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Interactive Comment

Interactive comment on "Technical note: Dimensioning IRGA gas sampling system: laboratory and field experiments" *by* M. Aubinet et al.

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Dear Dr Sargent,

Thank you very much for your nice feedback and very interesting suggestions. Some of them were really helpful to improve the manuscript;

Here is a first reply; point by point. It is not complete as it doesn't answer to your questions relative to the laboratory experiment. Our colleagues of the Laboratory of the University of Reims are preparing a more complete answer on this point.

Comment : This is a good paper, generally well written, of a good length, and with an appropriate level of detail in most cases. A notable exception is the lack of details on the rain cups tested.

Reply : Thanks for the comment. Following your suggestion, I added some details concerning their dimension and shape (see below). On the other hand, I think we should be careful with this information as the home made rain caps were not tested in all conditions (as said in the paper, we are not rain cap conceivers) and are certainly not ideal. The aim of our research was mainly to understand the reasons of the high frequency loss in the GSS. Especially, if we cited the stuffing gland, it's because it provided the highest cut off frequency, which was for us an important clue to identify the rain cap as the cause of the problem. Anyway, we would never recommend stuffing gland use in the field as it is not efficient as a rain protector.

Comment : A more serious issue is that the authors have used a nonconventional definition ofcutoff frequency, based on 50% amplitude response instead of 0.707. I would strongly encourage the authors to revise their results to conform to the usual convention.

Reply : Concerning the laboratory results, you are fully right: the calibration bench provides an amplitude spectrum so that the cut off frequency should be computed as the frequency where the amplitude is multiplied by 0.707. In consequence, we have to change the text on P10740 L17, Figure 2 and recalculate the results of Figure 4.

On the contrary, in the field study, the transfer function is computed as a ratio of power spectra. In these conditions, it is correct to compute the cut off frequency on the base of 50% of the transfer function. We thus don't change the values neither in Table 2 nor in Figure 5. We added at several places in the text comments specifying that power spectra were used. By doing this, the values obtained in the field and in the lab should compatible.

Comment : The abstract very good, although I think the importance of pressure drop in the rain cup is overstated, and may detract from the other, more important points.

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Reply : Thanks again. I agree that the question of pressure drop in the rain cap is not the most important feature of this paper but, it was anyway surprising to see that some rain cups (especially the former LICOR version) generates a 1.3 kPa pressure drop at 15 L/min, that we supposed due to a flow restriction in the cap. As this was quite unexpected I think important to maintain the sentence (which is anyway quite short). We also developed the point a little bit at the end of Sect 4.2.

Comment : The first paragraph seems a bit unnecessary. Models for pressure drop in tubing are well known, and showing that the measured pressure drop can be modelled adds little new, and tends to dilute the main message, which is the pressure drop in the filters.

Reply : As the tube plays a significant role in pressure drop, we can't ignore it and we need equation 1 to predict the pressure drop in the system. However we agree with you that the writing should be improved in order to better emphasize the problem of pressure drop in filters. We thus rewrote the paragraph.

Comment : The second paragraph provides either too much or too little detail. Equation 4 is used to generate the theoretical curve in Figure 4, along with "line path averaging (Moore, 1986) and sampling" (page 10742 line 20). The equation I assume the authors used is contained in Moore, 1986, but it is buried in the text, and out of context. If the authors feel this theoretical comparison is important, I'd suggest explicitly providing the equation used and/or providing a reference that applies more directly to a closed-path analyzer. Also, I can find no information in this paper for the effect of "and sampling". It would be interesting to a more thorough treatment of all of the individual components of the theoretical prediction. Alternately, perhaps this section could be omitted in order to focus on the main topic of the paper (frequency response degradation due to filters and rain cups).

Reply : I agree that the comparison with theory is not essential in this case. In addition, the tube attenuation cut off frequency predicted by Massman and Ibrom is very high

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and not limiting in this case. The development of Eq 2-4 was not very useful in the present case (it just showed that tube attenuation is very limited here). We will thus reduce this part.

Comment : Materials and Methods 3.1. Reply : The Reims team will reply to all your questions concerning the calibration bench (not recalled here) in a next comment.

Comment : Pg. 10740 line 12. Cutoff frequency is normally defined as the half-power point (not the half-amplitude point). It is the frequency where the power spectrum falls to 0.5,and thus the amplitude spectrum falls to the square root of 0.5 (0.707). Using the halfamplitude point largely invalidates the results given here, and I strongly encourage the authors to recalculate the results or at least make clear that the results are not the cutoff frequency as it is normally defined.

Reply : As said above we agree on this point.

Comment : 3.2.1 Site and set up description This is a good description of the field experiment, although it would be extremely helpful to add some details for the rain cups. The performance of the various rain cup designs is central to this paper. As a minimum, the internal volume of each design should be provided. Photographs or drawings would be most helpful.

Reply : Rain caps dimensions, volumes and shape were added.

Comment : 3.2.2 Data treatment Are the spectra amplitude spectra or power spectra? The transfer function is normally defined as the ratio of amplitude spectra.

Reply : In this case they are power spectra and the cut off frequency is correctly defined

Comment : Equation (5): Did the authors consider using the usual function for a first-order system? This is given as equation 2 in Moore (1986), for example. This is the physically correct model for a mixing volume (large rain cup).

Reply : We maintain the Gaussian model for the regression because it better fitted the experimental transfer function. However, we followed your suggestion and also tested the first order equation. See results below.

