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Interactive comment on "Gap-filling strategies for annual VOC flux data sets" *by* I. Bamberger et al.

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We thank Referee #1 for his/her helpful comments on how to improve our manuscript: 'Gap-filling strategies for annual VOC flux data sets'

Bamberger et al. present a comparison of four gap-filling methods designed for compiling continuous and year-round VOC flux data sets. One of their main findings is that gap-filling based on 30-minute flux values (the mean diurnal variation method) yielded lower errors for all studied VOCs than gap-filling based on daily averages. However, all methods produced rather similar cumulative carbon fluxes for the different VOCs in 2009 and 2011. The gap-filling errors were pronounced during the winter periods and the management events at the grassland site. Regardless of the gap-filling method, the root mean square error increased almost linearly when the amount of data gaps was artificially increased.

The paper is well suited to Biogeosciences. It provides new and useful information which can facilitate gap-filling of long-term VOC flux measurements at other sites in order to produce year-round time series. The methods are state-of-the-art and the analysis seems adequate. I recommend publication in Biogeosciences after the authors have addressed the few minor comments below.

Reply: We thank Referee #1 for his/her positive assessment of the paper

Specific comments

Comment 1: P17792, L3: Did the authors use other time windows than ±8 days to evaluate how much the window affects the gap-filling results?

Reply: The time window used in this publication was chosen as a compromise between as short as possible in order to capture short-term dynamics and as long as necessary in order to rely on a robust data basis. However, we also tested other time windows (16 days, 30 days) and came to the result that in general the annual error does not depend on the size of the time window. We added this information to the section 'Gap filling procedures': 'We also tested time windows of different sizes (e.g., +-16 days and +- 30 days) but the effect of the window size on annual cumulative fluxes and the associated gap-filling errors was, with the exception of monoterpenes, negligible.'

Most probably this behavior is due to the fact that the true flux is sometimes overestimated and sometimes underestimated by the application of bigger time windows. Over the course of a complete year, however, the variation levels out.

Comment 2: P17803, L3: The hailstorm on 16 July 2009 had a substantial effect on the monoterpene fluxes (Fig. 1) and consequently on the total cumulative carbon flux (Fig. 4). Could the authors estimate how the total cumulative carbon flux would chance if there had been a long gap (say few days to a week) right after the hailstorm? In general, how long gaps can be filled with the different methods?

Reply: Monoterpene deposition fluxes in such substantial amounts were observed only

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once within four years (2008-2009, 2011-2012) of VOC measurements at this site and are a truly exceptional (extreme) event. A longer data-gap of 14 days directly after the hailstorm would underestimate annual monoterpene deposition fluxes by up to 161 mg C m-2 if it would be filled with close-to-zero fluxes from before the hail storm instead. The maximum errors in Table 1 give a good approximation of the magnitude of the error introduced by gap-filling the worst case distribution of the amount of gaps encountered in the original data series. We exemplified this in the paragraph 'Errors due to gap-filling': 'The maximum errors represent the worst case of the concentration of data gaps around the date of the hailstorm and are, with errors of 83 mg C m-2 and 105 mg C m-2 lowest for the MDV and MGW methods. In contrast, the gap-filling by linear interpolation introduced errors up to 253 mg C m-2. However, events which cause comparable flux patterns and gap-filling errors to those seen for the monoterpene deposition in 2009 are certainly an exceptional case.'

There is no general restriction on the length of data gaps which can be filled. Regarding the window methods, the window size would have to be adjusted with longer data gaps. In case of the LUT methods the look up table can be adjusted according to the size of the temperature, PAR, GAI and precipitation classes and the linear interpolation would work anyway. The error introduced by the filling of a large number of data gaps is described in Figure 3 and discussed in the text.

Comment 3: P17805, L16: The authors suggest that more effort should be invested in year-round flux measurements (including the winter period) to get a better understanding of annual VOC exchange. This is a good idea. However, based on Fig. 4 it seems that the winter periods had a minor contribution to the total cumulative carbon flux, and one could easily overleap those periods without introducing remarkable errors. Do the authors assume that this contribution could be much higher during other years or at other sites?

Reply: Although the fluxes estimated for the winter period had a minor contribution to the overall cumulative flux of VOCs, Table 2 (old) reflects that the errors associated with

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this estimates are considerably higher compared to the errors of gap-filling during the measurement season (compare the rows 'error mean cum. flux'). This is a result of the high variability in the measured fluxes during days with snow cover. Thus, only winter measurements provide a way to judge reliably if wintertime fluxes are really negligible or if there are time periods in winter which show significant VOC fluxes.

Technical corrections Comment 1: P17799, L21: It seems that Table 3 is mentioned before Table 2. Please consider switching the order of Tables 2 and 3.

Reply: As suggested by Referee #1 and Referee #2 the order of Table 2 and 3 was switched.

Comment 2: Table 2, year 2011: "error mean cum. flux" or "std cum. flux"

Reply: We decided to use the term 'error mean cum. flux' as it is an error estimate based on the standard deviation of the measured wintertime fluxes.

Comment 3: Fig. 1: Please mention in the caption whether the asterisks and circles in the left and middle column present daily averages, medians or something else.

Reply: The symbols in Figure 1 represent daily averages. The caption was changed to: 'Time series of daily averages of photosynthetically active radiation (PAR), air temperature (Tair), the green area index (GAI) and VOC fluxes for the year 2009 (left column) and 2011 (center column) and average diurnal cycles for the same compounds and a selected time period in summer 2009 and 2011 (right column). The winter period (cyan), data gaps (red) and data cover (yellow) for the different VOCs are earmarked as horizontal bars at the bottom of each time series.'

Comment 4: Fig. 1, the y-axis label of the lowest panels: "C12H16" or "C10H16"

Reply: 'C10H16' is the right terminology and the typo was changed accordingly in a new version of Figure 1.

Interactive comment on Biogeosciences Discuss., 10, 17785, 2013.