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Geoscientific Model Development Discussions
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Interactive comment on "A coupled two-dimensional hydrodynamic and terrestrial input model to simulate CO_2 diffusive emissions from lake systems" *by* H. Wu et al.

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Responses to Reviewer's Comments

We appreciate your constructive comments and suggestions on the previous version of the manuscript. We have attempted to address every point raised. The following is the outline of the changes we have made.

Referee #2

1. The Reviewer commented "It is not clear why the authors call this a new model, Triplex-Aquatic (see Fig 1), since they are using CE-QUAL-W2 model but with a differ-

ent CO2 gas transfer function. I am not sure this constitutes a 'new' model.".

RE: We understand your concern. For the new model name of the TRIPLEX-Aquatic, it was the originally idea of our previous research project proposal and ongoing effort on coupling terrestrial ecosystems (e.g., forest soils) with aquatic ecosystems (e.g ., lakes) via linking a forest DOC model (TRIPLEX-DOC) with a lake model (CE-QUAL-W2). The name of TRIPLEX-Aquatic is just for the convenience of ongoing model framework development and our long-term model development goal and strategy. It was our hope that the TRIPLEX-Aquatic will be modeling framework (not a single model) which is able to incorporate terrestrial inputs into an aquatic carbon cycle model through coupling both forest model of TRIPLEX and DOC model (TRIPLEX-DOC) with a lake model (CE-QUAL-W2) to investigate lake carbon cycles with a particular emphasis on greenhouse gags (CO2 and CH4) emissions. This is just the first step toward a more comprehensive model framework by incorporating more processes with new submodels like CO2 flux. In next step, the processes of CH4 flux and sedimentation will be included. In the revised MS, we fully cited and credited the CE-QUAL-W2 model in both figures and the text as much as we can and clarify what is the "new" in this paper.

2. The Reviewer commented "No discussion of where the meteorological data were measured."

RE: We appreciated your good point! Hourly meteorological data, such as air average temperature, dew point temperature, wind speed and direction as well as cloud cover were obtained from weather monitoring station of Maniwaki Airport, Québec. The distances between Maniwaki Airport and the lakes are 17 km for the Lake Mary, and 29 km for the Lake Jean, respectively. Although the meteorological data of Maniwaki Airport for lake simulation may be less accurate because it is not the local weather station, the weather station of Maniwaki Airport is the closest station to the lakes (on page 11 lines 229-233 in revised manuscript(supplement file:gmd-2013-62-supplement.pdf)).

3. The Reviewer commented "This seems critical since CO2 flux from the surface is

an important function of wind speed and the temperature error statistics were unacceptably high (RMSE > 1.0oC). The choice of the wind speed function for the CO_2 gas transfer is especially critical. There was no discussion as to how wind data may or may not have affected model results or choice of a wind model for surface turbulence."

RE: For the water temperature, the kinetic coefficients were reset from an equilibrium temperature approach to the term-by-term formulation that was used to characterize the surface heat exchange (on page 8 lines 163-164 in revised manuscript), so that the model output agreed with the field data at the acceptable level (RMSE < 1°C). The verification of surface layer water temperature RMSE was 0.90°C during all simulation periods in both lakes (on page 15 lines 303-304 in revised manuscript), and the validation of the vertical water temperature RMSE was 0.28°C during fall turnover, and 0.96°C during spring stratification in Lake Mary (on page 15 lines 309-312 in revised manuscript). For the wind speed function, we have replaced the previous equation of K600 (Cole and Caraco, 1998) that focused on wind speed alone, with more recent equation (Vachon and Prairie, 2013) suggested by referee #1 (Vachon and Prairie, 2013) that provided a more complete predictive model of gas transfer velocities in lakes based on lake area (LA) together with wind speeds, because the system size acts as the main modulator of the effect of wind speed on gas exchange (on page 10 lines 199-208 in revised manuscript).

4. The Reviewer commented "Need to justify including Appendix A in this paper since this material can just be referenced from the CE-QUAL-W2 User Manual where it is presented."

RE: We thanks for your constructive comments. Following this suggestion, we have deleted the Appendix A, and added "The hydrodynamic and carbon dynamics have been well documented and are described in detail in the CE-QUAL-W2 (Cole and Wells, 2006). The scope of this study was only to describe CO_2 diffusion across the air/water interface and the newly re-designed TRIPLEX-Aquatic." (on page 9 lines 184-187 in revised manuscript).

5. The Reviewer commented "Sediment dynamics are an important contribution to inorganic C in lakes and reservoirs. There was no discussion of the role of sediment evolution of CO_2 and important sediment dynamics. The authors in Table 1 show a SOD rate of 1 g/m2/d but do not quantify its importance/sensitivity. The paper needs to see the impact of sediment CO_2 gas production relative to inflows and gas transfer."

RE: Thanks for the excellent point and suggestions! Following reviewer's suggestion, we have added more discussions as followings: "Sediment respiration is also an important source of CO_2 in lake system (Algesten et al., 2005; Kortelainen et al., 2006; Brothers et al., 2012). To investigate the potential effects of sediment dynamics on the CO_2 emission from the lake, we performed a sensitivity experiment with sediment oxygen demand levels ranging from 1 to 0 g m^{-2} d^{-1} in Lake Mary and Lake Jean. The mean contribution of benthic metabolism to surface CO_2 diffusive emission was approximately 23% to 47%. This result is in good agreement with the observed studies (Jonsson et al., 2001; Brothers et al., 2012) that revealed the benthic respiration in boreal lakes representing approximately 23% to 50% of the total carbon production." for the impacts of sediment dynamics on the lake CO_2 diffusive emission (on page 24 lines 495-503 in revised manuscript).