Comment : I suspect the authors would find reasonable agreement between their measurements and this model by simply setting tau = V/Q, where V is the volume of the rain cup and Q is volumetric flow. Showing whether this comparison is (or is not) valid might provide a valuable insight into rain cup performance.

Reply : We found the suggestion interesting and tested it in several cases. We found indeed that the higher cut-off frequencies are associated with the lower cap volumes. This is clearly a point that we will add in the paper and we thank you for that. However, quantitatively, the theoretical approach you suggest (based on a first order response and a characteristic time estimated as V/Q) does not work, providing much higher cut off frequencies than observed. Maybe the shape of the rain cap could also affect the frequency response. We didn't investigate this.

Comment : 4.1.1 Pressure drop I don't understand the comment that the measurements agree with theory with 5% accuracy. In figure 3 the "no filter" measurement at 10 LPM seems to be approximately twice the theoretical curve.

Reply : OK, a relative value is not relevant in this case. We'll thus express it in absolute value (0.3 kPa accuracy rather than 5 % accuracy).

Comment : 4.1.2 Cut-off frequency The results given in Figure 4, and the discussion given here, are misleading. The theoretical line agrees with what I would expect at the nominal 15 LPM flow, assuming the effect of the tube attenuation is small. However, the measured values, as I understand it, are based on the 50% point on the (amplitude) transfer functions. In order to compare measurements to theoretical curve (and to be reported as the cutoff frequency) the measured values must be based on the 0.707 amplitude point.

Reply : We agree and recalculate the cut off frequencies. They are now lower. There

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is no more agreement with theoretical curve (but my first theoretical approach was a little bit rough and maybe wrong). This puzzles me.

In your comment you said “The theoretical line agrees with what I would expect at the nominal 15 LPM flow, assuming the effect of the tube attenuation is small.” It could help me to specify on what you based this expectation? The tube effect is small, indeed. In this case, I expect the main attenuation to come to the mixing in the chamber. However, if I consider equation 2 of Moore 1986 and a chamber volume of 16 ml, I would find a cutoff frequency (0.707) at 15 L/Min much lower (2.5 Hz) than observed (5.4 Hz). Do you have another suggestion to compute this cut off frequency?

Comment : In spite of this, the last paragraph, “However: : :” is still valid - the fact that the filters did not affect frequency response is the main point of this paper.

Reply : Yes. Sure. It’s one of the two main points (the other is related to rain cap frequency response).

Comment : 4.2. Field results The results given for the field campaign are also misleading. The cutoff frequency should be based on the 0.707 point, not the 50% point.

Reply : These ones are correct. The transfer function was indeed computed as the ratio of power spectra.

Comment :

Pg 10744 line 22: “: : :destruction of the thermocouples: : :”: Although I have no field experience with this IRGA, the destruction of the thermocouple because of a large pore size filter does not seem intuitively probable. It might be appropriate to either expand on this idea or to omit this comment.

Reply : It’s specific to the enclosed system : in the LI-7200, as the tube length is limited, air temperature is still submitted to high frequency fluctuations in the measurement chamber. As a consequence, WPL corrections are needed but, in order to not overcorrect, they have to be based on temperature fluctuations inside the chamber

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rather than in open air. It is thus necessary to put high frequency thermocouples in the chamber. They are small and fragile and may be rapidly destroyed by dust impacts if the filter pore size is too large. We have to replace them quite frequently. We expand a little bit the comment to make it more clear.

Comment : Pg 10744 line 25..27: the anecdotal comments on experience with various pore sizes seems very helpful. I very much appreciate seeing this kind of information.

Reply : Fine ! Thanks !

Comment : The last paragraph of this section, "Practical considerations: : :" also provides valuable insight. However, the comment that metal filters are more prone to night cooling is not intuitively obvious to me. Presumably the blockage is from condensation caused by radiative cooling at night? This is of course a concern, and heating is a good way to prevent this, but I see no reason why metal filters would be more prone to this than plastic. Perhaps the authors could provide more explanation here.

Reply : Filter blocking result indeed from condensation caused by radiative cooling. We observed that the Swagelock filter was blocked more frequently at night than plastic filters. We attributed this to a more rapid cooling of metal compared to plastic. We changed the sentence in order to clarify.

Comment : 5.2 Rain cup impact

Of the three bullet points, the first one seems to summarize the main work presented in this paper. The second point does relate to pressure drop in the rain caps, which is also mentioned. Perhaps I have overlooked the importance of this issue, and some additional discussion could be added?

Reply : OK the discussion was a little bit expanded at the end of Sect 4.2.

Comment : This might become more obvious by including details of the rain cup designs.

Reply : Done

Comment : The third point is not discussed in the paper, and seems speculative and unnecessary.

Reply : Yes, you're probably right. We removed from the text.

Comment : The cut off frequency (6 Hz) given in the last paragraph is not valid, because it is based on 50% amplitude.

Reply : We confirm the value of 6 Hz as the cut off frequency was based on power spectra. However, this is quite noisy and uncertain because it is based on a limited number of spectra. It is anyway larger than 5 Hz.

Comment : The last paragraph also introduces several concepts that have not been discussed in this paper: cospectral cutoff frequencies, spatial separation, and defensible flux estimates. Perhaps this paragraph could be edited to apply more directly to the topics covered in this paper.

Reply : As the paper is aimed at field searcher in eddy covariance, we think that it is necessary to recall these points. My feeling is that reaching a cut off frequency of 10 Hz is practically impossible and most of the time not necessary. I tried to edit in order to less refer to concepts not discussed in the paper

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Interactive comment on Atmos. Meas. Tech. Discuss., 8, 10735, 2015.