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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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Dear Sean, here are some more thoughts, adding to the latest three contributions to this discussion.

1) First, let's try to be clear about the direction of the heat flux error. Fig. 1 in the manuscript shows a time series where at high wind speed during the night (around Day = 42 and 43 < Day < 43.5) the heat flux using the thermocouple is downwards (negative) while using the sonic it is upwards (positive). So far, I had understood from the manuscript that this was the main observation of interest. Apparently, Thomas Foken and the Anon Ref shared this understanding. However, none of the shown examples of spectra and cospectra represents this situation. In Fig. 3 (Day) all heat fluxes are positive. In Fig. 3 (Night) all are negative, and the one using the sonic has

the smaller magnitude, indicating serious decorrelation of the w and Ts signals, not a spurious correlation increase. In the figures of your reply to my first Comment, the same is true. (In Fig. 4 of the manuscript, also all daytime heat fluxes are positive and all nighttime heat fluxes are negative, as one would expect.) So I think it would be helpful if you could select some periods where w-Ts and w-Ttc have opposite sign.

2) In all the power spectra of sonic temperature that you show there is a "rising tail", indicating very high noise level. Fig. 3 and 4 show that the amplitude of this tail increases with wind speed, and I would hope that Campbell Scientific were interested in looking into the cause of this (see the two hypotheses in my initial Comment). Another effect of high wind speed is to shift the true turbulence spectra towards larger frequencies, where the true fluctuations and the instrument noise then combine and make it hard to filter the noise out.

3) From Fig. 2 in your "Response to J. Laubach" it is further apparent that a digital filter with 1 Hz cutoff successfully suppresses spurious w-Ts-correlation above 1 Hz. However, the main problem lies in the range between 0.02 and 1 Hz, where the w and Ts signals are substantially de-correlated. Whether it is possible to correct for this by a better despiking algorithm is not clear from the figures. (I suspect not, see my next point.) One would need to zoom in on the time axis in Fig. 1, to periods < 1 minute, to get a better idea what is going on.

4) The shown power spectra can further be distinguished by their behaviour at f < 0.1 Hz. In some cases (Fig. 3 Day, Fig. 4 bottom right panel) the sonic and thermocouple agree well in this range. In the other examples, the thermocouple shows the larger power. When this power difference occurs during the day, some of it may be due to radiation error of the thermocouple. This is not correlated with w, and thus the daytime cospectra of w-Ts and w-Ttc agree well with each other for f < 0.1 Hz. However, when such a power difference between Ts and Ttc occurs at night (Fig. 3b, Fig. 4 second row), it is associated with a significant magnitude reduction of the w-Ts cospectrum, indicating serious de-correlation between w and Ts. This de-correlation occurs because

the high spike (noise) level masks the true low-frequency variations, and the despiking algorithm is not able to restore them correctly.

5) I have used CSAT-3 sonics myself and dealt with some high-frequency noise. However, I have never seen them as noisy as here - but then, neither have I worked in frosty conditions, nor with such high wind speeds. My feeling is that conditions at your site have simply put the CSAT-3 outside its operating range, and I hope that you can work out in this paper if the problem is high wind speed as such, or only at low temperatures, or only during occurrence of particle drift, as Thomas Foken suggests.

6) Re snow drift: can that be indirectly addressed, by checking if data from snow-free periods (at this site or elsewhere) are subject to similar decorrelation?

7) A possible conclusion from all this is that heat flux measurements in conditions as encountered by you (see 5) how to specify them) must be made with separate fast-response temperature sensors. Since high wind speed provides enhanced ventilation, any radiation error will be ameliorated and thus be minor. (High-frequency loss due to sensor separation also decreases with increasing wind speed, making this a viable option.)

Best regards Johannes.

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