Manuscript: Title: The high frequency response correction of eddy covariance fluxes. Part 1: an experimental approach for analysing noisy measurements of small fluxes

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Reviewer's comments are shown in **bold**, while authors' responses are in red.

Reviewer 2 # George Burba

We thank the referee for his positive comments and appreciate the changes, correcting typos and improving English, and making the flow simpler and clearer for the general audience. Since there are two different files containing comments, in order to prevent repeating the same answers and provide clarity, we combined the comments from both pdf and word file, and summarized them below under the four different bullet points already highlighted by the referee. The comments from the word file are shown with page and line number in the manuscript. All editing corrections are accepted, hence they are not shown here.

1. It would be very helpful if authors could illustrate the actual fit and how it is different vs and convention technique (see specific comments). A simplified graphical example or two may go a long way. Reader needs some feel for what is changing and how much.

- **P6L12 (from the word file): So, in the beginning of this section, authors explain the existing procedure and demonstrate it graphically in Figure 1.**

  Then authors discuss the deficiency of the resulted black line due to the separate fitting of the blue line, and propose a new combined way to fit.

  Here, it may be very illustrative and helpful for the reader's understanding to present a similar plot (1B) with a graphical explanatory illustration of the new proposed procedure and show the difference of a new black line from the old black line.

  It may be hard to see the difference over the entire frequency scale, so perhaps it could be shown just for the portion of *f(Hz)* from 10^(-2) to 5 Hz?

- **P13L4 (from the word file): If it would be possible to show this in Figure 1B in a graphical explanatory way, it would really made it much easier to understand the new procedure.**

- Thank you for the suggestion. We updated Section 2.2, and Figure 1 (shown below with its caption). We preferred not putting another figure, but enhancing the current one. All steps in PSA_{I07}, and PSA_{A20} with advantages and disadvantages are explained in detail via referring to updated Figure 1.

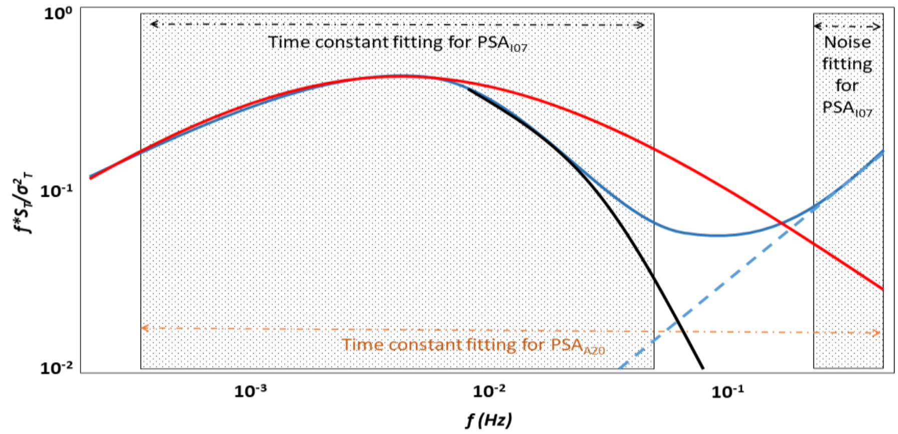

Figure 1. A diagram illustrating fitting procedures for PSA methods. Shown are the spectra of unattenuated and noise-free temperature (red line), and spectra of low-pass filtered and noisy scalar (blue-solid line) and after (black line) noise removal. For PSA$_{I07}$, the noise is detected via fitting a line (blue-dashed) to the high-frequency end of noisy scalar over the frequency range highlighted. Then, it is extended towards lower frequencies, and subtracted from the noisy spectrum, yielding noise-free spectra. Later, the time constant is calculated via fitting Eq. (4) to noise-free spectra over the frequency range highlighted. For PSA$_{A20}$, the time constant is obtained from one comprehensive fitting Eq. (7) to noisy spectra over the whole frequency range highlighted.

2. Examples of correction factors from the simulated dataset, and also from a few real-life datasets would also be helpful.

- **P13L5 (from the word file): Why? For simulated attenuation and SNR maybe, but for real-life data I am not sure.**
    - We added a real-world data, i.e. CO_2 from Siikaneva site, to demonstrate the performance of PSA$_{A20}$ in comparison with PSA$_{I07}$ and CSA$_{sqrt\ H,\ sync}$. The results are shown and discussed in Section. 4.4.

  What are correction factors for this dataset?
    - Following also the parallel request from the referee 1, Marc Aubinet, we added a figure (Fig. 2 shown below) illustrating the correction factors for a single case (i.e., τ=0.3 s, SNR=2).

