Dear Editor and reviewers',

We thank you very much for your thoughtful and constructive comments on our manuscript entitled 'An innovative eddy-covariance system with vortex intake for measuring carbon dioxide and water fluxes of ecosystems'. We have revised the manuscript according to the comments. The responses to each reviewer's comments are appended below.

We are looking forward to a possible publication of this manuscript in Atmospheric Measurement Techniques.

Yours sincerely,

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Itemized responses to each reviewer's comments

Reviewer 1's Comments

Specific Comments:

1. In view of its principle, the system should be more efficient for heavier dust particles. This paper shows that it works successfully in very polluted areas but it could be interesting to evaluate its performances in forest or grasslands ecosystems where dust is characterized by smaller particles.

Figure 4 suggests that the vortex system does not affect the system frequency response. However it has been tested in conditions that are not very challenging (as noted by the authours, the cospectra are already strongly attenuated above 0.1 Hz) and it could be interesting to test the system frequency response in conditions of higher frequency turbulence. This two remarks could be added in the conclusion section and suggested as further research perspectives.

Re: We have added the two remarks as the reviewer suggested in the conclusion section and suggested as further research (see line 337-346).

Miscellaneous:

1. L25, L49: The application field of the system is larger than announced by the authours as it may concern all trace gas analysers (not only H_2O and CO_2) and also enclosed paths systems.

Re: We revised as the reviewer suggested (see line 25-26, 53, 93-98, 124-126).

2. L192 (and below): the reference is in fact Aubinet et al (2000)

Re: We revised as the reviewer suggested (see line 217, 223, 382).

3. In reference list: check the order of the references (a.o. Burba is misplaced)

Re: We revised as the reviewer suggested.

Reviewer 2's Comments

General Comments:

1. In the conclusions the authors state, "There was no signficant attenuation of high frequencies, compared to the in-line filter-based system." I have the following comments related to this statement:

- a much more robust field comparison would be to have both a vortex and standard inlet systems setup side-by-side and operated over a long time period. In that way, a true comparison between instrument can be performed and the relative frequency respone between sensors can be presented.

Re: We agree with this comment, and have added this suggestion for future work (Lines 337-346).

- This statment in the conclusions apparently comes from Fig. 4...there are several questions about this figure (listed below), but from what I understand these normalized cospectra are from mid-day...if you want to convince me that the two different inlet types agree, you need to show that they agree during more than just mid-day conditions—-some comparison over a range of stability conditions should be shown.

Re: We have re-plotted figure 4 and presented data from both winter and summer, day and night (Lines 526). We acknowledge this limitation of our cospectral analysis, and suggest future experiments should address performance under conditions with higher frequency turbulence (Lines 337-346).

2. It is stated that the frequency response of sonic temperature produces an "ideal" response (p. 11). The results in Fig. 4 appear to suggest that the CO_2 and H_2O response are both exactly the same as that of temperature. One needs to keep in mind that this result is only for mid-day conditions and does not necessarily extend to other conditions (the discussion on p. 11-12 does not mention this important fact at all). I also don't see a "sharp attenuation when the frequencies > 0.1 Hz" for WC and WH...it looks to me that the WC, WH, and WT cospectra all follow each other very closely? Finally, why does the vortex inlet "warrant automating high-frequency spectral corrections"? Because of the comparison with WTs?

Re: First, we have re-plotted figure 4 and presented data from both winter and summer. Second, we have deleted the inappropriate expression about frequency response when the frequencies > 0.1 Hz. Third, our statement "warrant automating…" was confusing and has been deleted.

3. The vortex inlet appears to have a sharply angled side walls...was this element to the design given much consideration? There has been much research in the particle sampling community that might be relevant here. I give one example reference, but I'm sure there are many...

Re: The sharp angle at the bottom of the rain cap is intended as a drip edge to help reduce water droplets hanging on the edge. The effect of this shape on the motion of particles in the air stream was not considered specifically. Although the goal of the present work is to design an intake to reject particles rather than retain them, the physics are the same, and we thank the referee for providing this interesting reference.

4. The fluid mechanics in the inlet look like they might be quite complicated.. Has any wind tunnel or CFD modeling of the inlet been made? How does it perform in high winds?

Re: Coauthor Burgon has performed CFD modelling of air flow and particle trajectories within the vortex chamber. Although this is beyond the scope of the present paper, a few examples generated from the CFD model are included in a poster that presented a preliminary summary of the work presented in this paper:

Burgon, R., Sargent, S., Zha, T., and Jia, X., Field-Performance Verification of Carbon Dioxide, Water, and Nitrous Oxide Closed-Path Eddy Covariance Systems with Vortex Intakes, AGU Fall Meeting Poster B33C-0669, 2015.

We have not specifically evaluated the performance in high winds.

Specific Comments:

1. * p.3, l.47, "extent" should be "extend"...

Re: We revised as the reviewer suggested (see line 51).

2. * p.4, l.85, isn't the system not working properly in the examples already given? (ie, what do you mean by extreme cases?)

Re: Yes, this statement is redundant and has been deleted.

3. * p.5, l.108, how often is "frequently"? every week? every month?

Re: We have added "weekly or even daily" to clarify (see line 114).

4. * p.6, l.113, "The vortex intake..."

Re: We revised as the reviewer suggested (see line 120).

5. * p.8, l.157, "vortex inlet", not "vortex design"

Re: We revised as the reviewer suggested (see line 170).

6. * p.8, l170-172 and Fig. 2. it would be nice to add arrows and label some of the components shown in Fig. 2 that are discussed within the text.

Re: We revised as the reviewer suggested (see line 519).

7. * p.9, l.180, details about the "large filter"?

