path analyzer and an open path analyzer). This comparison focuses on the open path IRGA (LI-7500) which is identical to the in-situ IRGA. Data processing of the AmeriFlux PECS data was handled by EddyPro® (Version 4.2.1), an eddy covariance software package developed by LI-COR. We are in the process of updating the details of the AmeriFlux data processing and data screening on the AmeriFlux website. Please contact the AmeriFlux QA/QC Tech team if you have specific questions.

Four figures were generated for each variable compared. The top figure is a time series of both systems over the evaluation period. The middle figure is a time series of the differences between systems. The lower left figure is a scatter plot of both systems with a 1-to-1 line and a best fit linear regression with equation and fit parameters. Lastly, the lower right figure is a histogram of the differences between the systems with summary statistics. The enclosed figures only include periods where both datasets are available and QC'ed. Hence missing data periods occurred when data was screened from one or both systems either through data quality checks, rain, or no data (power outage).

Key Recommendations:

Overall, the comparison between the AmeriFlux PECS and the in-situ system was outstanding. We encourage you to continue your active participation in the AmeriFlux network. A few key findings are highlighted below.

- The Sherman Island sonic temperature had large temperature excursions (>4^{o}C) during the nighttime. The variance of sonic temperature agreed well between both systems as did the sensible heat flux so the error in the absolute sonic temperature does not appear to propagate to other terms. However, I would caution using the sonic temperature as a proxy for air temperature (e.g., correction terms).
- The comparison of the CO_2 variances showed a consistent bias (PECS>in-situ). The underestimation of the variation in CO_2 may have contributed to the lower CO_2 fluxes reported by the in-situ system. Service of your gas analyzer is recommended.
- We selected 4 comparisons (PAR, sensible heat, latent heat, and CO_2 flux) to benchmark against the network using the accumulated record of QA/QC site visits since 2002 (see Schmidt et al., 2012). Figure 1 is a histogram of relative instrumental error for each metric and how this site visit ranks. For these 4 comparisons, Sherman Island had absolute relative instrumental errors between 2-13%.

In closing, thank you for your cooperation before, during, and after the site visit. We are actively soliciting comments and/or feedback regarding the site visit process and report to maximize the utility of our visits. For all reports, we request a summary from the in-situ PIs to describe how the enclosed recommendations will be addressed. We are available to provide further analysis or discussion of the results, if needed. Thank you for working collaboratively with the AmeriFlux QA/QC Tech team.

Please review the general site information table in Appendix 1 of this document and let us know if you notice erroneous information.

All the best,

Stephen Chan[1], Sébastien Biraud[1], and David Billesbach[2]
AmeriFlux QA/QC Tech team
[1]Lawrence Berkeley National Laboratory
[2]University of Nebraska, Lincoln

Site Name: Sherman Island (US – Snd)
Visit Dates: 8-18 April 2013

Detailed Report

Turbulent fluxes:

The dominant wind direction was from the west and instruments were deployed facing into the wind. During the campaign, there were a few periods of northerly winds which produced some wind distortions between the systems (Figure 3). Therefore, the comparisons of fluxes and covariances were screened for periods when winds were from 0-100 and 330-360°. The excluded periods occurred during the first and last 2 days of the visit. Lastly, the data provided did not include any spectral corrections so we have removed those corrections from our dataset. If you would like to provide additional data, I am happy to conduct further analyses.

Latent heat (slope: 0.91, offset: -1.96 W m^{-2}, rel. diff.: 11.5%) fluxes were slightly underestimated by in-situ system (Figure 4). I was unable to identify any cause of this underestimation with the data provided. As described in the sections below, the variances of the vertical wind and H_2O agreed closely with the AmeriFlux system. The calculated CO_2 fluxes from the in-situ system were similarly underestimated relative to the AmeriFlux PECS (slope: 0.87, offset: -0.02 µmol m^{-2} s^{-1} rel. diff.: -12.5%) (Figure 5). The CO_2 variance from the in-situ gas analyzer was 20% lower than the PECS (see below) which could explain the underestimation of CO_2 fluxes. Direct comparison of the covariances of the vertical wind and gas scalars were not possible as the provided covariances included correction terms (e.g., WPL terms).

The in-situ friction velocity (slope: 0.97, offset: 0.02 m s^{-1}) and sensible heat flux (slope: 1.01, offset: 2.55 W m^{-2}) both agreed very well with the AmeriFlux PECS (Figures 6-7). The AmeriFlux PECS did not have a methane analyzer so no comparisons of methane fluxes were conducted; hopefully we will have these capabilities during our next site visit!

To place these results in the context of the broader AmeriFlux network, we selected a few metrics (sensible heat, latent heat, CO_2 fluxes) to benchmark (Figure 1) against the accumulated record of AmeriFlux QA/QC site visits since 2002 (Schmidt et al., 2012). To accomplish this, we changed the reference value from a site maximum (equation 1, Schmidt et al., 2012) to a fixed value (see Figure 1).

IRGA scalars and statistics:

Mean CO_2 and water vapor mole densities from the open-path IRGAs showed good agreement (Figures 8-9). A small negative offset (0.23 mmol m^{-3}) in CO_2 concentration was observed but only represented <2% of the mean value (Figure 8). IRGA response was also evaluated through comparisons of the half-hour variances for CO_2 and H_2O. The variance of water vapor had good agreement (Figure 10). However, the variance of CO_2 was underestimated by your IRGA and the distribution of differences was skewed (Figure 11). The differences in IRGA CO_2 variance were greatest during the daytime. I compared the CO_2 variance of PECS2 against the adjacent OSU system as a check and observed a close 1:1 relationship. Although the in-situ IRGA captured H_2O variations well, it failed to capture all the CO_2 variations which likely contributed to the lower CO_2 flux. If you have further ideas, please contact me.

Sonic wind components and temperature:

As mentioned previously, I discovered a few periods with discrepancies in wind components between the paired sensors. Differences were greatest for winds coming from the North (0-100^o and 330-360^o) (Figure 3). I suspected that flow distortions from adjacent systems or the EPA trailer were the cause. Those wind sectors were excluded from the comparisons of fluxes and the variances of the sonic components. The comparison of mean horizontal wind speed was quite good once affected wind directions were removed (Figure 12). The comparison of wind direction (derived from the sonic anemometers) was good although an offset of 18^o was observed (Figure 13).

Mean sonic temperature showed a systematic underestimation (slope: 0.73, offset: 6.85^o C, rel. diff.: -15.1%) relative to the AmeriFlux sensor (Figure 14). The difference was largest at night (> 4^o C). However, the half-hourly variances of the sonic temperature (slope: 0.91) agreed quite well as did the sensible heat flux (Figures 7, 15). I would recommend tracking the sonic temperature against another temperature sensor to confirm this finding. I would also caution using the sonic temperature as a proxy for air temperature. Lastly, the variances of the rotated sonic wind components (u, v, w) all agreed favorably to the AmeriFlux PECS sonic (Figures 16-18).

Meteorological and radiation measurements:

All meteorological variables compared very well. Air temperature (slope: 0.99, offset: -0.11^o C) and relative humidity (slope: 1.00, offset: -0.59 %) from the HMP sensors differed by less than one percent

(Figures 19, 20). Barometric pressure (slope: 1.00, offset: 0.03 kPa) compared very favorably to the AmeriFlux PECS sensors (Figure 21).

Due to differences in vegetation within and outside the fenced enclosure, the AmeriFlux PECS was unable to observe a similar footprint for the upwelling radiation components (shortwave, longwave, and PAR). For this report, only the downwelling (incoming) radiation components will be presented. On average, incoming shortwave radiation agreed to within a few percent (Figure 22). We operated our four component radiometer (Kipp and Zonen, model CNR4) with the ventilator/heater continuously running which caused the small nighttime offset. A bias of 20 W m^{-2} was observed for incoming longwave radiation with the in-situ sensor lower relative to the AmeriFlux PECS sensor (Figure 23). I do not believe that this was due to the aforementioned use of the ventilator/heater on the AmeriFlux PECS CNR4 because a comparison between the two AmeriFlux systems (one running the ventilator/heater, one without) showed very small differences. Net radiation was not evaluated because of the differences in footprint between the systems. The Sherman Island incoming photosynthetically active radiation (PAR) sensor was in excellent agreement (slope: 1.01, offset: 6.29 µmol m^{-2} s^{-1}) (Figure 24). I would like to remind you that the AmeriFlux QA/QC Tech laboratory provides calibration of PAR sensors at no cost. No diffuse radiation sensor was available during the campaign.

References:

Schmidt, A., C. Hanson, W. S. Chan, and B. E. Law, Empirical assessment of uncertainties of meteorological parameters and turbulent fluxes in the AmeriFlux network, J. Geophys. Res., 117, G04014, doi:10.1029/2012JG002100, 2012.

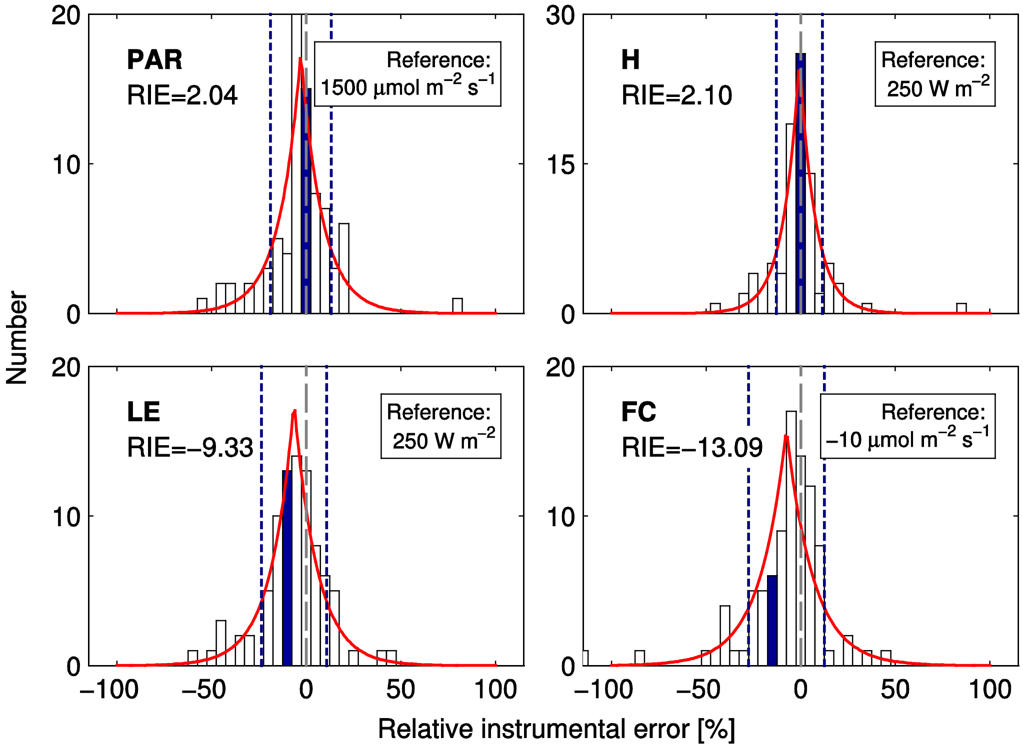


Figure 1 – Histogram of relative instrumental error (RIE) for 4 selected variables based on the accumulated record of AmeriFlux site visits. Blue colored bar denotes the RIE from this site visit (bar width = 5%). Laplace distribution illustrated in solid red line. Dashed, vertical blue lines denote mean ± √2β, where β is a scale parameter describing the Laplace distribution. The term √2β is equivalent to the standard deviation in a normal distribution.

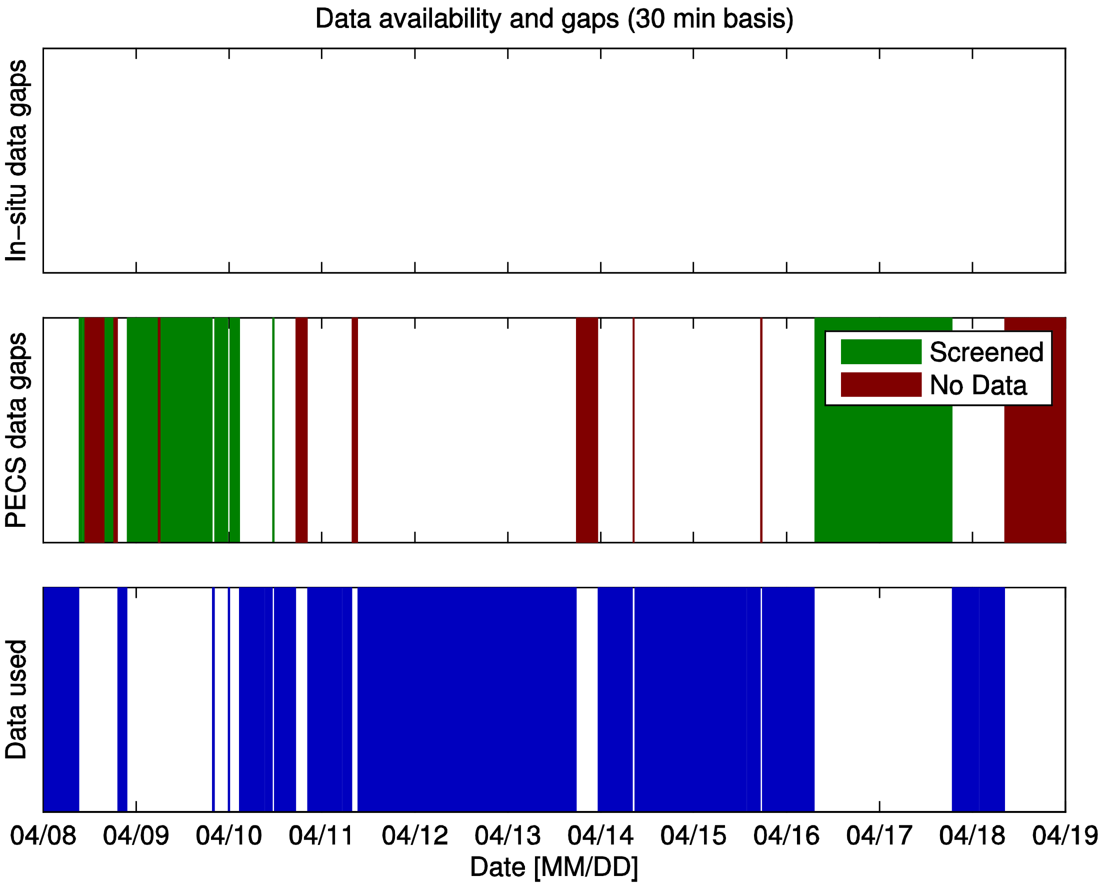


Figure 2 – Data gaps from in-situ system (top) and PECS (middle). For the PECS, red areas were due to power outages at the site and green areas were screened based on wind direction (Figure 3). Periods when data was available from both systems is shown in the lower panel.

