

Interactive comment on “Water vapor density and turbulent fluxes from three generations of infrared gas analyzers” by Seth Kutikoff et al.

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Authors used regular fonts for Referee's comments and blue fonts for our responses.

This manuscript performs a sensor comparison of water vapor sensors for the eddy covariance method of deriving latent energy fluxes. They compare three version of the Li7500, and find relatively similar (and positive) performance of the three sensors. While generally well put-together and written, there are some gaps. Notably, the pre-publication comments from Referee 2 seem to have been missed and were un-addressed. I know the Copernicus system sometimes makes it difficult to see the attached comments (please find them). Those major comments and mine here below should be addressed and resolved prior to publication.

C1

Response: Thank you for your review and insight which improved our paper. We responded to all of your comments as well as those from referee #2 .

Important highlights from the missed review that generally denote “major revisions”: 1. Define how 20 Hz data spike thresholds of 30+ and 2- g/m³ were determined.

Response: Authors maintain this plausibility range as a way to cover all possible observations in our dataset (they represent the range of growing season values).

2. The Lasslop et al., 2008 paper seems mis-cited.

Response: We removed this reference, as its relation to the error analysis used in this paper does not add clarity to the sentence.

3. The use of rmsd is sometimes used to indicate that one instrument is performing well, rather than to indicate merely a difference in performance between instruments.

Response: We agree on this point. The rmsd is a frequently used measure of the difference between values (sample or population values) predicted by a model or an estimator and the values observed. It is a measure of accuracy in an instrument's performance.

4. Consider seriously the issues of transducer shadowing and other non-IRGA instrument errors (including possible errors in R_n , G , and J and why EBC may not be the best metric).

Response: Transducer shadowing effects were heavily investigated during early 3D sonic anemometer development in the 1980s and 1990s. The optimum design is to minimize shadow effects (air flow distortion dynamics and line/path integration) for the sonic anemometer's geometry (e.g., a 120-degree orthogonal geometry). There aren't many studies on this issue for gas analyzers although strictly speaking, they do have some shadow effects. We agree that there are many non-IRGA instrument errors, especially sonic w component and its spectral property. However, due to surface energy imbalance problems as well as evapotranspiration hysteresis, we considered EBC

C2

as a secondary metric for evaluating the performance of three generations of infrared analyzers.

Major comments:

1. “advective conditions” are referred to without a definition of how they were determined.

Response: Thank-you for pointing this omission out. We have added a brief description and references in our revision as below:

“This condition was defined by finding half-hour observations between 10:00 and 18:00 LST in which latent heat exceeded available energy (a difference between net radiation and soil heat flux), or sensible heat flux was significantly negative ($\leq -10 \text{ W m}^{-2}$) (Kutikoff et al., 2019).”

2. Fig 7 should add the energy balance terms (At least their sum, in accumulation) and then discussed in more detail in the text

Response: Thank you for your insight. At the same site, available energy ($R_n - G$) and sensible heat flux H (assuming there were no significant differences between the two sonic anemometers we used. One sonic was shared by two IRGAs so that H from them are the same) are the same for three types of IRGAs. The LE (or ET) is of our interest (shown in Figure 7). A composite signal (e.g., energy balance term) might mask the true signal that we are seeking.

3. In general where Fig 7 is described the term “Energy balance closure” should appear at least once (and described, compared to literature, etc.)

Response: Eddy covariance has experienced energy balance closure (EBC) problems over decades. We used the latest version of CSAT3 when we took observations. In addition, two adjacent IRGAs shared one CSAT3 in our study. The EBC problem is not our objective in this study but we recently submitted a paper about energy imbalance problems and evapotranspiration hysteresis to another journal.

C3

4. Discuss the possible differences in CO₂ flux (or, if that is coming in a different paper), about the implications of the LE flux differences on the WPL corrections for CO₂ or CH₄ fluxes (or other gas fluxes).

