Vertical patterns of CH4 emission along tree stems of *Alnus japonica* and *Fraxinus mandshurica*

Kazuhiko Terazawa 1), Kenji Yamada 2) Tadashi Sakata 3), Shigehiro Ishizuka 3)

1) Tokyo Univ. of Agriculture, Japan
2) Hokkaido Research Organization, Japan
3) Forestry and Forest Products Research Institute, Japan
Introduction: What can we learn from vertical patterns of stem CH$_4$ emission?

- “Tree-mediated CH$_4$ emission” is one of the emission pathways of soil-born CH$_4$ in wetland ecosystems.

- Vertical patterns of stem CH$_4$ emission may give us some insight into the underlying mechanisms of tree-mediated CH$_4$ emission, such as,
  1. Mode of CH$_4$ transport in a tree body
  2. Source of CH$_4$, emitted from stem surface
# Materials & Methods

<table>
<thead>
<tr>
<th></th>
<th><em>Alnus japonica</em></th>
<th><em>Fraxinus mandshurica</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>N of sample trees</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Age (approx.)</td>
<td>60-year-old</td>
<td>80-year-old</td>
</tr>
<tr>
<td>Height</td>
<td>23 – 24 m</td>
<td>26 – 30 m</td>
</tr>
<tr>
<td>Diameter (at BH)</td>
<td>24 – 36 cm</td>
<td>26 – 34 cm</td>
</tr>
<tr>
<td>Max height for flux measurement</td>
<td>5.15 m</td>
<td>4.5 m</td>
</tr>
<tr>
<td>Date of flux measurement</td>
<td>Aug. &amp; Sep. 2014</td>
<td>July 2016</td>
</tr>
</tbody>
</table>

*CH₄ concentration analysis: GC/FID*
**Result:**

- **Vertical profiles of stem CH$_4$ flux (up to 5m)**
  - For 3 *Alnus* trees

  ![Graph of stem CH$_4$ flux](image)

  - **Largest emissions at the stem bases.**
  - **Drastic decrease in CH$_4$ flux with increasing stem height.**
Vertical profiles of stem CH₄ flux (up to 5m)  
- For 3 *Alnus* trees -

- Continuous upward decrease in CH₄ flux at higher positions.
- Detectable CH₄ emissions even at 5m above the ground.
**Vertical profiles of stem CH$_4$ flux (up to 5m)**
- For 3 *Alnus* trees -

Vertical profiles of stem CH$_4$ flux (up to 5m)
- For 3 *Alnus* trees -

Vertical patterns can be regressed by a power function.

- Vertical patterns can be regressed by a power function.
Vertical profiles of stem CH$_4$ flux
- A simple diffusion model for *Alnus* -

**Assumption 1**
- $\text{Flux} = -D_{\text{radial}} (C_{\text{in}} - C_{\text{atmosphere}})$ \(\cdots\) Fick’s law
  - $D_{\text{radial}}$ Radial gas diffusivity in a tree stem

**Assumption 2**
- $C_{\text{in}}$ is determined by both radial and axial gas diffusion.

**Assumption 3**
- No convective flow, and No gas transport by sap flow.
- No CH$_4$ production, and No CH$_4$ oxidation in a tree body.
**Vertical profiles of stem CH₄ flux**  

- **A simple diffusion model for Alnus** -

**Diffusion equation**

\[ \frac{\partial^2 C_{in}}{\partial Z^2} = K \ C_{in} \]

stem height

\[ C_{in} = A \cosh \sqrt{K} Z + B \sinh \sqrt{K} Z \]

(Hyperbolic function)

**Parameter K**

\[ K = f \left( \frac{\text{Radial gas diffusivity}}{\text{Axial gas diffusivity}} \right) \]

**Assumption 4**

Parameter \( K \) decreases with increasing stem height.

**Hypertrophied (well-developed) lenticels at the stem base.**
Good fit between observed values and model estimation.

Suggesting that CH4 may be transported mainly by diffusion in the tree stem according to the concentration gradient from soil to the atmosphere.
Vertical profiles of stem CH$_4$ flux (up to 5m)
- For 3 Fraxinus trees -

- Irregular vertical patterns in stem CH$_4$ flux
- Higher CH$_4$ emissions at higher stem positions,
  suggesting potential CH$_4$ sources in the tree stem?

Different alphabets indicate the statistical differences in flux between heights within each tree.
1. Significant CH$_4$ emissions were detected even at 5m above the ground on a stem of Alnus and Fraxinus trees.

2. In Alnus trees, CH$_4$ emission rates were highest at the lowest measurement position on the stem, and decreased with stem height.

3. Relationship between stem height and CH$_4$ emissions in Alnus can be explained by a diffusion model.

4. By contrast, in Fraxinus trees, vertical patterns in CH$_4$ flux were irregular, and CH$_4$ emission rates were higher at the upper measurement positions in some cases.

5. Further researches are needed, taking into account the possibility of CH$_4$ production in a tree stem.
Thank you for your attention!

... Special thanks go to my students for their help.