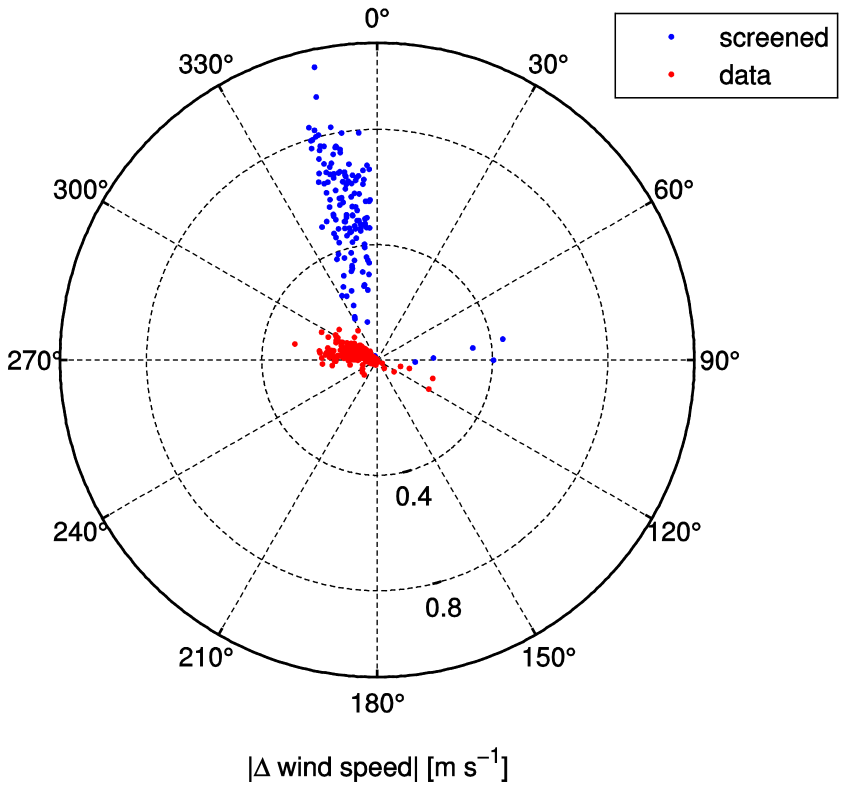


Figure 3 – Difference in horizontal wind speed between PECS and in-situ as a function of wind direction. Blue highlighted points show filtered wind sectors.

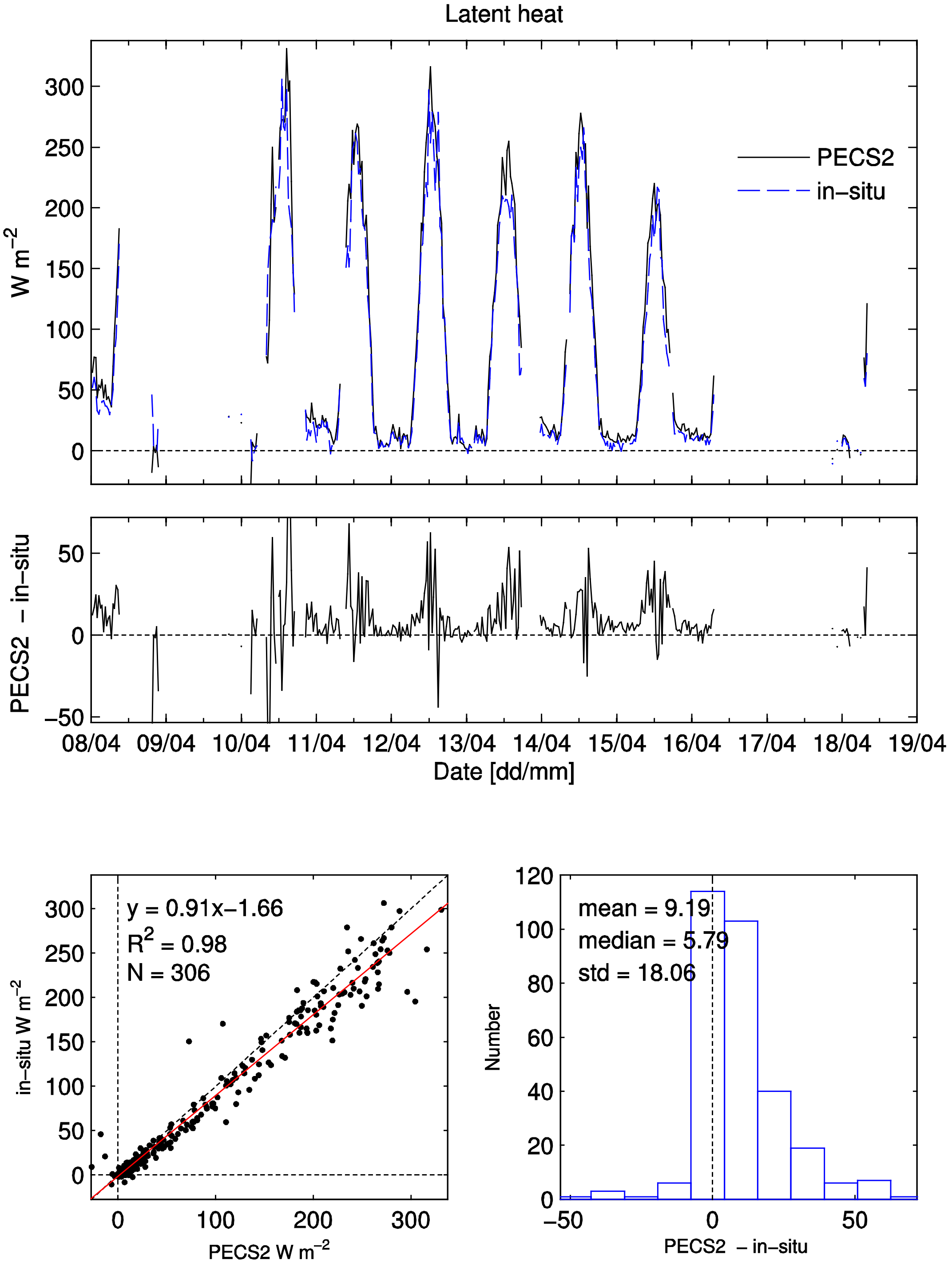


Figure 4 – Latent heat fluxes.

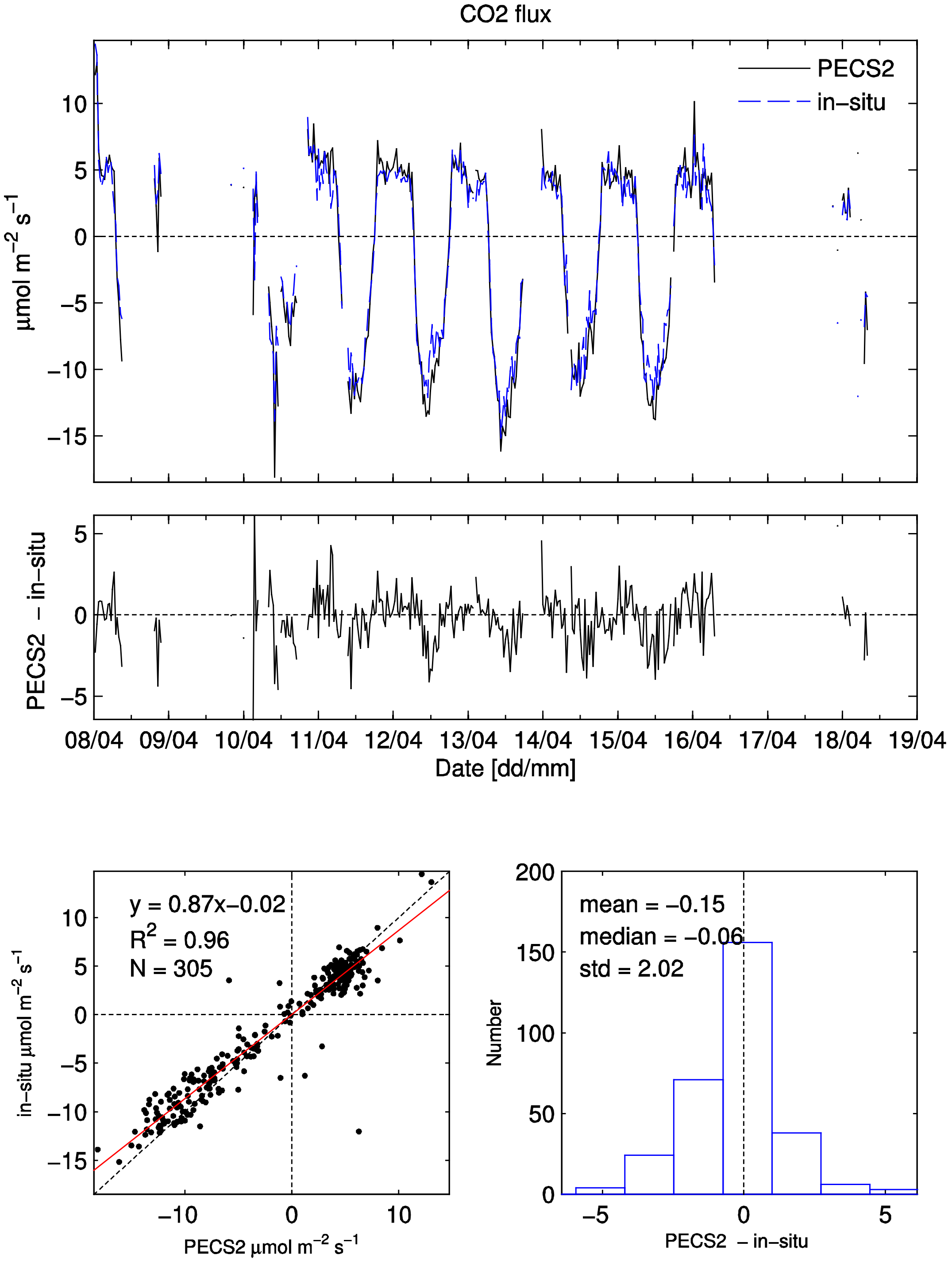


Figure 5 – Carbon dioxide flux.