Response: This is a very interesting topic that is beyond the scope of this paper. We are conducting CO₂ spectral analysis from these three analyzers and hope to come out with a different paper.

5. L409 “. . .no conflict of interest”. I fail to see how this can be true. One of the coauthors works for the company that produces these sensors. I don’t think it’s likely or necessarily an unethical conflict of interest, but it should certainly be stated and justified. The paper helps make the point that this company’s sensors are well-suited for purchase and use.

Response: Authors conducted this study collaboratively with USDA ARS, Kansas State University, and LICOR-Bioscience. The IRGAs have been widely used in flux communities for nearly 30 years. Our observations and data analysis were objective and unbiased for the purpose of advancing the science. It is not our intention to favor any particular instrument and only present evidence-based scientific results.

Reviewer minor comments 1. L18 “means” is too jargony. Consider: Water vapor density fluctuation means exhibited. . . , while their variances were occasionally. . .

Response: This comment is helpful, and we have made the change as suggested.

2. L19 “following rainfall events” – for how long?

Response: We keep this phrase unchanged because averaged days from one day to a few days are dependent on weather conditions.

3. L20 “recent” and “results” seem out of place; “widened cospectra” should be quantified.

Response: Yes, we deleted “recent” and “results”. Thanks for your careful review.

C4

Regarding “widened cospectra”, it is not our intent to quantify cospectra specifically but to examine contents of high frequency and/or low frequency energy components. The integral of cospectra is the flux value for the integrating time period.

4. L39 add a paragraph break before “The accuracy of”

Response: Done.

5. L46 “optical approaching” seems like the wrong word

Response: Deleted “approaching”.

6. L52 “showed that zero drift” – sounded like “showed no drift” – “zero” here is a jargon word. Say something more clearly like “drift of the calibration zero, i.e., the bias”

Response: Done. Thank you.

7. L64 define “relatively low”

Response: A weekly or bi-weekly calibration is usually required for high accurate measurements from eddy covariance. Therefore, the low instrument stability for an eddy covariance system (fast-response system) is relative to the measurements by a slow-response system, for example, air temperature measurements in a weather station system.

8. L85 I think both “error” can be “errors”

Response: Done.

9. L96 sounds biased; replace “a newer” with “one set of”, analyzer with analyzers, and change “earlier” to “other”

Response: Excellent criticism, and we have made these changes.

10. L100 is there a reference for this field and instrumentation? It’s written about as if it is well-known.

C5

Response: Added reference to recent publication using this field and instrumentation.

11. L114 add “Each” before “gas analyzer” and “the” before “sonic”

Response: Done.

12. L155 “rotation” not “rotations”

Response: Thank you. Done.

13. L161 “results of” can be “the”

Response: Done.

14. L229 “are” seems jarring after the previous sentences in past tense; I think “Were” is better

Response: Done

15. Fig 1 caption use “turbulence” and not “turbulent”

Response: Done.

16. Fig 2 the dots for the HMP155-S are almost impossible to see over the shading.

Response: We updated this figure to better display HMP155-S.

17. Section 4.1 needs paragraphs; perhaps one with the However in line 333. Consider also outlining and clarifying the focus and main points; the section wanders.

Response: We tightened up, restructured, and condensed the content in this paragraph.

18. L369 remove “different”

Response: Done.

19. L369, 371, 373, and elsewhere – be careful with “This” that lacks a follow-up noun; these words all generate ambiguity.

C6

Response: Great suggestion. Replaced “this” with “this drift” on L212, “this advection coincided” on L298, “These flux results are encouraging” on L324, “This behavior” on L351, and “These findings” on L369.

20. L377 swap “into” and “primarily”

Response: Done.

21. L393 add “the” before “corn”

Response: Done.

— The END of point-by-point response for referee #1

Please also note the supplement to this comment:

<https://amt.copernicus.org/preprints/amt-2020-302/amt-2020-302-AC1-supplement.pdf>

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-302, 2020.