Eddy Covariance Measurements Of CO2 Fluxes Above Lake Superior

Jennifer W. Mwangi1, Noel R. Urban1, Judith A. Perlinger1, Mark D. Rowe1, Ludovic Bariteau2, and Christopher W. Fairall3

ABSTRACT

Lake Superior has been reported to be seasonally supersaturated with respect to atmospheric CO2, and fluxes estimated from measured pCO2 are regionally significant. Comparison of pCO2 within the lake and atmospheric CO2 measured 400 m above ground at a site 100 km south of the lake suggests that pCO2 decreases with increasing distance from the lake between 0.1 and 0.4 g C m-2 d-1. These fluxes, though small compared to terrestrial fluxes (8 to 4 g C m-2 d-1), are quite significant on an annual basis, ~140 g C m-2 yr-1. The annual flux of CO2 from the lake is oppositely directed in the season as the atmospheric flux of CO2. The lake is a sink of CO2 from the atmosphere.

RESULTS

I. Data Quality Control (QC) Test

Quality control screening was conducted first by visual inspection, followed by procedures outlined in the Handbook of Quality Control Procedures and Methods for Surface Meteorology Data (5). Vertical wind speed creates platform motion which can affect the flux measurement. The algorithm was designed to filter the data and remove any vertical motion caused by the platform.

II. Motion Correction

Vertical wind speed creates platform motion (1), which if not corrected for would cause an overestimation of CO2 fluxes. A MATLAB motion correction algorithm was employed to correct for platform motion. The algorithm was tuned based on visual density plots and found to satisfactorily remove vertical motion caused by the ship motion.

III. Stationarity

Several variables were analyzed to verify time periods in which atmospheric conditions remained constant and data from these sections were used to calculate CO2 fluxes. Variables tested for stationarity included:

1) 3-D wind speeds from anemometer;
2) Fine-wire thermocouple air temperature;
3) Air specific humidity;
4) Pressure from CO2/H2O analyzer

IV. Magnitude and Direction of CO2 Fluxes

EC CO2 Flux vs BA CO2 Flux

Table 1: Comparison of EC and BA Results

<table>
<thead>
<tr>
<th>Location</th>
<th>EC Flux (g C m-2 d-1)</th>
<th>BA Flux (g C m-2 d-1)</th>
<th>R²</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Williams Lake</td>
<td>0.1 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.73</td>
<td>0.85</td>
</tr>
<tr>
<td>Minnesota</td>
<td>0.1 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.73</td>
<td>0.85</td>
</tr>
<tr>
<td>Alaska</td>
<td>0.1 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.73</td>
<td>0.85</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.1 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.73</td>
<td>0.85</td>
</tr>
<tr>
<td>North Atlantic</td>
<td>0.1 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.73</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Characteristics of the study lake: Lake Superior is a deep lake with an estimated surface area of 825,100 km² and a maximum depth of 406 m. The lake is connected to the Arctic Ocean through the Straits of Mackinac, and its southern end is connected to the Lake Michigan/Huron basin.

REFERENCES


Author Information

Michigan Technological University, 1440 Townsend Dr., Houghton, MI 49931. B.839.msw@michigan.edu, b.badis@cns.mtu.edu, mendozajf@mtu.edu, liudovic.bariteau@mtu.edu, cjfairall@mtu.edu

Acknowledgements

This research was funded by NSF (OCE0628545). Previous work (for the 2007 sampling trips) conducted by Cindy Schafer and Mark Rowe enabled an easier instrumentation setup on the boat and faster data analysis. Also, field work assistance obtained from colleagues in the department (Mark Rose, Cory McDonald, Paul Pawelzik, John Befler, Alyssa Latta, Lisa Weidemann, Bashar Abdulahaba, Rosamaria Flores, Josh Johnson, and Mark Weis) enabled us to efficiently carry out measurements around the B.P. Quetico. We thank Captain R. Stephen Roffe for his expert ship operation.