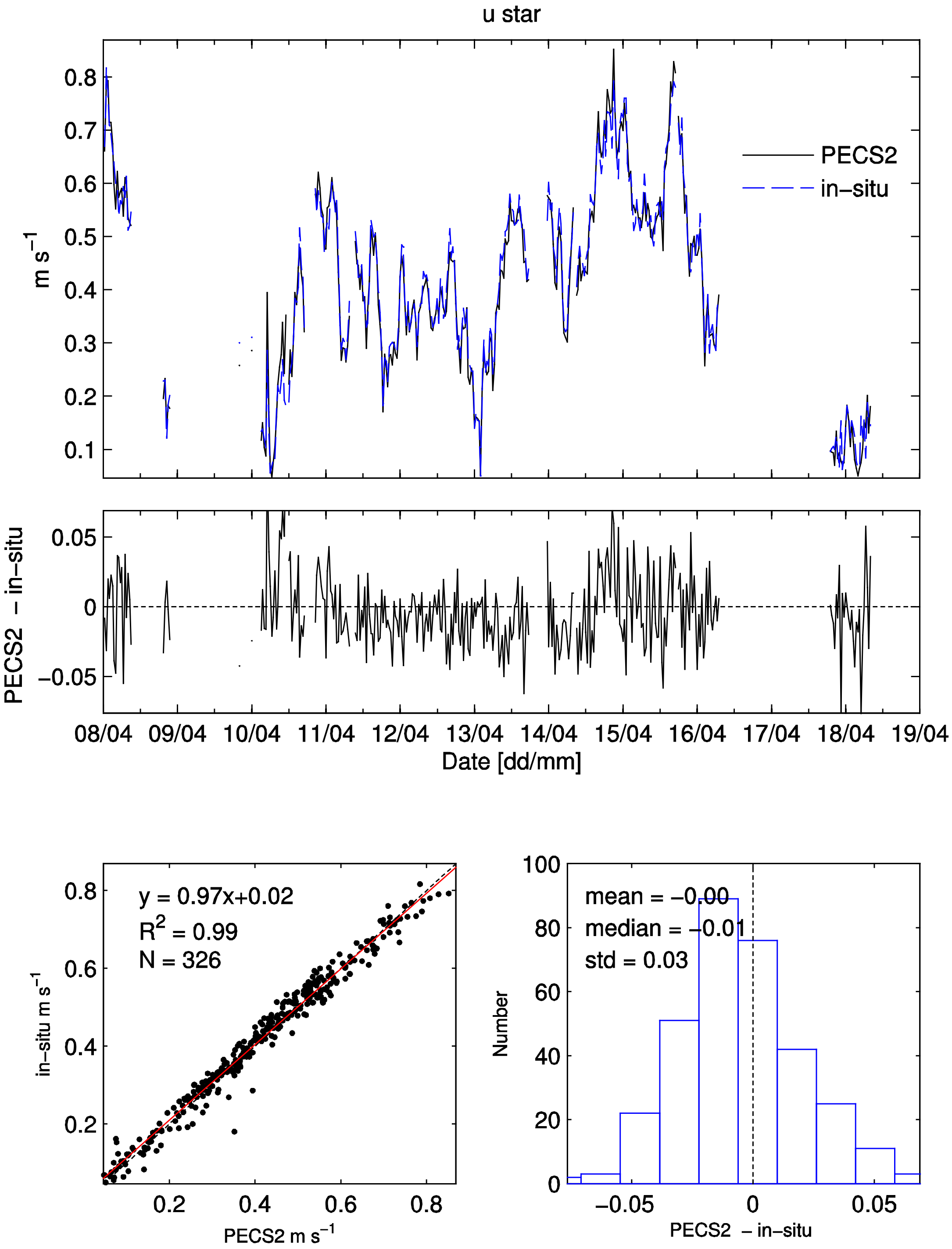


Figure 6 – Friction velocity.

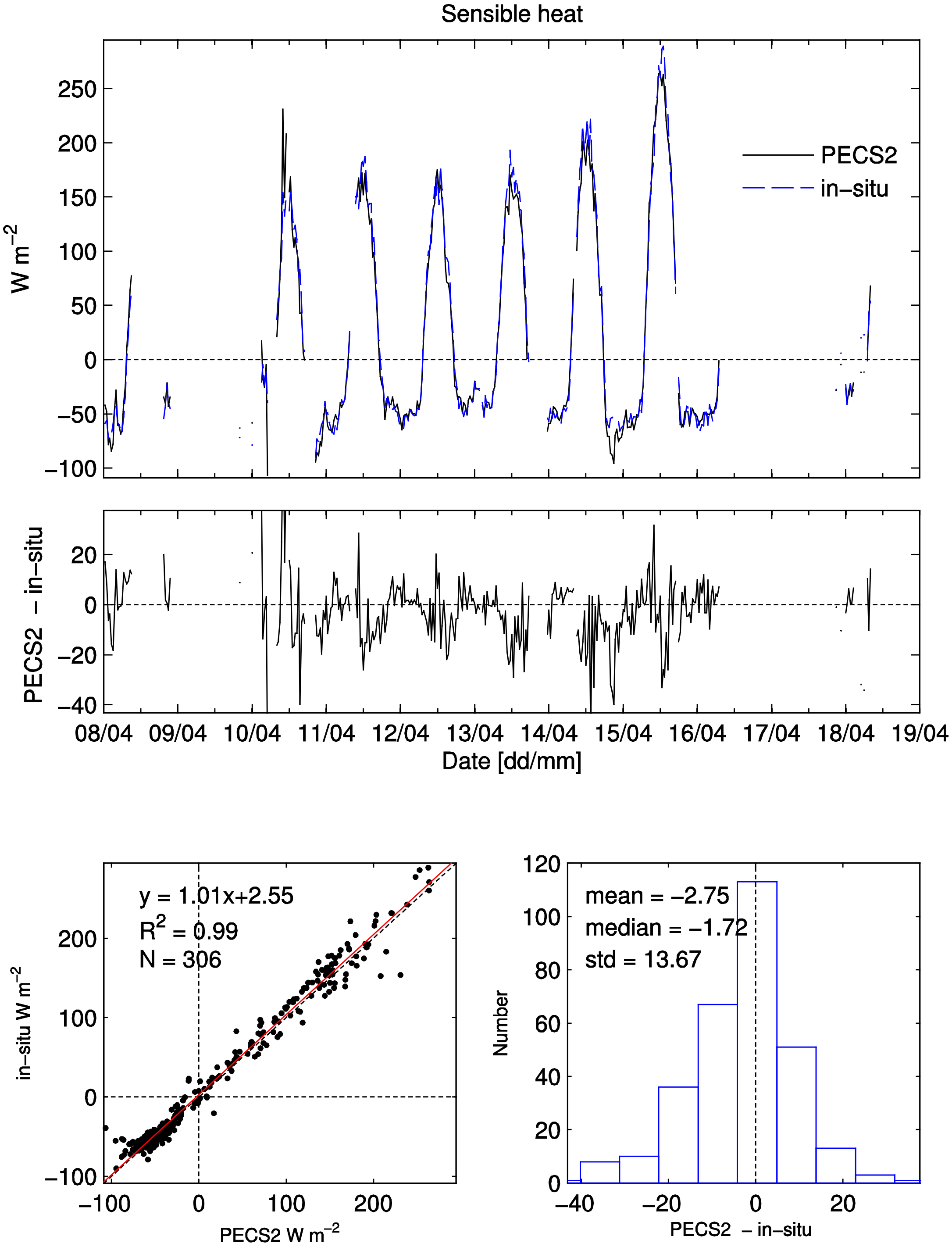


Figure 7 – Sensible heat flux.

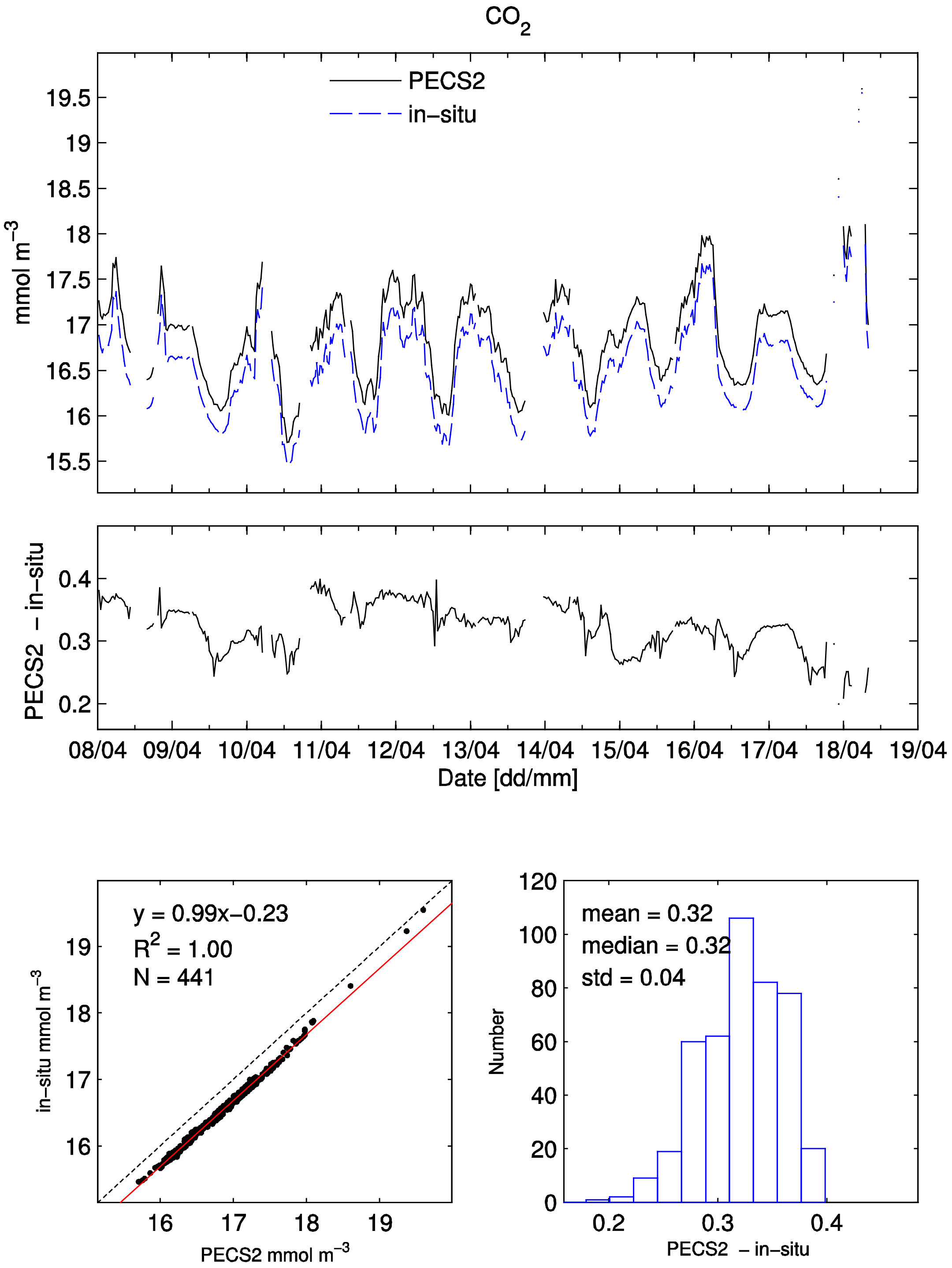
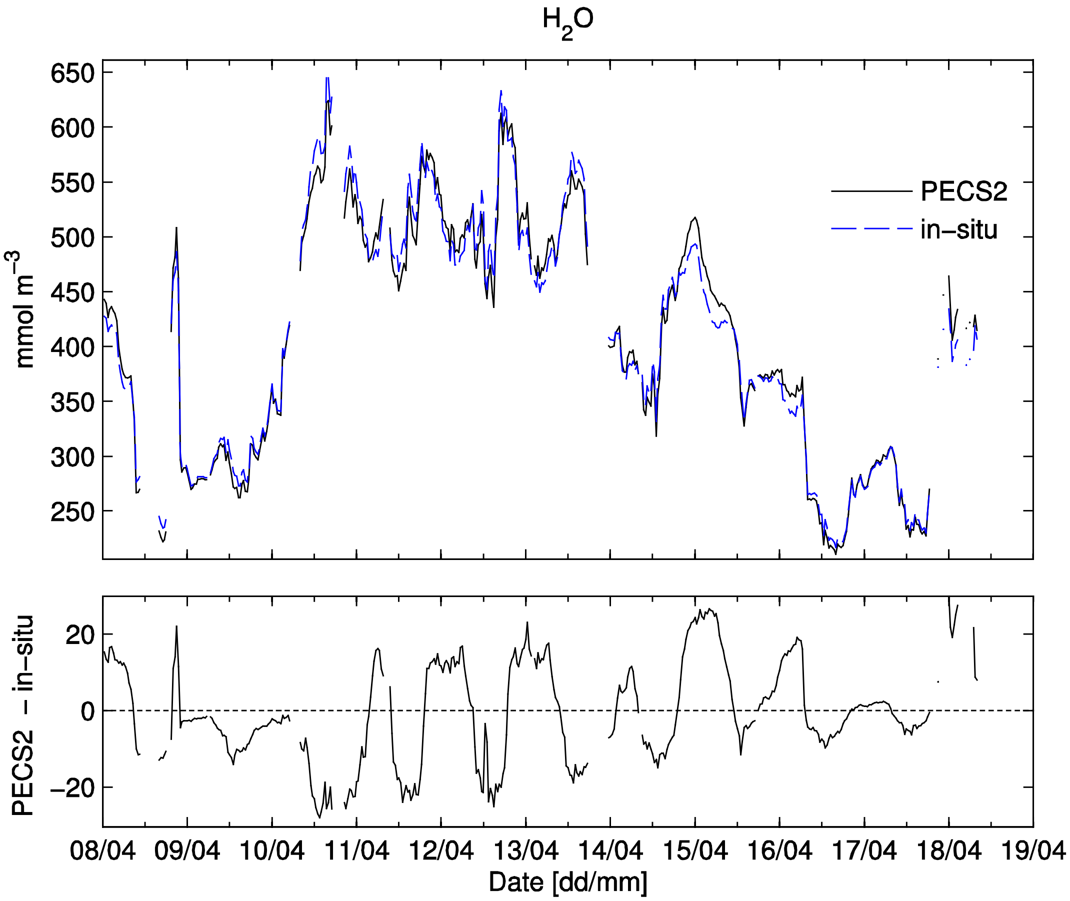


Figure 8 – Carbon dioxide molar densities.



