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Atmospheric Measurement Techniques Discussions

Interactive comment on "A Bayesian model to correct underestimated 3D wind speeds from sonic anemometers increases turbulent components of the surface energy balance" *by* John M. Frank et al.

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(1) Comments from Referee

Anonymous Referee 2 Received and published: 18 July 2016

The work presented in "A Bayesian model to correct underestimated 3D wind speeds from sonic anemometers increases turbulent components of the surface energy balance" by J.M. Frank et al. makes a valuable contribution to the improvement and refinement of the eddy-covariance technique for measuring the exchange of mass and energy between the land and atmosphere. The objective of the paper is to show a

method which provides a better correction to wind velocities from sonic anemometers for transducer shadowing. The paper is well written and the methods are clearly explained. The three hypotheses laid out by the authors are well substantiated, and throughout the paper the focus on refuting or supporting these objectives is maintained.

The authors showed that by using the 3D correction obtained from the Bayesian approach to high frequency wind velocity data, the measurements from vertically and horizontally mounted anemometers would be more similar. The correction increased vertical wind velocity and sensible heat flux by 10% with a 2% uncertainty. A re-analysis of data from several North American flux sites where the posterior correction was applied to the eddy-covariance data resulted in the turbulent components of the energy balance increasing between 8 to 12%.

Closure of the energy balance in eddy covariance studies can often be problematic, and casts doubt on the mass and energy fluxes derived from the data. Eddy covariance data is also plagued with missing data, which is usually missing not at random, and therefore exacerbates the energy balance closure problem. By reducing sources of systematic bias, it allows investigators to better understand remaining discrepancies in the energy balance. By producing mass and energy fluxes which are closer to the true values, the application of this correction to eddy covariance data would provide better ground-truthing data for land-atmosphere exchange models.

The only draw-back of this analysis carried out on this paper is the small percentage of available data used to derive the posterior correction. As discussed by the authors, the logical next step would be to translate this method to a framework which could make use of parallel computing to speed up the calculations, thereby allowing more data to be used, a larger number of unique corrections, and for the MCMC chains to continue for more steps. If this correction is shown to be stable and consistent when derived from a larger sample of data, and is shown to apply to other anemometers, what would be the proposed uptake of this research? Do the authors expect that the correction will be applied by the firmware of the different anemometers, and therefore current

anemometers would then apply the correction to the wind velocity data after a firmware update? Or would it be possible to apply the correction in the post-processing of the raw eddy covariance data, and therefore allow historical data to be re-processed?

(2) Author's response

For now, we anticipate this specific posterior correction will be used for sensitivity tests and error analysis during post-processing of raw eddy covariance data. We deliberately made it available as a supplemental file to encourage users to investigate the potential for how much transducer shadowing could influence their understanding of physical processes at their field sites. We also encourage development of the Bayesian model to obtain better resolution in the correction and to extend it to include different manipulations and anemometers, etc. We are disappointed that we could only analyze 5% of our available data, and we look forward to developments that adapt our model to high performance computing and parallel processing. There may become a time when a 3D shadowing correction is produced that would be appropriate for inclusion in instrument firmware. If that time should come, there would need to be a discussion among manufacturers and the community on how to adapt Bayesian uncertainties to the sensor output.

A problem hindering all research into sonic anemometer errors is there is no consensus on what is an appropriate standard to validate against. This was discussed recently at the AmeriFlux meeting. We are encouraged that using an omnidirectional standard in conjunction with experimental manipulations within a Bayesian framework might provide a framework to answer this tough question. Yet, this study is merely the first step. In response to Anonymous Referee 3, we conducted a brief field validation experiment where we tested a completely new manipulation (i.e. askew). While we were disappointed that the results for this manipulation were fairly ambiguous, we interpreted this to mean that there is a wealth of information yet to be incorporated into this type of analysis.

(3) Author's changes in the manuscript

There were no changes to the manuscript in response to Referee 2

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