Temporal and Spatial Variations of CH$_4$ Emission in Lake Taihu Measured with the Transfer Coefficient Method

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Outline

- Introduction
- Objectives
- Methods
- Results
- Conclusions
1. Introduction

- Lake is an important natural source of CH$_4$ in the atmosphere (Walter et al., 2006; Bastviken et al., 2004, 2011; Podgrajsek et al., 2013).
- The amount of CH$_4$ emission from global lakes is about 8-48TgCH$_4$yr$^{-1}$, which contributes about 6-16% of global natural source emission (Bastviken et al., 2004; Palma-silva et al., 2013).
- However, the amount is uncertainty because of different types of lakes and its complex environmental and biological control mechanisms.
1. Introduction

- Environmental factors, such as temperature, wind speed, and aquatic biomass control CH$_4$ emission from lake (Yvon-Durocher et al., 2014; Matthes et al., 2014; Morin et al., 2014).

- Lake Taihu located Yangzi river Delta is the biggest shallow lake in China. Lake Taihu has spatial heterogeneity because of the different types of vegetation (Liu et al. 2007), spatial pattern of pollution (Zhao et al., 2011), and wind wave situation (Qin et al., 2007, Lee et al., 2014).

- CH$_4$ emission in Lake Taihu may show spatial pattern.
1. Introduction

• The temporal and spatial pattern of CH$_4$ emission in Lake Taihu is basis for estimating accurately CH$_4$ emission from the whole lake.

• Currently, Algal bloom is a severe environmental problem in Lake Taihu.

• The biomass formed by algal bloom may impact the temporal and spatial pattern of CH$_4$ emission in Lake Taihu and the total amount.
2. Objectives

• Identify the temporal and spatial variations of CH$_4$ emission in Lake Taihu.
• Obtain the total amount of CH$_4$ emission in Lake Taihu.
• Discuss the impact of environmental and algal bloom on CH$_4$ emission in Lake Taihu.
3. Methods

3.1 Sites information

Meiliang Bay: Semi-enclosed bay;

Gonghu Bay: Floating plants and emergent macrophytes zone;

Northwest: Hyper-eutropica zone;

Center: the center of lake;

Eastern part: Submerged macrophytes;

Southeast part: Transition zone between phytoplankton and macrophyte;

Dongtaihu Bay: Submerged macrophytes and pen fish farming zone.

Figure 1 Locations of Flux sites (×) and sampling sites (●) (Lee et al, 2014; Yan et al, 2011)
3.2 Measurements

- CH$_4$ flux is monitored at different temporal scales and spatial scales.

- Water sample is collected at MLW sites every day.

- Water samples are collected at BFG site, DPK site, XLS site, and PTS site every one or two month.

- Water samples are collected in whole lake every three month.
3.2 Measurements

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Latitude/longitude</th>
<th>Water depth(m)</th>
<th>Start time</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLW</td>
<td>31.42°N/120.21°E</td>
<td>1.8</td>
<td>2011.07</td>
</tr>
<tr>
<td>DPK</td>
<td>31.27°N/119.93°E</td>
<td>2.5</td>
<td>2012.07</td>
</tr>
<tr>
<td>BFG</td>
<td>31.17°N/120.40°E</td>
<td>1.7</td>
<td>2012.12</td>
</tr>
<tr>
<td>XLS</td>
<td>31.00°N/120.13°E</td>
<td>2.0</td>
<td>2013.01</td>
</tr>
<tr>
<td>PTS</td>
<td>31.23°N/120.11°E</td>
<td>2.8</td>
<td>2013.04</td>
</tr>
</tbody>
</table>

Water samples collected in whole lake began in 2011
3.3 Transfer Coefficient Method

- Transfer coefficient method calculates CH$_4$ emission flux according to the concentration difference between water surface and the atmosphere.

\[
\begin{align*}
F &= (C_w - C_s) \times k \\
\text{k/k}_600 &= (S_c/S_{c600})^{-n} \\
k_{600} &= 2.07 + 0.215 \times U_{10}^{1.7} \\
U_{10}/U &= \ln(10/Z_0)/\ln(3.5/Z_0)
\end{align*}
\]

- $k$ is the gas transfer coefficient (m d$^{-1}$) ; $C_w$: CH$_4$ concentration (mol m$^{-3}$) dissolved in the surface water (at the depth of 20-cm) ; $C_{eq}$: the CH$_4$ concentration in water that is in equilibrium with the atmosphere in situ temperature; $S_c$ is the Schmidt number of a given gas at given temperature and water density and $S_{c600}$ is the Schmidt number 600 at temperature of 20 °C; $U_{10}$ is the wind speed at 10-m height; $Z_0$: roughness height; $k_{600}$ is the gas transfer coefficient adjusted to Schmidt number 600; U: the wind speed measured at 3.5m height.
4. Results

4.1 Temporal variation of CH$_4$ emission

Figure 2 Temporal variation of CH$_4$ emission at MLW site
4.1 Temporal variation of CH$_4$ emission

Figure 2  Temporal variation of CH4 emission at BFG site, DPK site, and PTS site, XLS site.
4.2 Spatial variation of CH$_4$ emission

Figure 3. Spatial variation of CH$_4$ emission in spring (a), summer (b), autumn (c), and winter (d).
4.3 Temporal pattern of spatial variation of CH$_4$ emission

Figure 4 Temporal variations of spatial pattern of CH$_4$ emission flux in 2012(a), 2013(b), 2014(c), and average CH$_4$ emission (d) in Lake.
### 4.3 Temporal pattern of spatial variation of CH$_4$ emission

Table 2. CH$_4$ emission in different zone

<table>
<thead>
<tr>
<th>Zones</th>
<th>Surface area (km$^2$)</th>
<th>Emission flux (mmol m$^2$ d$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2012</td>
</tr>
<tr>
<td>Meiliang Bay</td>
<td>100</td>
<td>0.086</td>
</tr>
<tr>
<td>Gonghu Bay</td>
<td>215.6</td>
<td>0.050</td>
</tr>
<tr>
<td>Eastern part</td>
<td>316.4</td>
<td>0.170</td>
</tr>
<tr>
<td>Dongtaihu Bay</td>
<td>131</td>
<td>0.211</td>
</tr>
<tr>
<td>Southwest</td>
<td>443.2</td>
<td>0.018</td>
</tr>
<tr>
<td>Northwest</td>
<td>394.1</td>
<td>0.249</td>
</tr>
<tr>
<td>Center</td>
<td>737.5</td>
<td>0.020</td>
</tr>
<tr>
<td>Lake Taihu</td>
<td>2338</td>
<td>0.095</td>
</tr>
</tbody>
</table>

Average: 0.090 mmol/m$^2$d
4.4 The control of temperature on CH$_4$ emission

Figure 5 relationship between water temperature and CH$_4$ emission.
5. Conclusion

- In Lake Taihu, the CH$_4$ emission is higher in summer and autumn than that in winter and spring.
- The CH$_4$ emission is higher in eastern lake, Dongtaihu bay, and Northwest lake than the other zones.
- The spatial pattern of CH$_4$ shows interannual variation.
- The average value of CH$_4$ emission from whole lake is about 0.090 mmol/m$^2$d.
- The contribution of algal to CH$_4$ emission is less than the submerge macrophytes and water temperature control CH$_4$ emission in Lake Taihu.
Thank You!