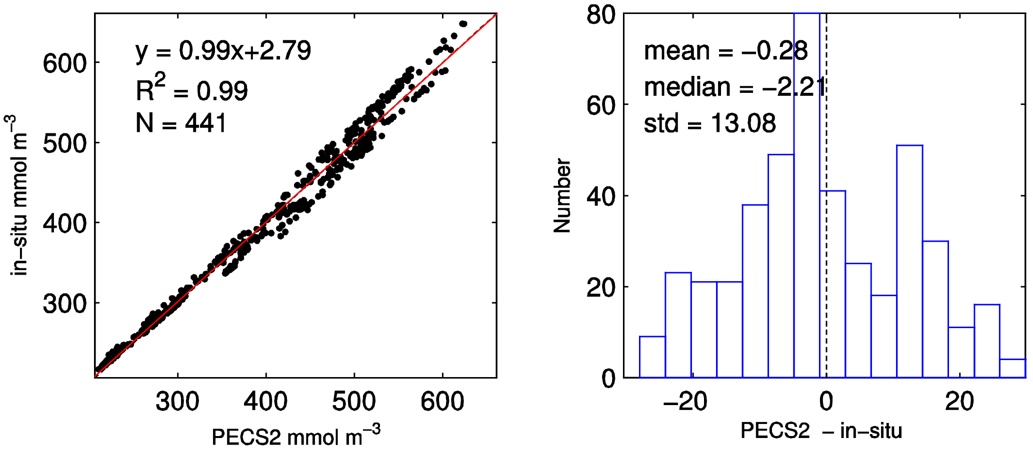


Figure 9 – Water vapor molar densities.

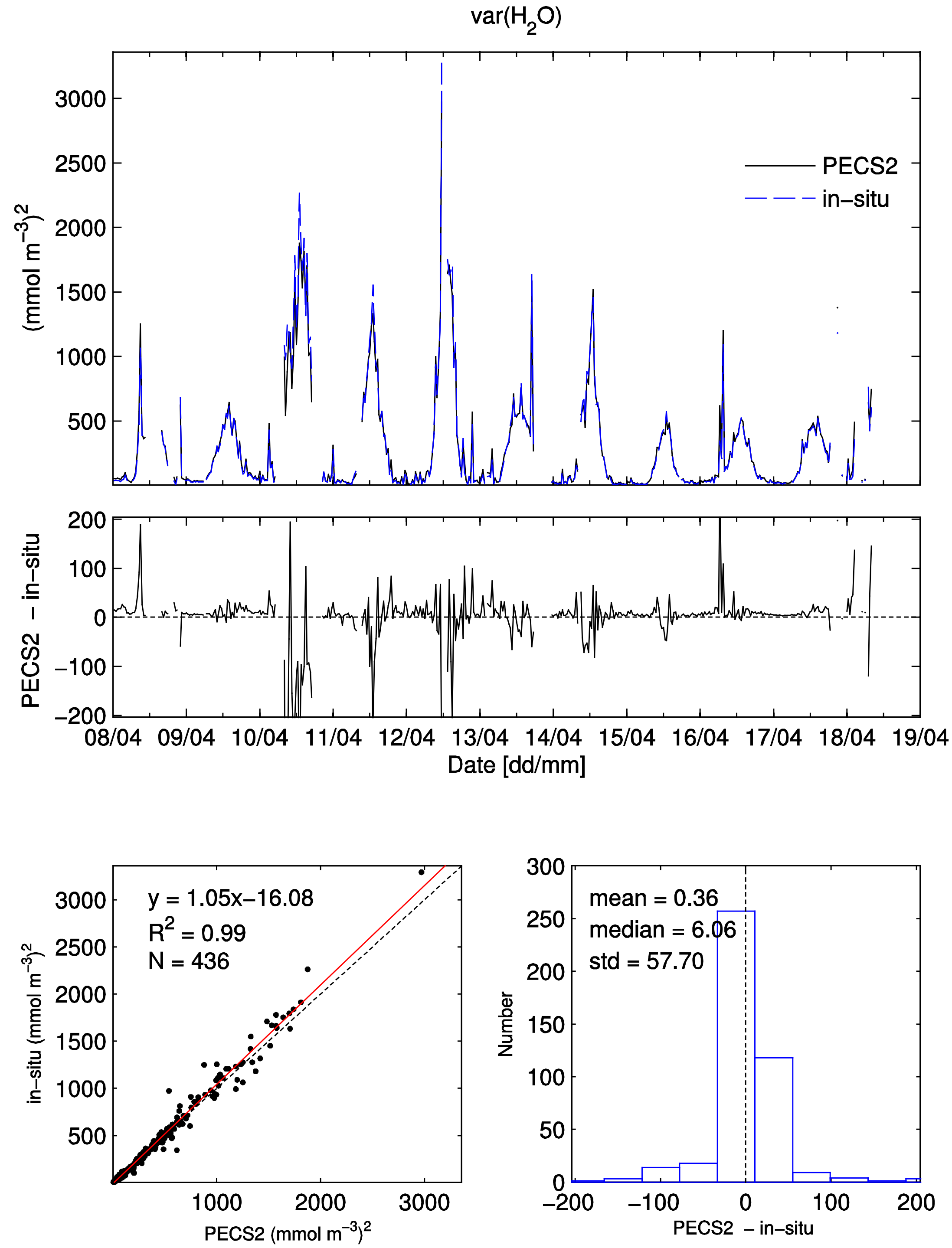


Figure 10 – Variance of water vapor.

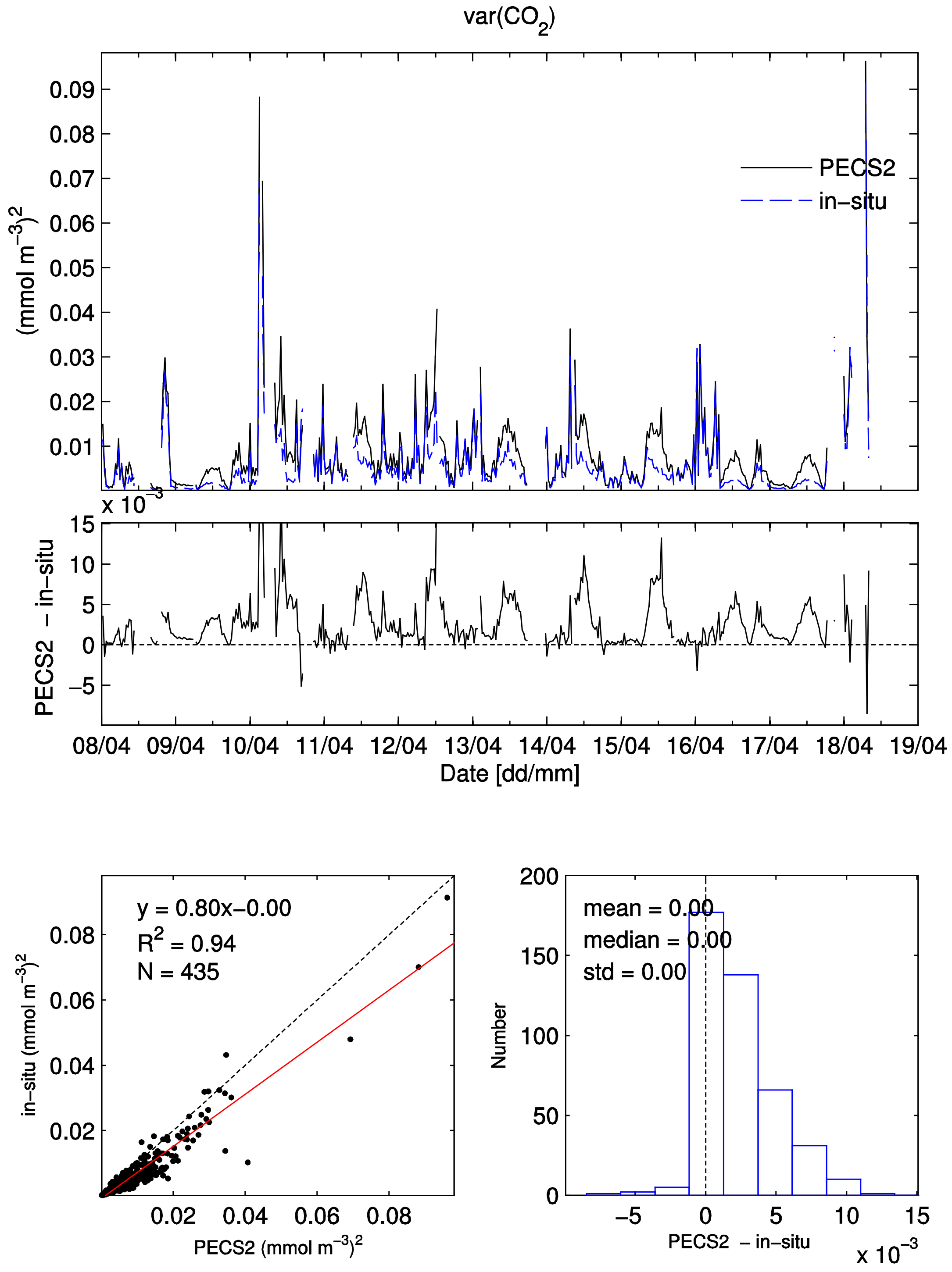


Figure 11 – Variance of carbon dioxide.

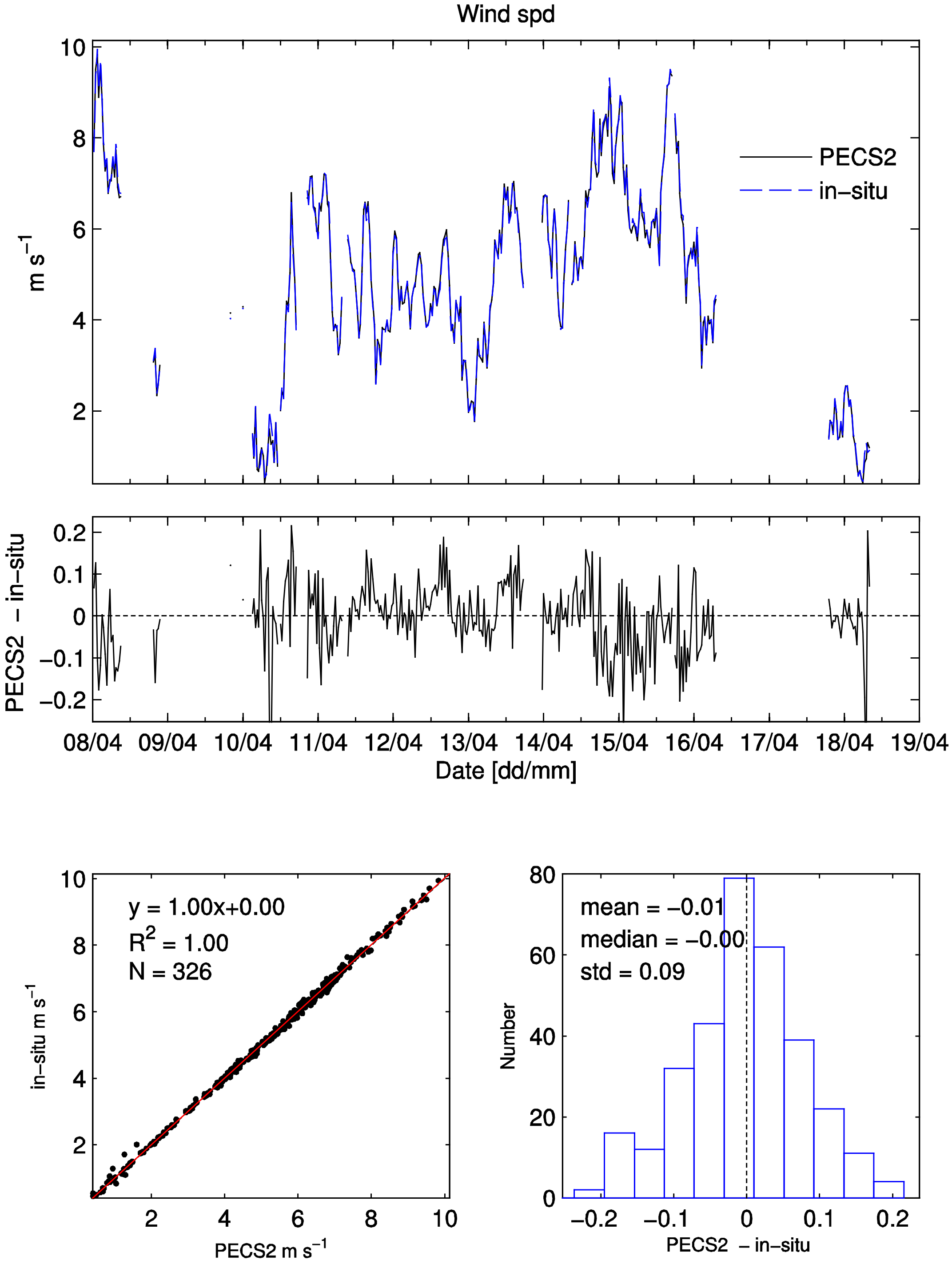


Figure 12 – Mean horizontal wind speed.

