Geosci. Model Dev. Discuss., 6, C1883–C1888, 2013
www.geosci-model-dev-discuss.net/6/C1883/2013/

Geoscientific Model Development Discussions
Open Access

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.

H. Wu et al.

haibin-wu@mail.igcas.ac.cn

Received and published: 4 November 2013

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 #1

1. The Reviewer commented "The CO2 model is a useful addition, but relatively outdated given recent work on the importance of convectively driven gas exchange".

RE: Thank you very much for your excellent point and suggested recent publications! Because this project was conducting during 2009-2011. At that time, the two papers (Read et al., 2012; Vachon and Prairie, 2013) you suggested have not been published and available yet. That is the main reason that we used old equations for CO2 model. Following Reviewer's suggestion, we have replaced the previous equation of K600 (Cole and Caraco,1998) that focused on wind speed alone, with recently equation (Vachon and Prairie, 2013) that provided a more complete predicative model of gas transfer velocities in lakes based on lake area (LA) together with wind speeds (on page 10 lines 201-208 in revised manuscript(supplement file: wu_text.pdf)). We have re-run all model simulations and got new results.

2. The Reviewer commented "It seems watershed loading of inorganic carbon was not considered. This can be an important component of the carbon budget for a lake, and makes the inference about terrestrial DOM support of lake CO2 efflux questionable".

RE: Thank you for your valuable comments! We totally agree with you. We had considered the inorganic carbon (DIC) from watershed as one of the input parameters of model because it is an important component of the carbon budget for the lake in our manuscript (also on page 12 line 240 in revised manuscript).

3. The Reviewer commented "The number of samples available to calibrate this model seems untenable. It is difficult to constrain parameter values of a model of this complexity with large amounts of data (e.g. sensor network data)..."

RE: Yes, we do appreciate the reviewer's good point and understand the limitation and the uncertainty of the limited number of samples used for the calibration of the model and constrain model parameters in this study. For testing the model, we conducted four times for field campaigns in the two lakes from 2006 to 2007 because of the remote region, during periods following ice breakup in May 2006 (16 sampling time points in 6 days) and 2007 (15 sampling time points in 2 days), summer stratification in July 2006 (10 sampling time points in 2 days) and when fall overturn occurred in October 2006

(14 sampling time points in 3 days) for the center of Lake Mary, and during periods in July2006 (27 sampling time points in 2 days), October 2006 (1 sampling time point in 1 day), May 2007 (14 sampling time points in 1 day), July2007 (20 sampling time points in 2 days) for the center of Lake Jean. Although we realized that the number of samples is obviously limited, we had tried our best to use these limited field observations for model calibration and validation. This was just the first step toward to validate the simulation of CO2 diffusive flux in boreal lakes. In next step, the more validations of the model with more measured data from different lakes across different regions will be conducted and reported separately as soon as the results are available. We have added more discussions about this point in revised MS (on page 25, line 515-519)

4. The Reviewer detail comments:

- 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 (such as 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.

- Following the Reviewer’s suggestions, we have replaced the previous CO2 flux model (Cole and Caraco, 1998) with recently CO2 flux model (Vachon and Prairie, 2013)

based on a more complete predictive model of gas transfer velocities in lakes using wind speed together with lake area (on page 10 lines 201-208 in revised manuscript).

- Although the model simulation for the lakes has differences in cell dimension (e.g. 50 m in length for the longitudinal segments in Lake Mary and 160 m in Lake Jean), these schemes have detailed resolution to compute water velocities that affect the spatiotemporal distribution of temperature and biological/chemical constituents. Therefore, the differences in cell dimension may not significantly impact overall dynamics and numerical results.

- The distances between Maniwaki Airport and the lakes are 17 km for the Lake Mary, and 29 km for the Lake Jean. Although the meteorological data of Maniwaki Airport for lake simulation may be less accurate because it is not the localized weather station, the weather station of Maniwaki Airport is the closest station to the lakes. We added these information in revised MS (on page 11 lines 229-233).

- Yes, as suggested, we added more information about TRIPLEX-DOC model (Wu et al., 2013) that is capable of estimating DOC and hydrologic dynamics in forest soils by incorporating both ecological drivers and biogeochemical processes in the age-sequence of temperate forests (on page 11 lines 235-237 in revised manuscript).

- The hydrological submodel in the TRIPLEX-DOC (Wu et al., 2013) takes into account water input (e.g., precipitation, surface inflow, snow and ice melt), output (evaporation and transpiration), runoff, and water transfer within the unsaturated zone (infiltration, gravity drainage, and matrix redistribution). The model can simulate soil water flux of runoff and leaching to river and groundwater in the lake hydrologic budget.

- We have deleted the “one species of blue-green algae”, because the inflow of algae was inputed in zero (on page 12 line 241 in revised manuscript).

- Yes, the kinetic coefficients are the parameters for production and consumption of carbon constituents in Table 1 (on page 43 in revised manuscript).

- The 16 sampling in 6 days indicated the 16 sampling time in the centre point of Lake Mary and Lake Jean (on page 12 lines 254-262 in revised manuscript).

- We agree. Following reviewer's comments, we have deleted "In general, these results suggest that the model reasonably represented surface and vertical variations of water temperature, pH, DO, pCO2 and hydrodynamics of the lake system." (on page 16 line 334 in revised manuscript).

- Because the DOC values in different sampling times during daily period have significant variation, while the simulated values were relative stable. Although the simulated values were not accurate, the values reasonably distributed in the middle of the daily observational period (on page 16 lines 341-344 in revised manuscript).

- Although no measurements of pCO2 or flux were made near ice off in Lake Mary and Lake Jean, the hydrodynamic simulation is able to characterize time variable longitudinal/vertical distributions of thermal energy in water bodies, then the model could be well-calibrated to capture the ice cover during the winter period and no CO2 flux from water. At the end of the winter season, the model simulated successfully the principal characteristics of a high CO2 flux episode just after ice melt over a period of approximately ten days (Fig. 7a, b). During this period the model estimated that approximately 80% of the CO2 contained in the water column of Lake Mary and Lake Jean was emitted into the atmosphere (on page 18 lines 373-377 in revised manuscript).

- In this paragraph, we wanted to evaluate the impact of terrestrial DOC on lacustrine CO2 diffusive emissions, based on a comparison between no-DOC/DOC inputs and CO2 fluxes was performed while keeping other variable inputs at normal values. If there is no input of terrestrial DOM to the lake, terrestrial DIC and sediment respiration will support for the net heterotrophy of the lake because of DIC loading and sediment dynamics also as the primary drivers.

- Because Section A2- the carbon cycle submodel was focused on the description of the carbon cycle in the lake, however, the inputs and outputs of DOM and DIC were

included explicitly in the model by added the DOM/DIC to the organic/inorganic pools in the lake, which follows the approach of the CE-QUAL-W2 model (Cole and Wells, 2006).

- Yes, following reviewer's comments, we have added the recent papers in the revised text.

Please also note the supplement to this comment:
http://www.geosci-model-dev-discuss.net/6/C1883/2013/gmdd-6-C1883-2013-supplement.pdf

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