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Atmospheric Measurement Techniques Discussions

Interactive comment on "Using sonic anemometer temperature to measure sensible heat flux in strong winds" *by* S. P. Burns et al.

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The thoughtful and insightful comments by Johannes Laubach are greatly appreciated. We have not quite finished considering all aspects of these comments, but we wanted to reply to comments 3–4 to clarify the data despiking used in our study. Our replies to these two comments are below and we will post replies to all the comments within the next couple of weeks.

Comment 3: *High-frequency noise can show up in the original time series as "spikes", and spikes in the wind and temperature signals of a sonic anemometer can be correlated (if they have a physical cause in the underlying speed-of-sound measurement). Was any algorithm to detect and remove spikes used? If so, was its effectiveness*

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Interactive Discussion
Discussion Paper

tested?

Reply 3: We were concerned about spikes. As we noted in Table 1, footnote "d": "CSAT data deemed unacceptable by the CSAT diagnostic flag were replaced with a linear fit between valid samples (for low wind wind speeds data were rarely flagged, but for higher winds around $2-4$% of the samples were flagged)". The CSAT3 diagnostic flag checks for the following conditions: no response from the anemometer, lost trigger, poor signal lock, that the difference in speed of sound between the three transducer pairs is less than $\approx 4\,^{\circ}$C, and whether the sonic signal amplitude is too high or low (see Campbell Scientific, 2011 for details). We visually inspected which data the diagnostic flag detected as spikes (see Fig. 1) and deemed it was detecting the most egregious spikes so we did not do further de-spiking. However, we will attempt some additional despiking with standard algorithms (such as that described by Højstrup (1993)) and report back whether or not this makes any difference. Also, in any future version of our paper, we will attempt to make the details about despiking clearer by supplying this information within the text rather than as a Table footnote.

There could be be a question of whether or not replacing the despiked data with a linear fit between valid points works well or not. We have not explored any other alternatives within our study.

It is interesting to observe that spectra of the raw and despiked CSAT temperature did not differ dramatically (Fig. 2). We presume this is because the sonic temperature is already so noisy that the dramatic spikes in the raw data do not drastically affect the spectra. Also, note that the despiking had very little effect on the vertical wind spectra (this is not too surprising).

Comment 4: *It is well-known that high-frequency noise can be corrected for by filtering. In order to obtain valid covariances, it suffices to filter one component only, either w or T. Why is this not attempted, and then checked if filtered data lead to plausible surface*

AMTD

5, C67–C72, 2012

energy budgets?

Reply 4: In our initial examination of the sensible heat flux H problem, we attempted to low-pass filter the CSAT3 temperature as a fix. Unfortunately, we neglected to mention this aspect of our analysis within our paper, so we include an example here. In Fig. 1 we show the time series of the despiked (using the CSAT diagnostic word) and low-pass filtered sonic temperature time series. When the low-pass filtered temperature is used to compute H we found that it is in close agreement with H calculated using the raw and despiked-only sonic temperature (e.g., low-pass filtering does not improve the estimates of H). Note, we have shown results with a low-pass filter cut-off frequency of 1 Hz in Fig. 2, but we also used a cut-off value of 0.1 and 0.5 Hz and this did not improve the estimate of H from the CSAT.

We hope this short response clarifies the despiking we performed and we welcome any additional comments or ideas about what we have done.

References

Campbell Scientific, 2011: CSAT3 Three Dimensional Sonic Anemometer Manual (Revision 10/11), Campbell Scientific, Inc., Logan, Utah, 70 pp., (Available at www.campbellsci.com).

Højstrup, J.: A statistical data screening procedure, Measurement Science and Technology, 4, 153–157, 1993.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 447, 2012.

AMTD
5, C67–C72, 2012

Interactive Comment

Fig. 1. Time series of (upper panel) measured temperature and (lower panel) horizontal wind speed U and relative humidity RH. Note that the temperature time series are offset from each other as specified in the legend. The sonic temperature from the CU CSAT has been despiked using the CSAT diagnostic word (green line) and despiked plus low-pass filtered at 1 Hz with a Butterworth zero-phase shift digital filter (black line). The thermocouple T_{tc} was sampled at 10-Hz and located within a few cm of the CSAT transducers. For the period between day of year 318 to 318.1, the CSAT diagnostic flag detected 1.4% of the 10-Hz samples as spikes.

Fig. 2. Mean nighttime values of: vertical wind spectra S_w, temperature (either T_s or T_{tc}, see legend) spectra S_T, $\overline{w'T'}$ cospectra $(Co)_{wT}$, and sensible heat flux H ogive versus frequency f. These are 30-min periods between midnight and 9:00 MST on 14 November, 2010 which corresponds to part of the time series shown in Fig. S1. The CU CSAT temperature has been despiked and filtered as described in the legend (more details are in the caption of Fig. 1). The dashed line shows a -2/3 slope.