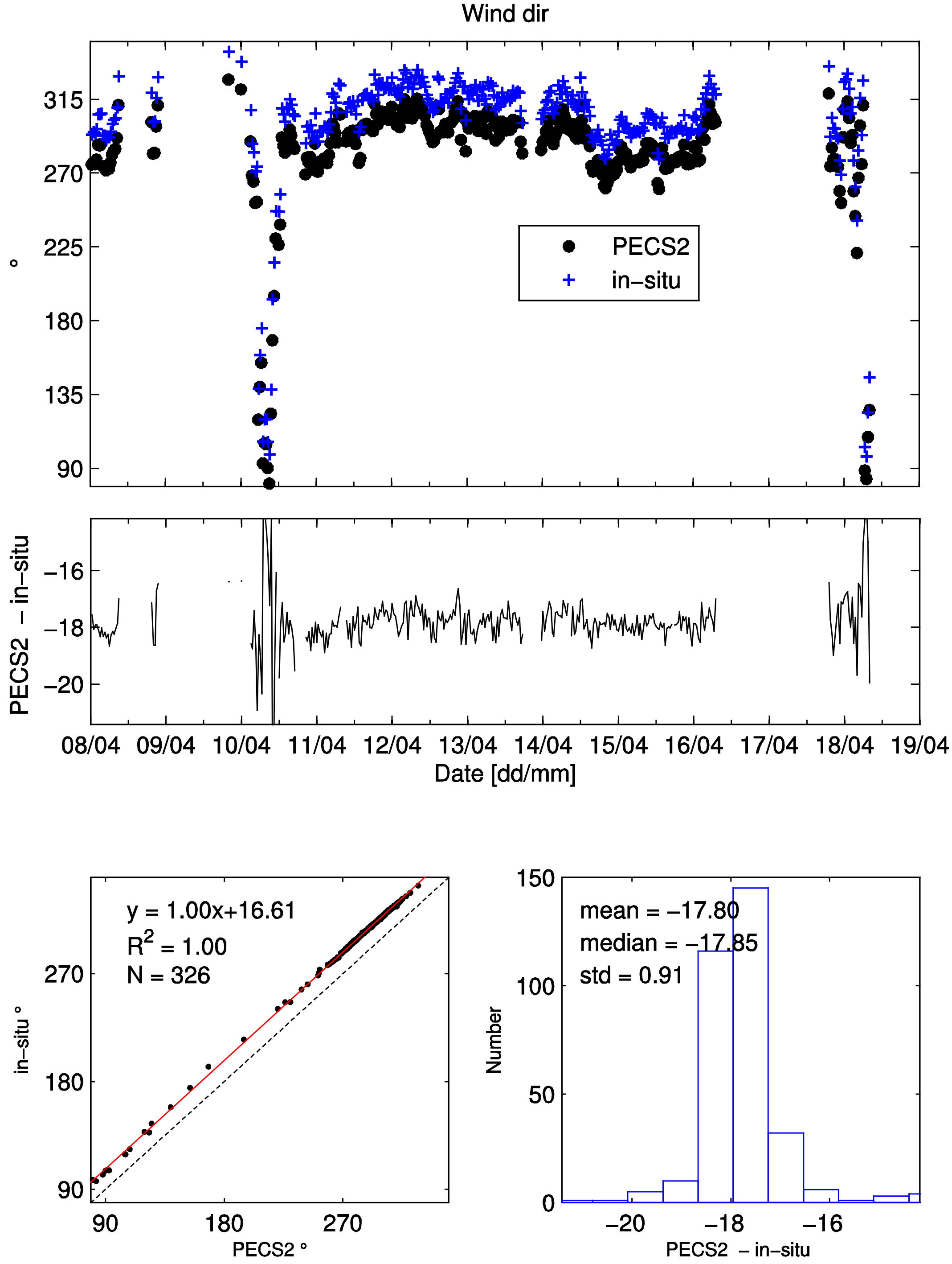


Figure 13 – Wind direction.

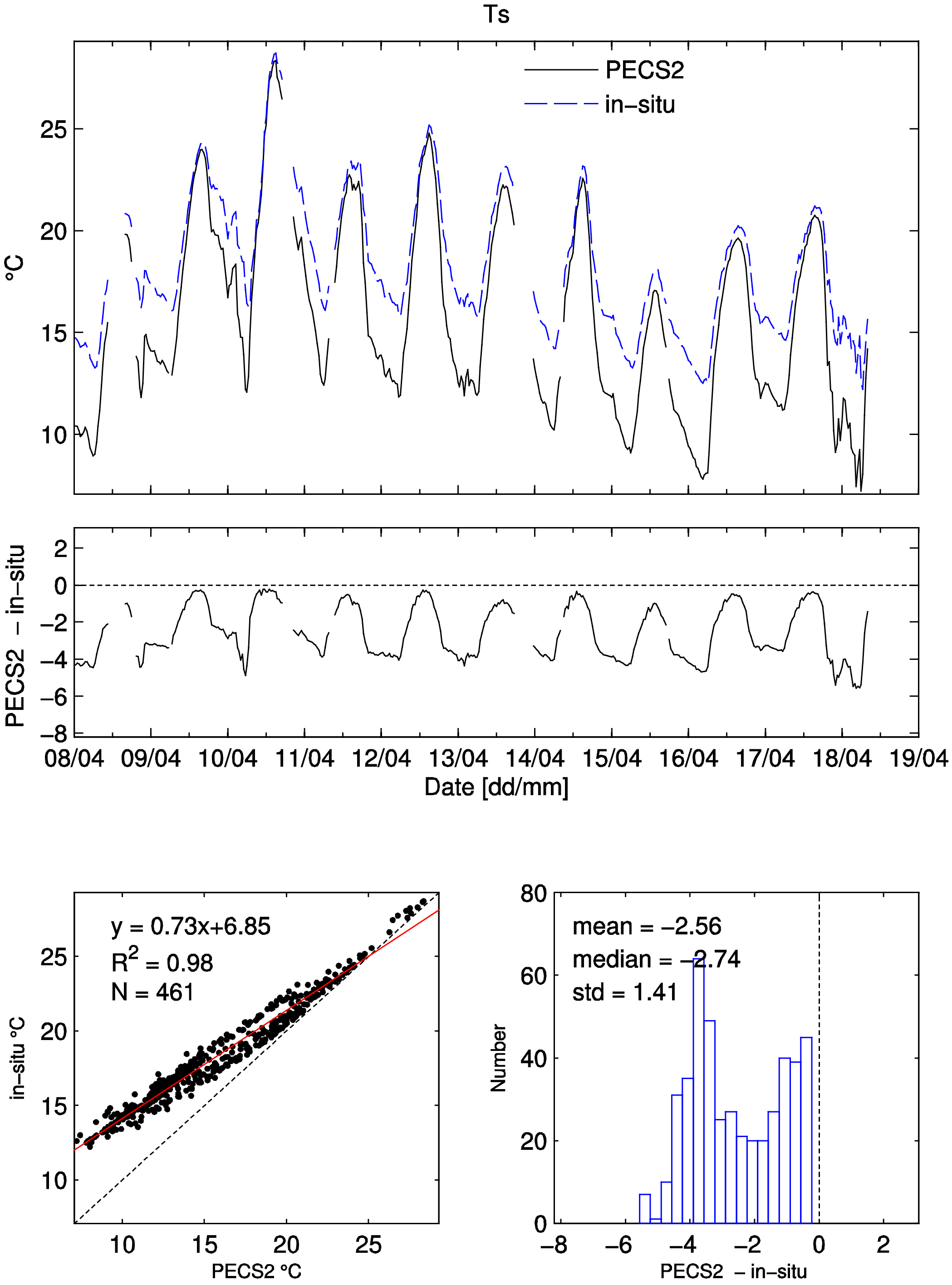
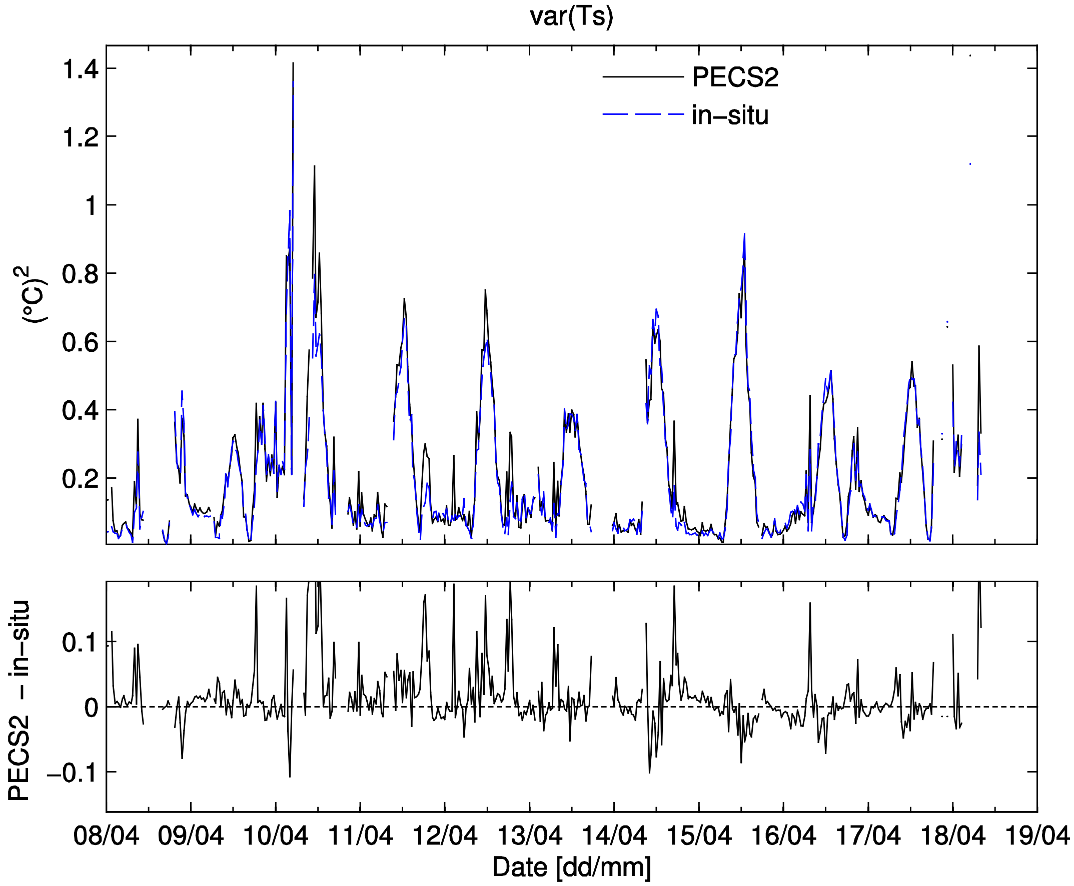


Figure 14 – Sonic temperature.



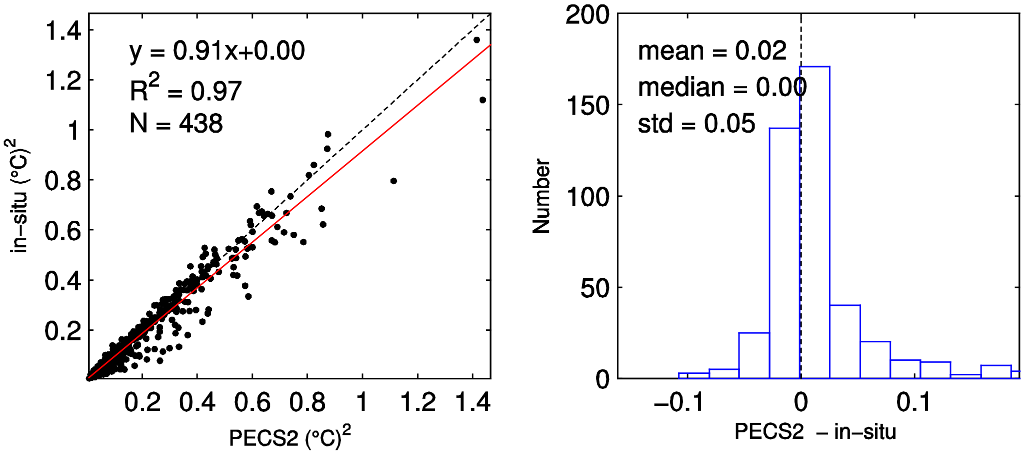


Figure 15 – Variance of sonic temperature.

