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Author responses to comments of referee #2

We would like to thank the referee for the effort and time he/she put in to review our manuscript. We are grateful for his/her careful and considered comments and will make every attempt to fully address these comments in the revised manuscript.
In the following list, the points raised by the referee are written in **bold** characters, whereas our responses are shown in blue characters.

The manuscript "The Applicability and consequences of the integration of alternative models for CO2 transfer velocity into a process-based lake model" of Petri Kiuru, Anne Ojala, Ivan Mammarella, Jouni Heiskanen, Kukka-Maaria Erkkilä, Heli Miettinen, Timo Vesala, and Timo Huttula is a interessting scientifc report about the performance of different gas exchange models for simulations of CO2 fluxes between lakes and atmosphere. The article represents the high scientific expertise of the finish research community. No doubt, the authors did a grandiose job. In my understanding, the article can be accepted after two minor improvements.

(1) The authors wrote on page 7, line 4 that the lake has a maximum width of only 0.3km. This raises the question whether the footprint of the EC measurements is really representative for the lake-atmosphere exchange. How did the authors approximate the width of the parabolic footprint? And how did the authors consider transversal advection, i.e., advection orthogonally to the mean flow (wind) direction?
The estimation of the flux footprint distribution functions was made using the model by Kormann and Meixner (2001). The average footprint contributing to 80 % of the flux ranges from 100 m up to about 300 m from the measurement platform depending on atmospheric stability conditions as described in Mammarella et al. (2015). However, the simple footprint model may have overestimated the footprint because it does not take into account the additional turbulence generated by the surrounding forest. Neverthless, it is justified to assume that the source area of the measured fluxes was on the lake surface because only the measurements during the periods when the wind was blowing along the lake were used in the analysis.
The wind is channeled along the lake for most of the time. When the wind is blowing along the lake, the footprints are within the lake fetch. Transversal wind directions were filtered out in the data used in the study. Typically, 15 % of the flux data are excluded from the analysis, when the wind is not blowing along the lake (the excluded wind directions are 350°–130° and 180°–320°). However, in calm nights some air can be transversally advected even if the wind is along the lake. In principle, the standard quality checking (described in detail in Mammarella et al. (2015)) removes the data contaminated by advection. Although the advection may still affect the concentrations and temperatures, the covariances with wind, that is, the eddy fluxes, are somewhat immune to advective effects.
We will add discussion on the foregoing issues in section 2.2.3.
"The estimation of the flux footprint distribution functions was made using the model by Kormann and Meixner (2001). The average footprint contributing to 80 % of the fluxes varies from 100 m up to about 300 m from the measurement platform depending on atmospheric stability conditions as described in Mammarella et al. (2015). Only wind directions along the lake (130°–180°and 320°–350°) were included to ensure that heat fluxes from the surrounding land were excluded. Furthermore, possible remaining effects of transversal advection during calm nights were removed through EC quality screening."

(2) The authors discuss in section "4.2 Comparison to CO2 flux measurement" potential reasons for discrepancies between EC flux measurements and simulations results. Especially, they mentioned measurement errors and the spatial variability of governing parameters as major reasons. In my understanding, the authors are completely right with this statement. However, I would like to encourage the authors to provide quantitative support for this statement through a short error analysis.

Estimates of the random uncertainty of EC fluxes on Lake Kuivajärvi for the years 2010 and 2011 have been studied in detail in Mammarella et al. (2015). On average, the estimated total relative random error was around 10 % for both sensible and latent heat fluxes. The estimated relative CO_2 flux random error was approximately double as large as that of energy fluxes, 20 % of measured fluxes, which is a typical value for EC CO_2 flux reported also in other types of ecosystems.

We will include some quantitative error analysis, related to both the underestimation of surface heat fluxes and the random measurement error, in the text:

"[. . .] The differences may be in part attributed to an underestimation of surface heat fluxes by the EC method, which was seen, for example, in a study on energy balance over a small boreal lake by Nordbo et al. (2011) and also in Mammarella et al. (2015). The sum of the measured EC heat fluxes in Lake Kuivajärvi was on average 83 % and 79 % of available energy in 2010 and 2011, respectively, in Mammarella et al. (2015). In addition, the total relative random error of the EC measurements is generally around 10 % for both sensible heat flux and latent heat flux as estimated in Mammarella et al. (2015). [. . .]"

References

Kormann, R. and Meixner, F. X. (2001), An analytical footprint model for non-neutral stratification, Bound.-Lay. Meteorol., 99, 2, 207–224, doi:10.1023/A:1018991015119.

Mammarella, I., et al. (2015), Carbon dioxide and energy fluxes over a small boreal lake in Southern Finland, J. Geophys. Res.-Biogeosci., 120, 1296–1314, doi:10.1002/2014JG002873.