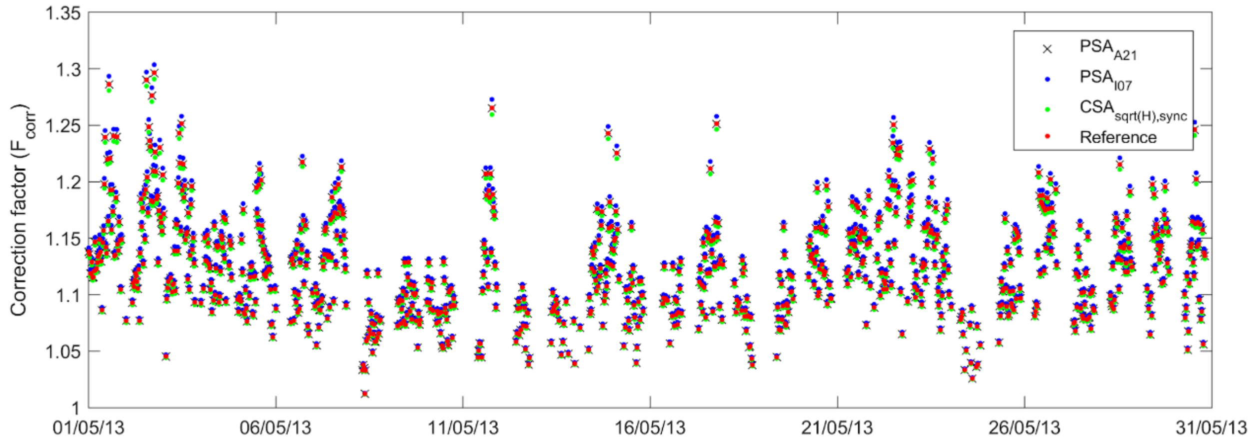

Figure 2. Correction factors (F_{corr}) of half-hourly fluxes calculated with different approaches, i.e. PSA$_{A21}$ (black cross), PSA$_{I07}$ (blue point), CSA$_{sqrt(H),sync}$ (green point) and the reference (red point) for the case with tau=0.3 s and SNR of two.

Is it possible to add examples of correction factors for other independent datasets for both PSAI07 and PSAA20?

- The estimated time constants for a real-world data are added to the manuscript. However, we didn't further process the fluxes, hence F_{corr} is not provided as the resulting figure would look similar to Figure 2. shown above.

- **P14L10 (from the word file): Only for truly "white" simulated noise.**
  - We replaced the relevant sentence "It shows that noise contamination does not affect the shape of the cospectra" with "It shows that the white noise contamination did not cause linear increase in the high-frequency end of the cospectra, enabling the time-constant calculation without additional procedure related to noise removal".

3. The need for non-time-lag adjusted cospectra should be explained very carefully. I suggested some ideas in the attached. Without such explanations, the two non-timelag adjusted cospectral approached seem like artificial issues created solely for the purpose of solving them.

- **P14L13 (from the word file): This is an impressive performance.**

  Are there ever cases when time-lag correction is not applied first?

  This reads strange: would not use of time-lag-uncorrected values just be artificially making two bad cases (green and red)?

  Do we even need to show and discuss green and red? -- It seems that these can be removed from the manuscript.

  P18L5 (from the word file): I am still not sure why these two are needed to be in the paper.

  Running co-spectra without time lag does not seem to make sense. Of course, without time lag compensation covariances are not going to be as good.

  I guess I can only imagine that with very-very low fluxes, it is difficult to confidently determine the lag, so cases 1 and 2 could potentially be an illustration of the impact of inability to determine the lag.

  If this is indeed the case for using #1 and #2 in the manuscript, it may be good to explain it very clearly/explicitly in Introduction, and one more time in MM so reader understands the goal.

- Regarding using time-lag uncorrected CSA approaches, it is clear that it causes confusion as those cases (i.e., $CSA_{sqrt(H)}$ and CSA_H) are not in use in literature. We agree with the referee. The relevant approaches are removed. The $CSA_{sqrt(H),\ sync}$ is the only approach used for CSA in the manuscript at the moment. We simply referred the use of square-root of the transfer function to the companion paper by Peltola et al. (2020).

4. In the Conclusions section, it may be very useful to provide an assessment on the ease and reliability of the automaton for each of the compared techniques. I have included some ideas. The full impact of the newly proposed technique would only happen if a broad community accepts it and start using it. Automation or semi-automation is one of the keys to such acceptance and use.

- **P19L9 (from the word file): It seems like CSA approach (fig 7 blue) can be implemented automatically without a need of the interaction from the user.**

However, the price to pay for doing it this way is reduced performance of the correction with increased SNR, in other words, when fluxes are small.

PSAA20 seems to require an input from the user before correction can be properly implemented. User needs to look at the data and determine the nature of the noise, etc.

However, this provides a much better performance in all cases, including small fluxes (Fig 5B).

User interaction needed for PSA seems to be not more complex than the interactions needed for U* threshold tools. or for setting up max and min for theoretical time lag correction. So it is quite doable.

If the above understanding is correct, it may be worth adding a paragraph to the Conclusion regarding the ability to automate frequency corrections for small fluxes using new method or both new old and new method.

Perhaps, such paragraph could go here, just before "Finally, given the constraints…" and could include authors' recommendations on the automation. Maybe something similar to what I have described in this comment above, if it is correct of course.

- It is clear that EC data processing is quite laborious, and in particular, some steps, i.e. the frequency response correction, require expertise on micrometeorology and signal processing, hence automating the process as much as possible is of great importance. We showed that the new PSA_{A20} method requires less user interference compared to PSA_{I07} if the type of the noise is determined in advance. However, since the limitation of the new method is not tested against different types of noise in our study, we are reluctant to provide a guideline on automating the time-constant estimation.

P1L5 (from the word file): May be a bit confusing choice of a symbol, since H is frequently used for sensible heat flux.

- Indeed, H is frequently used for sensible heat flux. However, in many key studies on the frequency response correction (e.g., Ibrom et al. 2007, Mammarella et al. 2009, Fratini et al. 2012), the same symbol (H) was used to describe the transfer function. Thus, we followed the literature. But still, in order to prevent the possible confusion we didn't use any symbol to describe the sensible heat flux when mentioning it in the manuscript.