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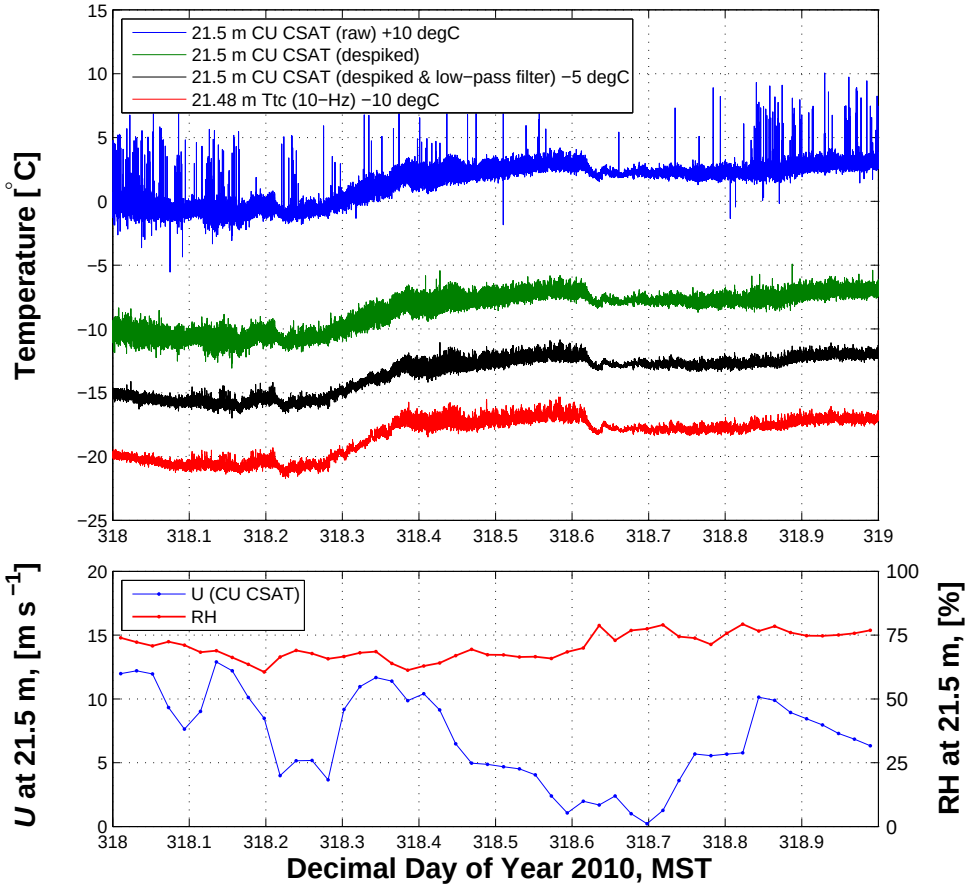

Fig. 1. see caption above

AMTD
5, C67–C72, 2012

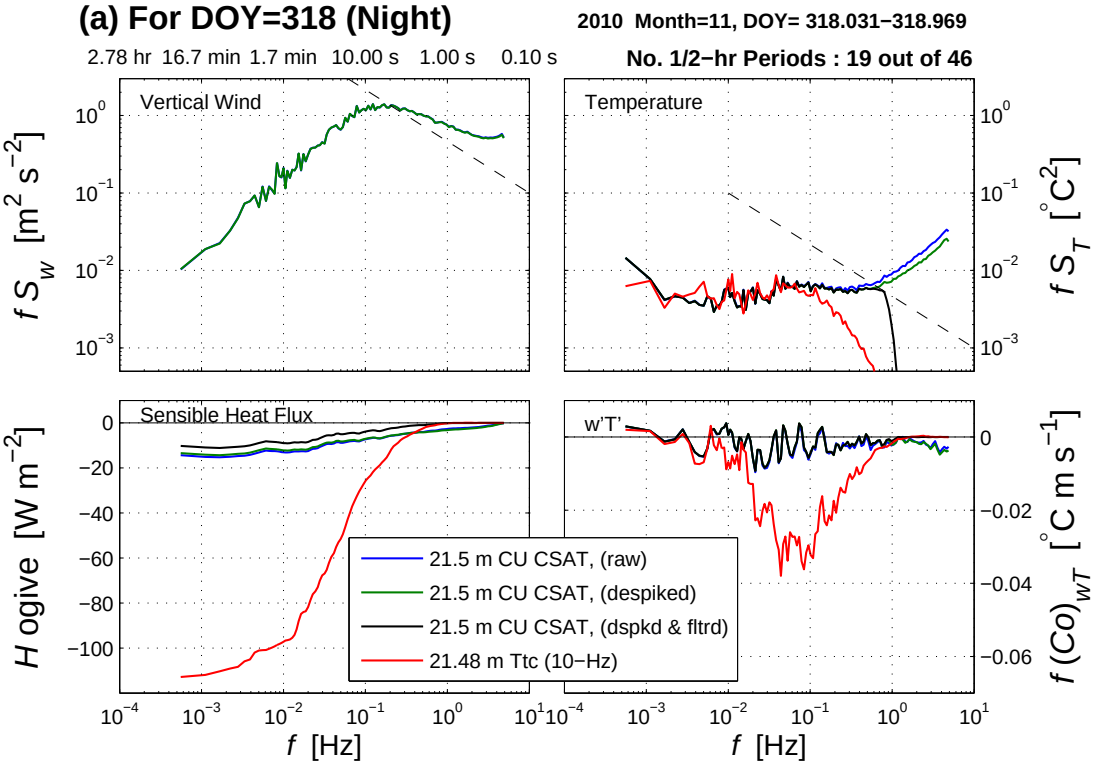

Fig. 2. see caption above

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5, C67–C72, 2012

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