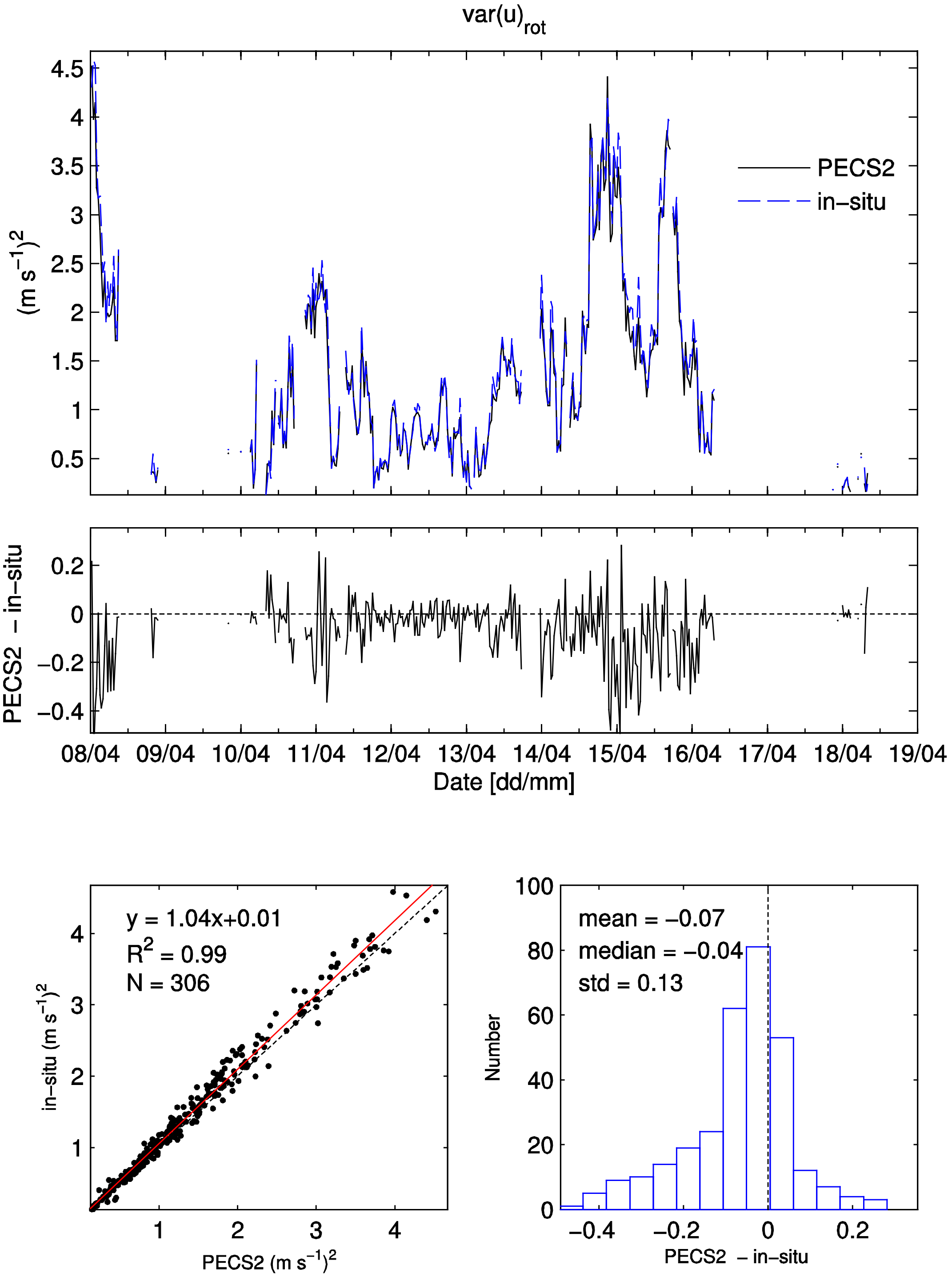


Figure 16 – Variance of rotated u sonic component.

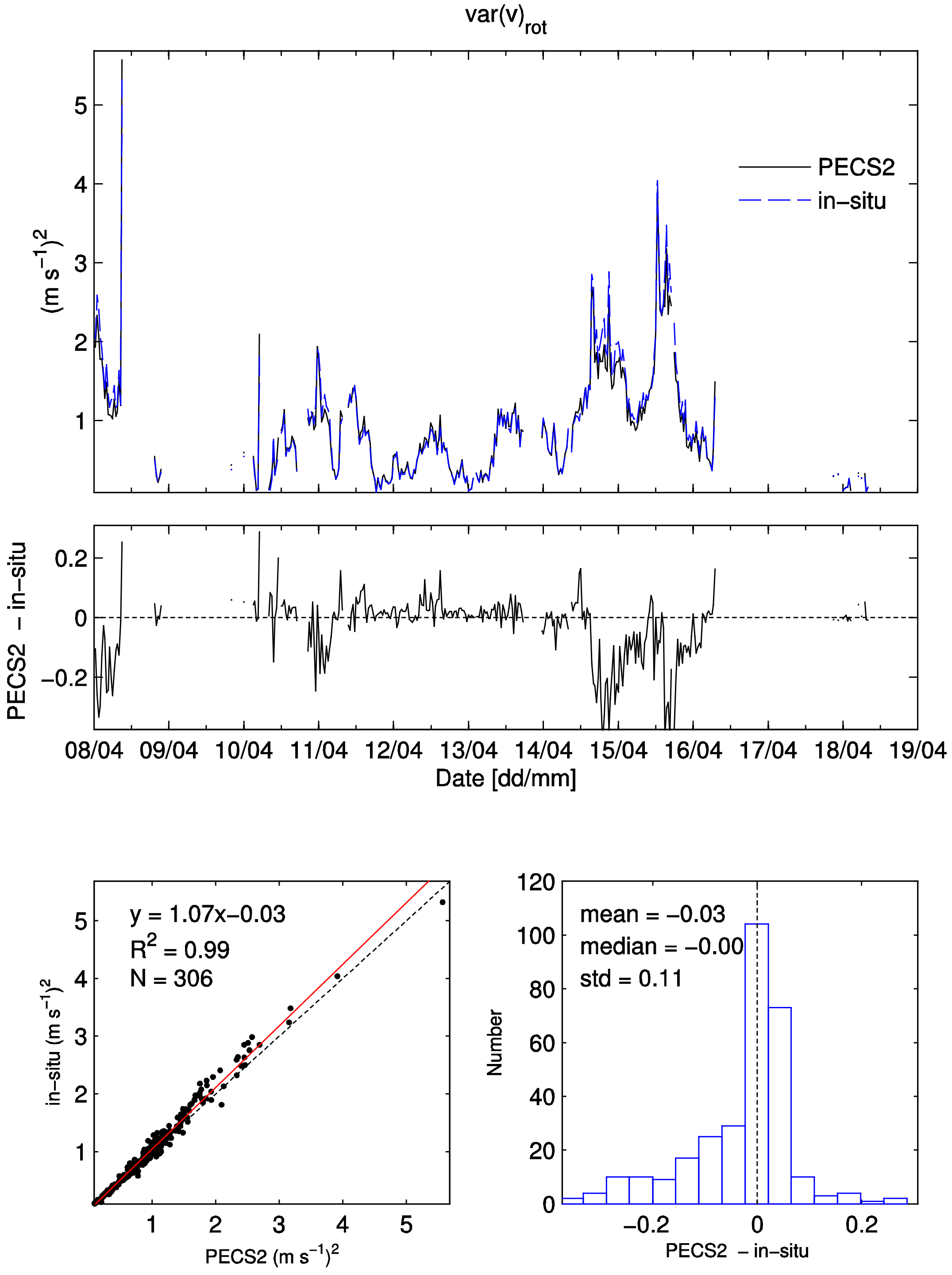


Figure 17 – Variance of rotated v sonic component.

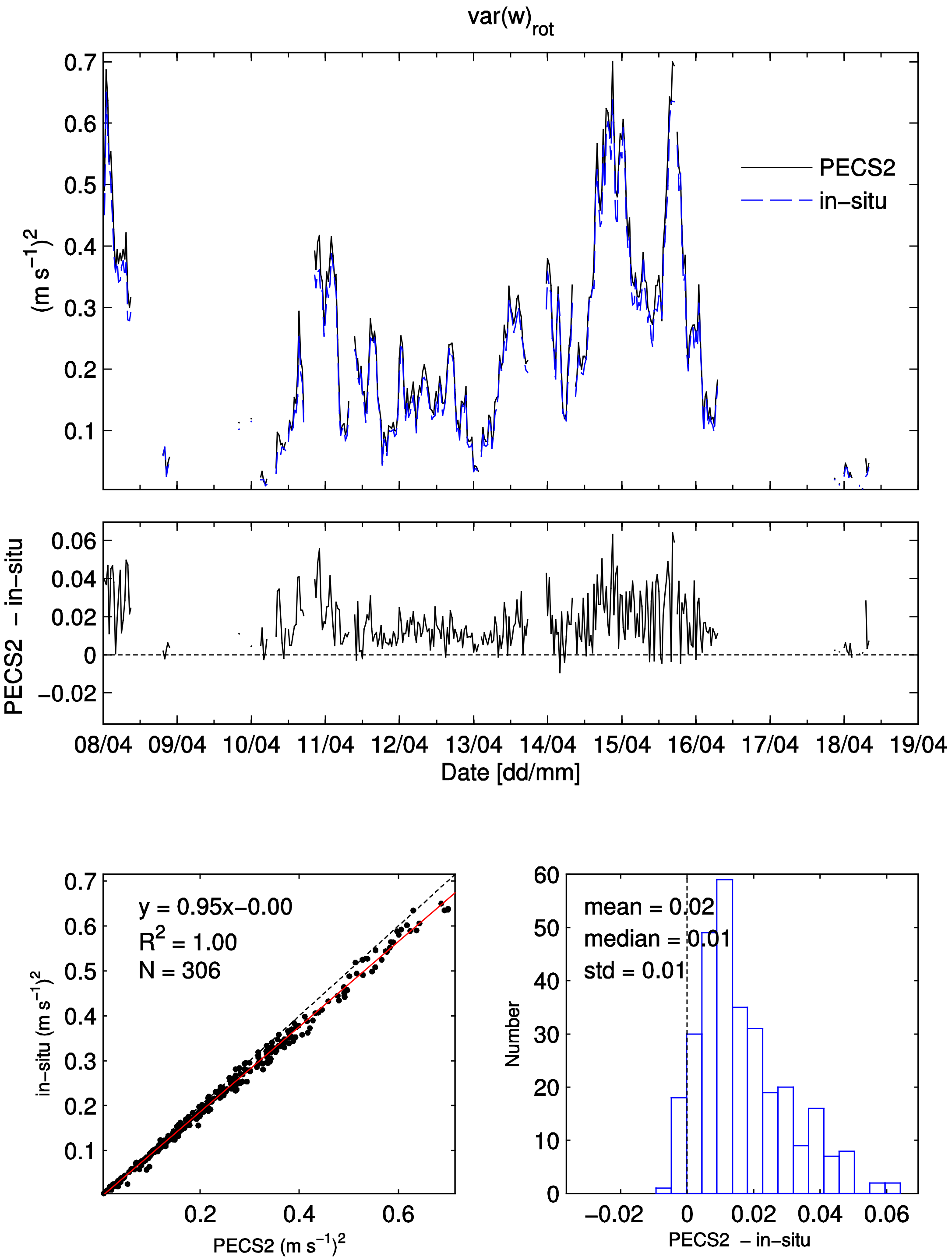


Figure 18 – Variance of rotated w sonic component.

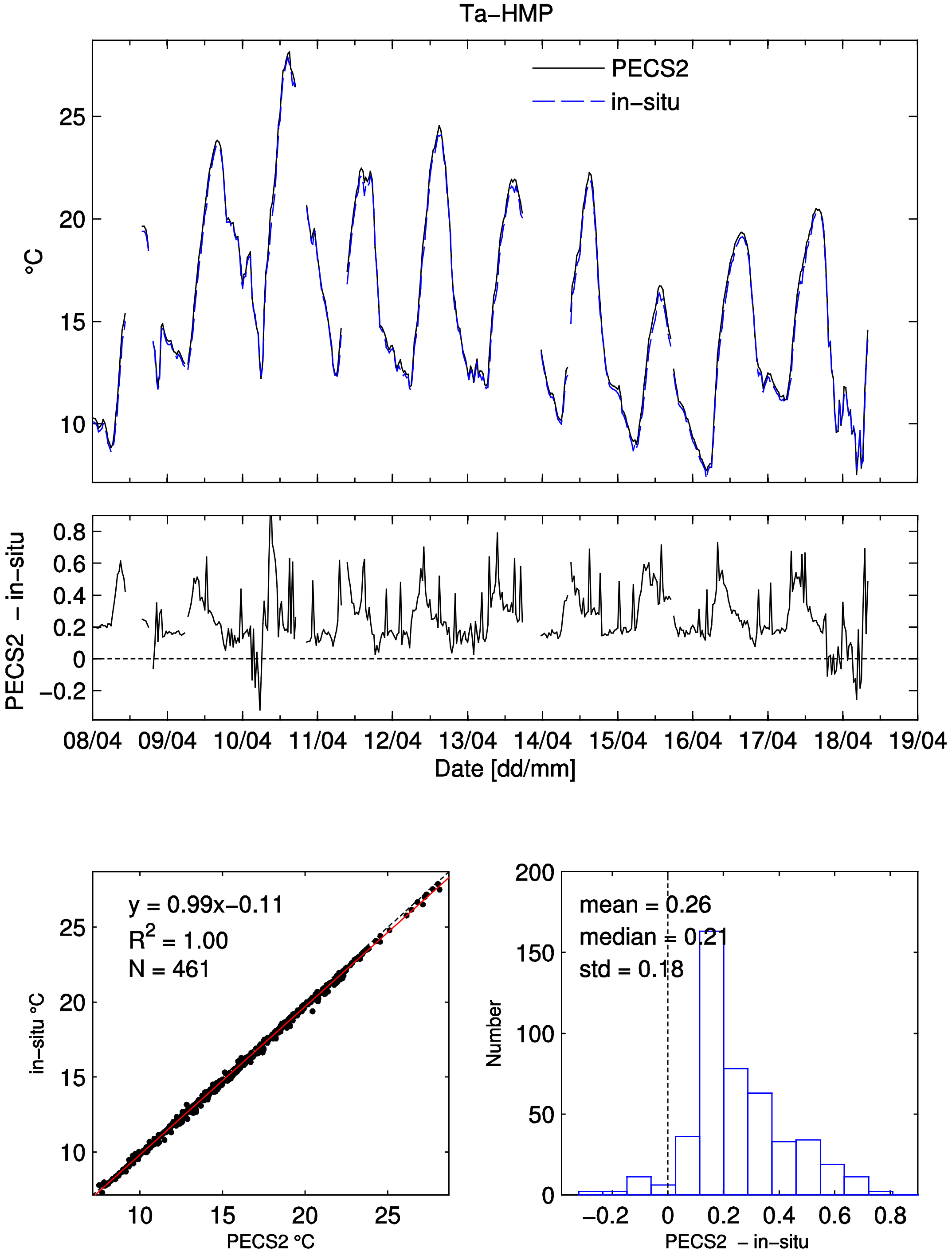


Figure 19 – Air temperature.