Re: We revised as the reviewer suggested (see line 194-195).

8. * p.9, l.190, mounted on the tower at a height of 11.7 m. (similar fix to wording for the Badaling site).

Re: We revised as the reviewer suggested (see line 213-214).

9. * p.9, l.192, this statement is rather vaugue (or, is there a better reference with more specific details about these EC data?).

Re: We have added more specific details about EC data (see line 215-219).

10. * p.10. l.207, what do you mean by "very well"? Can this result be quantified?

Re: We have quantified the frequency response in laboratory test and moved this text into the instrument description (see line 199-204).

11. * p.17, "Mchale" should be "McHale" (similar for McPherson).

Re: We revised as the reviewer suggested (see line 89, 431).

12. * p.25, Fig.4, these are normalized cospectra so please state that in the legend.

Re: We revised as the reviewer suggested (see line 526).

13. * p.26, Fig. 5, what happened to the vortex inlet that is shown in Fig 5b. It is clearly much better than the inline filter, but it also appears to have some problem. Was a specific component of the vortex system getting plugged up?

Re: The vortex intake does have a filter in the bypass path, to protect the orifice that controls the bypass flow. The filter used is relatively large, so it clogged more slowly than the original inline filter, but it clogged at the Olympic Park site and was replaced on average every 46 days (Table 1). Because this filter is not in the sample path, it's size does not affect the system frequency response. A follow-up experiment is planned in which this filter will be replaced with a much larger one to try to extend the maintenance interval further (see line 327-331).

14. * p.27, Fig. 6, any idea about the cause of the small "wiggles" in the differential pressure time series for the vortex inlet (I don't see any such wiggles with the inline filter)?

Re: The small oscillations in differential pressure have a diel cycle, and thus correlate with ambient temperature, but the physical cause has not been studied. This oscillation is commonly observed with the inline filter, although it is not apparent in the time periods shown in Fig 6 (line 555).

15. * in both Figs 5 and 6 the filters are clearly getting quite dirty–but the optical signal strength (red line) for the inline filters is practically unchanged (even in the very dirty environments) ...is there any explanation for this seemingly surprising result? Also, is there any reason why the optical signal strength for the inline filters shown all start so low (near 80%) while those for the vortex intakes are all close to 100%?

Re: A clogged filter will continue to remove particles from the air stream, and it reduces the air flow, which further slows the rate of window contamination. The windows were cleaned based on optical signal strength (line 253-255), not every time the filter was replaced.

Reviewer 3's comments

Major comments:

1. Please present the CO_2 flux – both its calculation method and its values – in Figs 5-6 so we can see what range of flux conditions this method has been tested. This calculation/ presentation is important to give context for Fig 4 as well and should present the separation distance from the sonic anemometer in each set-up from the closed-path inlet. The type of logger used and method of logging (e.g., voltage signals, SDM) should also be presented as this may affect high frequency attenuation.

Re: We have presented the CO_2 flux - both its calculation method and its values – in Figs 5-6 and given context for Fig 4. At the same time, we presented the separation distance from the sonic anemometer in each set-up from the closed-path inlet and the type of logger used, method of logging (see line 208-209, 213-219, 527-536, 548, 555).

2. Is the pattern shown in Fig 4 consistent for other months of the test periods? Particularly since the manuscript shows how variable the air quality conditions are (Fig 1, 5, 6), it will be useful to have cospectra presented from different months and periods of time. A maximum signal attenuation should then be presented.

Re: Yes, the pattern shown in Fig 4 was consistent for other months of the test periods. In order to further illustrate this, we have presented data for the month of January (high incidence of haze), June (low incidence of haze), 2014, for the in-line filter-based EC measurements, and January (high incidence of haze), June (low incidence of haze), 2015, for the vortex intake-based measurements (see line 239-243, 526).

Minor comments:

1. Line 93: consider adding references to other landscapes that may benefit from such a system – e.g., measurements during or near fire/burn events (forests, croplands, or prairies), measurements at remote sites with infrequent access where filter changing should be minimized, etc.

Re: We have added references to other landscapes (see line 93-98).

2. Line 207 – quantify how well this system performs, rather than the "Very well" given here.

Re: We have quantified the frequency response in laboratory test (see line 199-204).

3. Figs 5-6 – is it possible or relevant to add a timeline of the haze index presented in Fig 1 to these graphs? Could we then relate the haziness to the filter replacement time? And/or we could normalize the performance under similar conditions? Rather than a time series a specific quantified range could replace "periods of very hazy conditions" and "periods of low haze" in the figure caption.

Re: We agree with this concern, but unfortunately, we don't have the relevant data about haze index. In this paper, in order to illustrate the seasonal nature of Beijing's air quality, we collected one year (2015) of data about haze index through the daily weather forecast. To minimize the concern that one year may be better or worse than another, we selected a long time to verify performance of the vortex intake, including the periods of high and low incidence of haze, and have shown time series of three months for each case. We have added a suggestion that future work should include side-by-side comparisons (line 341-346).

Technical/editing suggestions:

1. Line 125: convert from "study site is" to "study sites are"

Re: We revised as the reviewer suggested (see line 137).

2. Line 137: consider whether "restoration" is a better word than "recovering"

Re: We revised as the reviewer suggested (see line 149).

3. Line 212 etc – I would tend to use a subscript for the "s" in "Ts"

Re: We revised as the reviewer suggested (see line 235-236, 262 etc).

4. Line 220 change the position of the apostrophe from the plural "s"' to the singular "'s" to follow "each"

Re: We revised as the reviewer suggested (see line 244).

5. Line 246 – probably “in” or “with” are better choices than “when the” for the size of frequencies

Re: We revised as the reviewer suggested.