6. The Reviewer commented "The choice of a CO_2 gas transfer coefficient needs to be justified compared to the existing or other models of surface film transfer."

RE: In revised MS, we have replaced the previous function of K600 (Cole and Caraco, 1998) with recently equation (Vachon and Prairie, 2013) that provided a more complete predictive model of gas transfer velocities in lakes based on lake area (LA) together with wind speeds. We added "Because this simulation in CE-QUAL-W2 model was simply designed the gas transfer coefficient for CO_2 is related to that of oxygen transfer using a factor of 0.923 (Cole and Wells, 2006), and most of these CO_2 transfer velocities are lower (Fig. 2) than the measurements that collected from aquatic systems of different size lakes (Vachon and Prairie, 2013), whereas some of velocities (e.g., Eq-1, Eq-5, Eq-8, Eq-13) are much higher than the observations under high wind speed. As a result, these transfer velocities make it impossible to reliably simulate CO2 diffusive fluxes from lakes." (on pages 6-7 lines 128-137 in revised manuscript)

7. The Reviewer specific comments:

- We have changed "The first model, hydrological processes start by representing hydrodynamic conditions." to "The first model, hydrological submodel simulates the hydrodynamic conditions in lake." for clear expression (on page 6 lines 112-113 in revised manuscript).

- We have replaced "...since hydrology controls physical mixing processes between spatial components" with "...since hydrology controls physical mixing processes between different spatial components of lake" (on page 6 lines 113-114 in revised manuscript).

- Yes, we have changed "An equilibrium temperature approach was used to characterize the surface heat exchange" to "The term-by-term formulation was used to characterize the surface heat exchange" (on page 8 lines 163-164 in revised manuscript).

- Good suggestion! Following reviewer's suggestion, we have added the comparison (see new Fig. 2): "The third model, the simulation of CO2 diffusive fluxes at the air/water interface uses a new boundary layer model developed by Vachon and Prairie (2013) for the CO2 diffusive flux in temperate lakes. Because this simulation in CE-QUAL-W2 model was simply designed the gas transfer coefficient for CO2 is related to that of oxygen transfer using a factor of 0.923 (Cole and Wells, 2006), and most of these CO2 transfer velocities are lower (Fig. 2) than the measurements that collected from aquatic systems of different size lakes (Vachon and Prairie, 2013: Eq-14), whereas some of velocities (e.g., Eq-1, Eq-5, Eq-8, Eq-13) are much higher than the observations under high wind speed. As a result, these transfer velocities make it impossible to reliably simulate CO2 diffusive fluxes from lakes." between the CO2 gas exchange model and the existing CE-QUAL-W2 formulation. (on pages 6-7 lines 128-137 as well as new Fig. 2 in revised manuscript).

- Following reviewer's comments, the kinetic coefficients have been examined and reset from an equilibrium temperature approach to the term-by-term formulation that was used to characterize the surface heat exchange (on page 8 lines 163-164 in revised manuscript), so that the model output agreed with the field data at acceptable level (RMSE < 1°C). The verification of surface layer water temperature RMSE was 0.90°C during all simulation periods in both lakes (on page 15 lines 303-304 in revised manuscript), and the validation of the vertical water temperature RMSE was 0.28°C during fall turnover, and 0.96°C during spring stratification in Lake Mary (on page 15 lines 309-312 in revised manuscript).

- For the model calibration and model validation, the calibration was carried out by tuning appropriate model parameters to match the predicted and measured data from Lake Mary in 2007 to obtain the best possible fit within acceptable ranges specified by Cole and Wells (2006) (Table 1). The model was verified against more data measured at Lake Mary in 2006 during which it was subjected to different ambient weather and flow conditions from those prevailing during model calibration in 2007, in order to test if the model was capable of accurately simulating the hydrodynamic regime and aquatic carbon dynamics under climatic conditions differing from those used for calibration. The model was also validated against measurements taken in Lake Jean from 2006 to 2007. Although the validation data may be not the statistically independent data sets, they are the available data that we have.

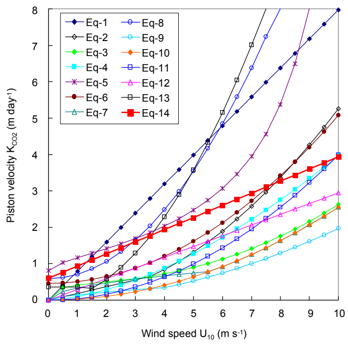
- We have changed "provide reasonable simulations of hydrodynamic and carbon processes" to "provide the potential to predict the hydrodynamic and carbon processes" (on page 25 lines 512-514 in revised manuscript).

- As suggested, we have added the reference of CE-QUAL-W2 in the figure 3 (on page 41 lines 877-878 in revised manuscript).

Please also note the supplement to this comment:
http://www.geosci-model-dev-discuss.net/6/C1889/2013/gmdd-6-C1889-2013-

supplement.pdf

Interactive comment on Geosci. Model Dev. Discuss., 6, 3509, 2013.



Wu et al., Fig.2

Fig. 1. Fig.2