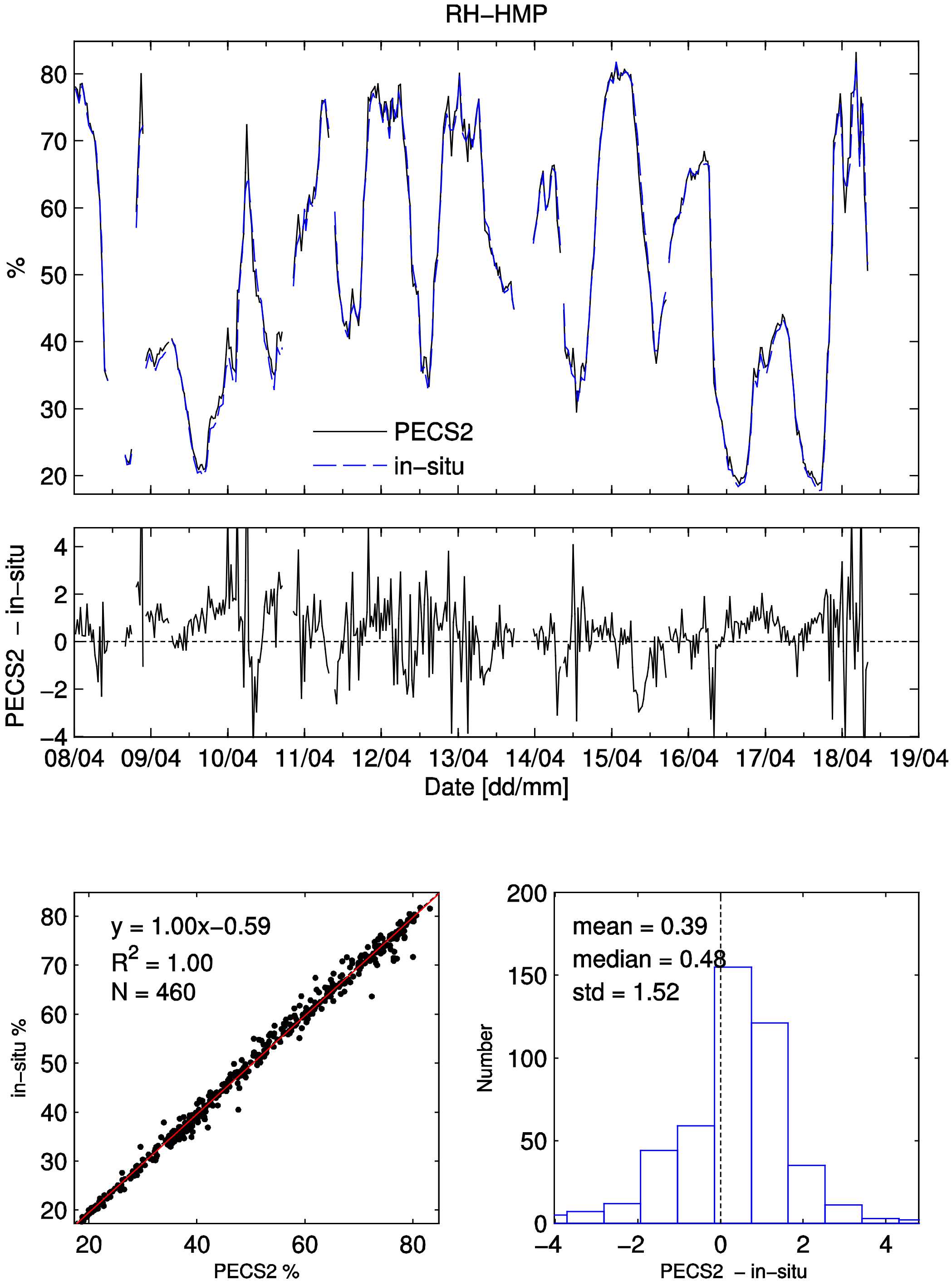


Figure 20 – Relative humidity.

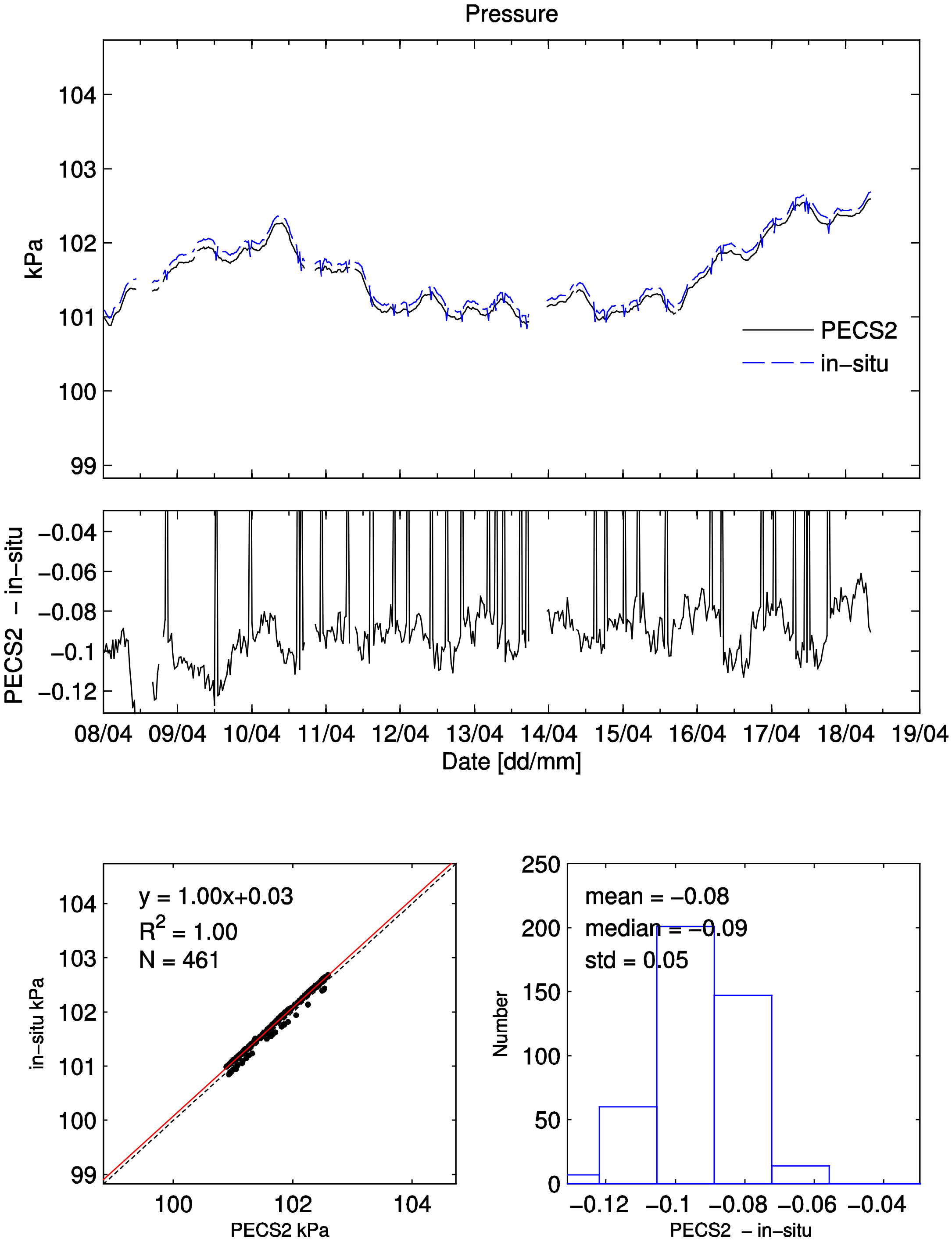


Figure 21 – Barometric pressure.

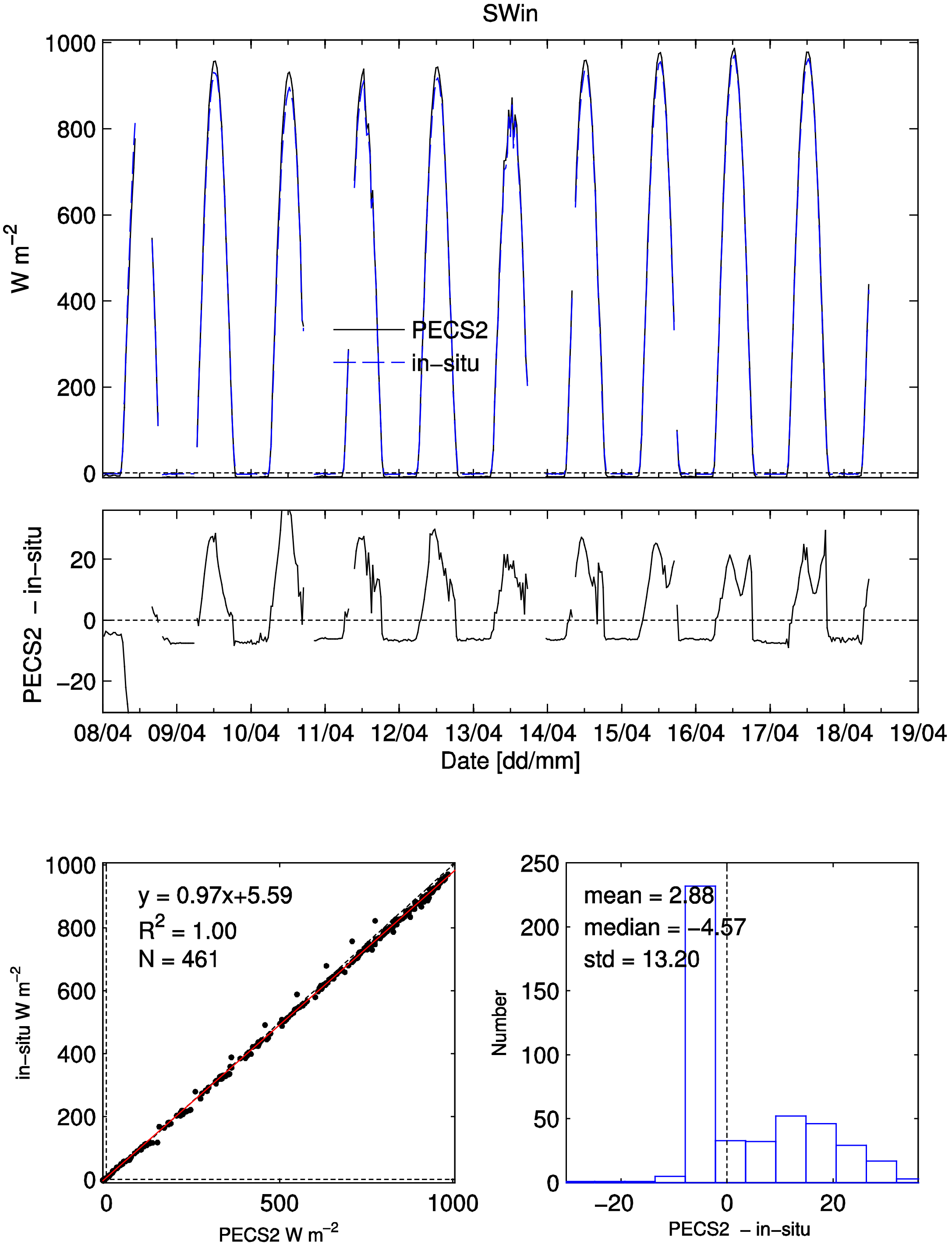


Figure 22 – Incoming shortwave radiation.

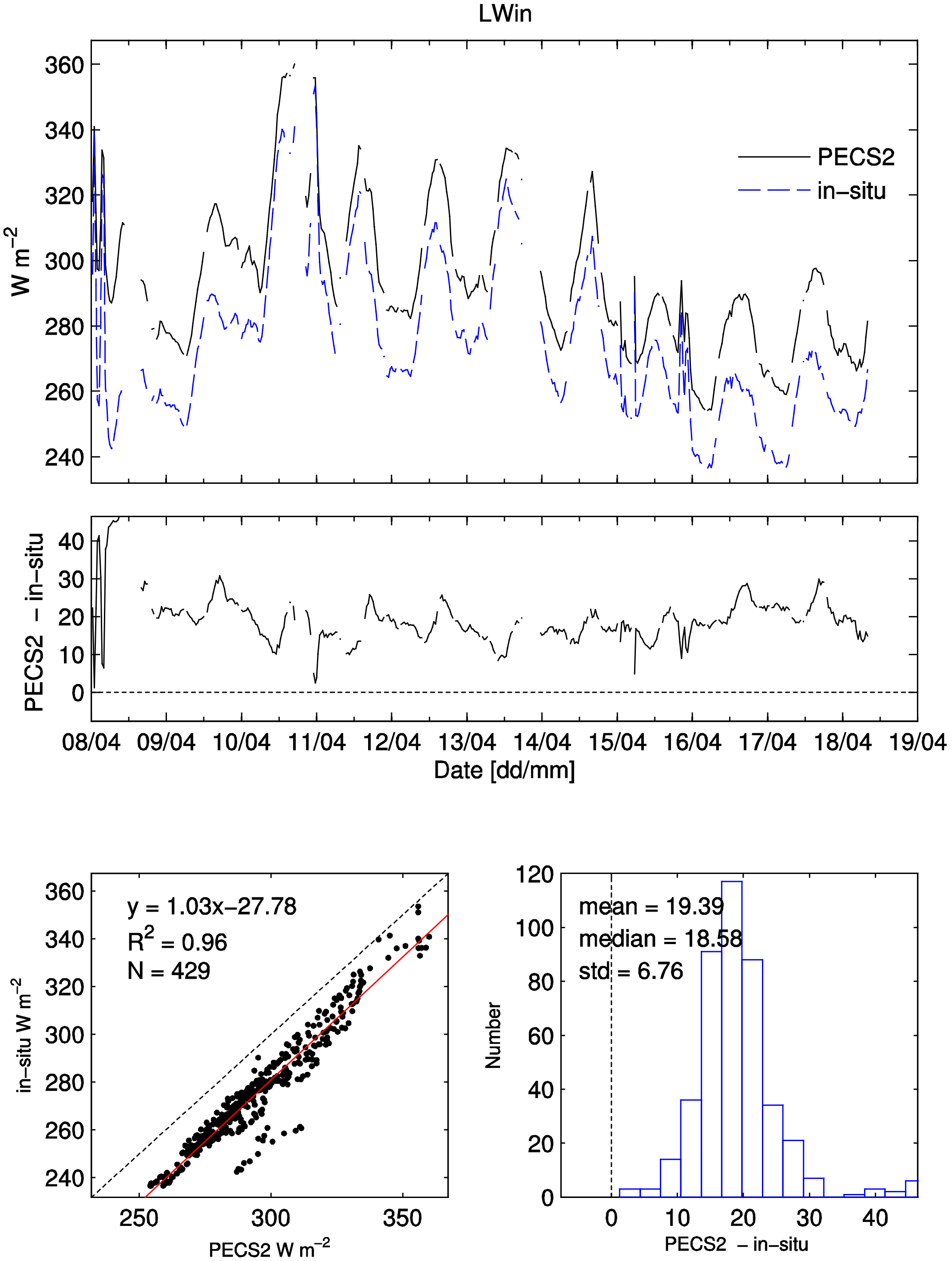


Figure 23 – Incoming longwave radiation.

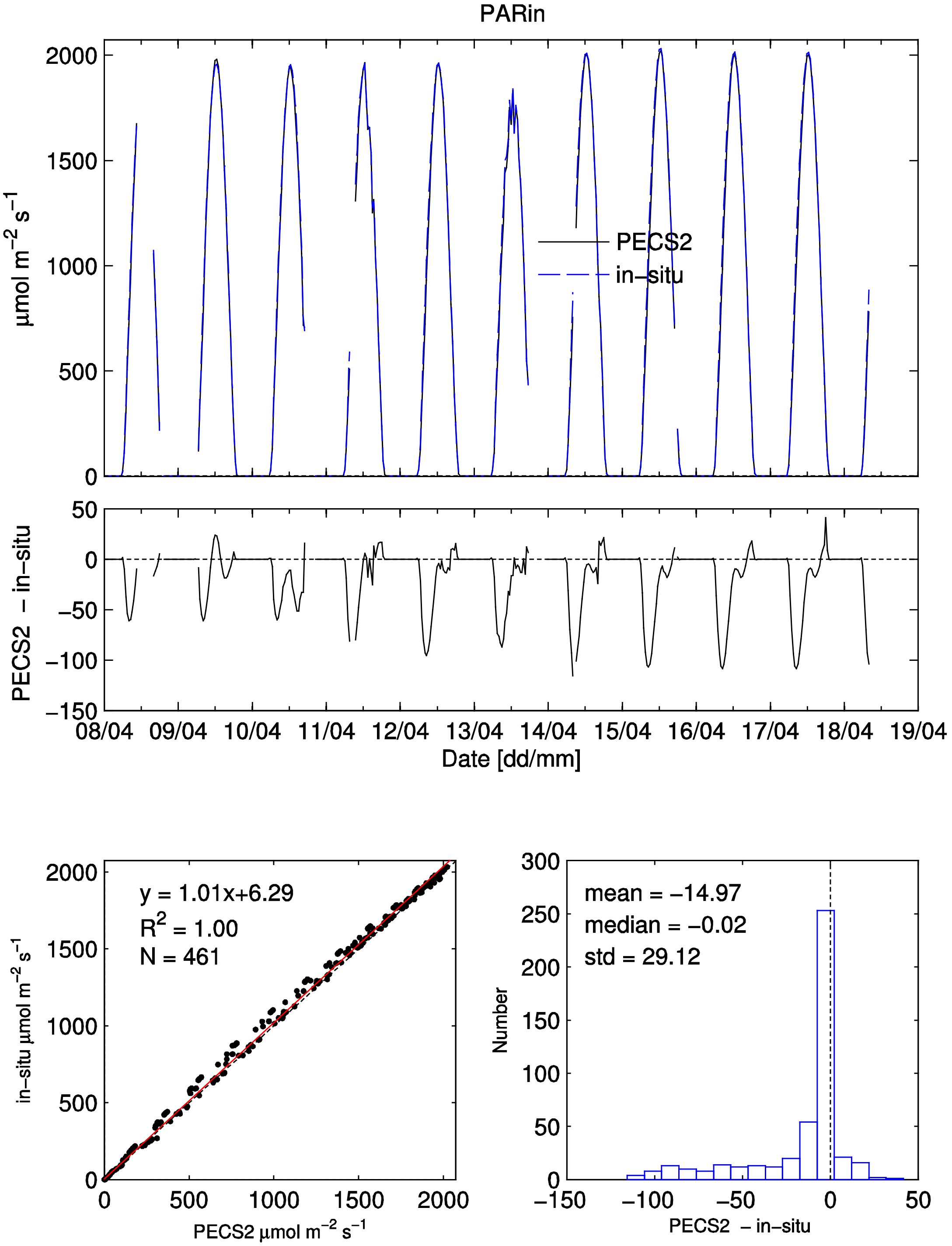


Figure 24 – Incoming photosynthetically active radiation (PAR).

Site Name: Sherman Island (US – Snd)
Visit Dates: 8-18 April 2013

Table 1 – Summary of basic statistics from linear regression and for each system of compared variables.

	Regression				AmeriFlux PECS2				In-situ			
	slope	intercept	R2	N	mean	std	max	min	mean	std	max	min
CO2 flux	0.87	-0.02	0.96	305	-1.28	7.06	13.06	-18.11	-1.13	6.38	14.45	-15.17
Latent heat	0.91	-1.66	0.98	306	84.27	92.09	330.98	-26.89	75.08	85.38	306.07	-10.55
Sensible heat	1.01	2.55	0.99	306	19.95	92.3	263.8	-106.7	22.7	94.22	288.91	-90.22
u star	0.97	0.02	0.99	326	0.41	0.18	0.85	0.05	0.42	0.18	0.82	0.05
Ts	0.73	6.85	0.98	461	15.69	4.6	28.34	7.22	18.24	3.4	28.71	12.2
var(u)_{rot}	1.04	0.01	0.99	306	1.37	0.94	4.52	0.14	1.44	0.99	4.58	0.13
var(v)_{rot}	1.07	-0.03	0.99	306	0.92	0.67	5.57	0.09	0.95	0.72	5.32	0.09
var(w)_{rot}	0.95	0	1	306	0.25	0.16	0.7	0.01	0.23	0.15	0.65	0
var(Ts)	0.91	0	0.97	438	0.21	0.21	1.44	0.01	0.2	0.2	1.36	0.01
CO_2	0.99	-0.23	1	441	16.87	0.52	19.59	15.71	16.55	0.52	19.55	15.46
H_2O	0.99	2.79	0.99	441	405.42	107.88	623.95	210.46	405.7	108.01	648.15	216.58
var(CO_2)	0.8	0	0.94	435	0.01	0.01	0.1	0	0.01	0.01	0.09	0
var(H_2O)	1.05	-16.08	0.99	436	289.02	397.83	2970.25	6.82	288.66	422.86	3291.95	4.39
Ta-HMP	0.99	-0.11	1	461	15.63	4.54	28.13	7.54	15.37	4.5	27.87	7.29
RH-HMP	1	-0.59	1	460	51.25	18.11	83.19	18.65	50.87	18.24	81.75	17.63
Pressure	1	0.03	1	461	101.57	0.47	102.59	100.88	101.65	0.47	102.68	100.84
Wind spd	1	0	1	326	4.94	2.13	9.83	0.41	4.95	2.13	9.94	0.45
Wind dir	1	16.61	1	326	281.39	39.56	326.92	80.54	299.19	39.74	343.31	96.66
SWin	0.97	5.59	1	461	290.86	362.35	986.21	-9.97	287.98	351.89	969.91	-4.34
LWin	1.03	-27.78	0.96	429	293.73	22.08	360.06	254.2	274.34	23.69	353.42	236.56
PARin	1.01	6.29	1	461	589.03	726.16	2021.97	-0.04	604	737.35	2031.8	0

Appendix 1 – Site information

General Site Information

Site name:	Sherman Island
Mean canopy height (m); provide source of measurement:	0.2 m
Time zone of site data acquisition?	Pacific Standard Time (PST)
Was PEC system sync'd to their local time? when?	on setup day (5 April 2013)
Sampling frequency of fast response system:	10 Hz

http://ameriflux.ornl.gov/fullsiteinfo.php?sid=189
Latitude (+N/-S): 38.0373 (38° 2' 14.280")
Longitude (+E/-W): -121.7536 (-121° 45' 12.960")
Elevation: 0 m
Declination: 13.85° E on 2013-04-18

Site Instrumentation (make/model) - heights recorded below

Instrument	Make/model
Sonic anemometer	Gill Wind Master Pro
Fast temperature sensor	N/A
IRGA#1 (open/closed)	LI-7500
IRGA#2 (open/closed)N	N/A
Other gas analyzer (describe)	Closed-path CH4 (LGR)
Radiometer#1 (specify net or which component)	CNR1
Radiometer#2 (specify net or which component)	Homemade NDVI sensor
PAR#1	Kipp & Zonen (down-welling)
PAR#2	Kipp & Zonen (up-welling)
Temp. sensor#1 (is aspirated?)	HMP 45 (not aspirated)
Temp. sensor#2 (is aspirated?)	N/A
Humidity sensor (is aspirated?)	HMP 45
Barometer	
Wind sensor	
Vertical profile systems (temperature, winds, trace gases)	N/A
Miscellaneous sensors (describe)	Rain gauge
Miscellaneous sensors (describe)	Misc below ground sensors

Eddy covariance details (sensor heights, orientation, separation)

	PECS#2	in-situ
Sonic anemometer		
height [m]	2.85	?
orientation of sensor [o]	8	20
distance from tower/tripod [m]	0.2	1

orientation of boom (if different) [o]	N/A	N/A
Open-path IRGA (measure relative to sonic)		
Vertical separation [cm] (pos if IRGA is above sonic)	-17	?
E/W separation [cm] (pos if IRGA is east of sonic)	-5	?
N/S separation [cm] (pos if IRGA is north of sonic)	-14	?
Closed-path IRGA (measure relative to sonic)		
Vertical separation [cm] (pos if IRGA is above sonic)	-15	N/A
E/W separation [cm] (pos if IRGA is east of sonic)	18	N/A
N/S separation [cm] (pos if IRGA is north of sonic)	-5	N/A
Inlet tube length [cm]	100	N/A
Inlet tube inner diameter [mm]	5	N/A
Inlet tube flow rate [lpm]	15	N/A

Slow response details (sensor heights, orientation, and separation)

	PECS#2	**in-situ**
Radiometer#1 - height [m]	2.2	?
Radiometer#1 - orientation [o]	194	198
Radiometer#2 - height [m]	N/A	N/A
Radiometer#2 - orientation [o]	N/A	N/A
PAR - height [m]	2.2	?
PAR - orientation [o]	194	?
Temp. sensor#1 - height [m] (Asp)	2.05	?
Temp. sensor#2 - height [m] (HMP)	2.05	?
Humidity sensor - height [m]	2.05	N/A
Barometer - height [m]		
Wind sensor - height [m]	N/A	N/A

Appendix 2 – Photo of installation during comparison

Installed eddy covariance systems at Sherman Island during AmeriFlux intercomparison from left to right (PECS1, in-situ, OSU, PECS2). Photograph orientation is south.