Alnus japonica stand, northern Japan

Vertical patterns of CH_4 emission along tree stems of *Alnus japonica* and *Fraxinus mandshurica*

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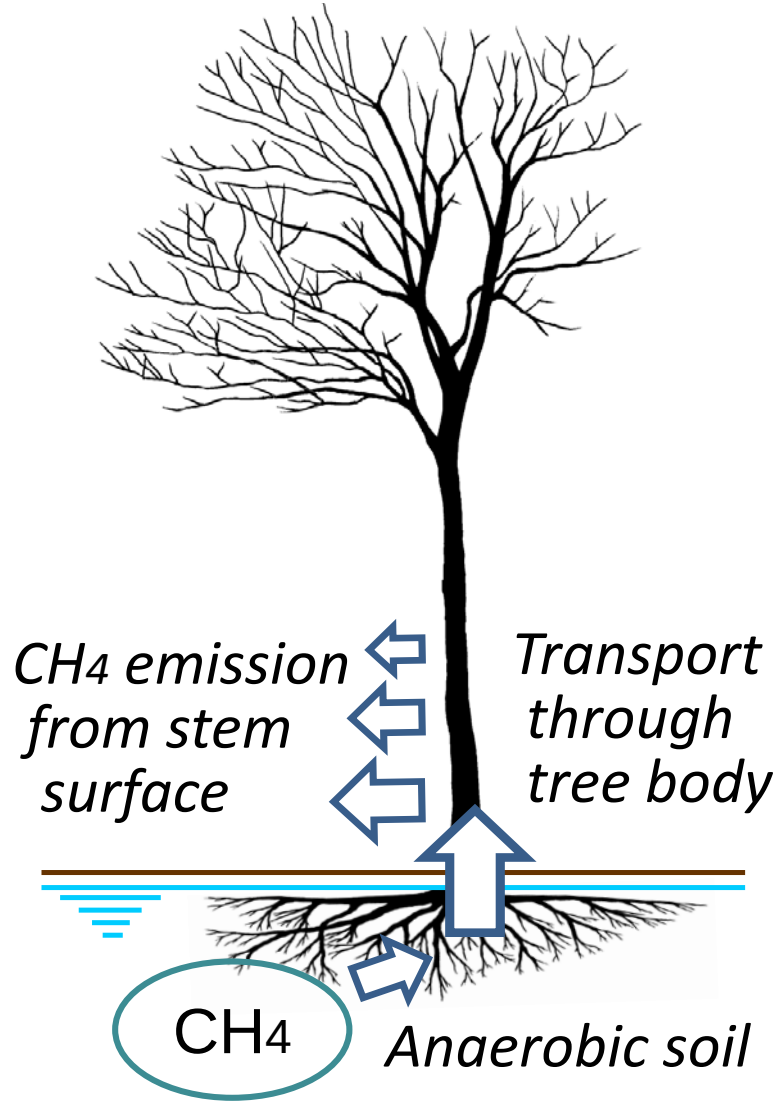
Introduction: ***What can we learn from vertical patterns of stem CH_4 emission?***

- "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,

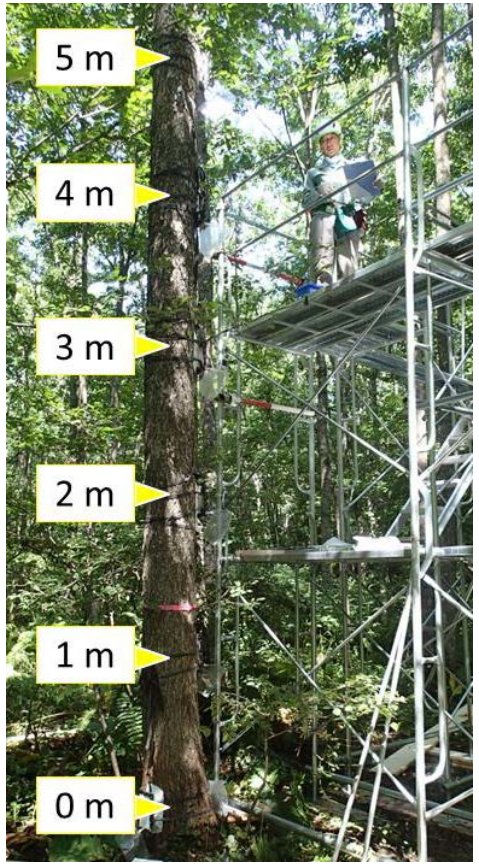
  i) Mode of CH_4 transport in a tree body

  ii) Source of CH_4, emitted from stem surface



Materials & Methods

	Alnus *japonica*	***Fraxinus*** *mandshurica*
N of sample trees	3	3
Age (approx.)	60-year-old	80-year-old
Height	23 – 24 m	26 – 30 m
Diameter (at BH)	24 – 36 cm	26 – 34 cm
Max height for flux measurement	5.15 m	4.5 m
Date of flux measurement	Aug. & Sep. 2014	July 2016



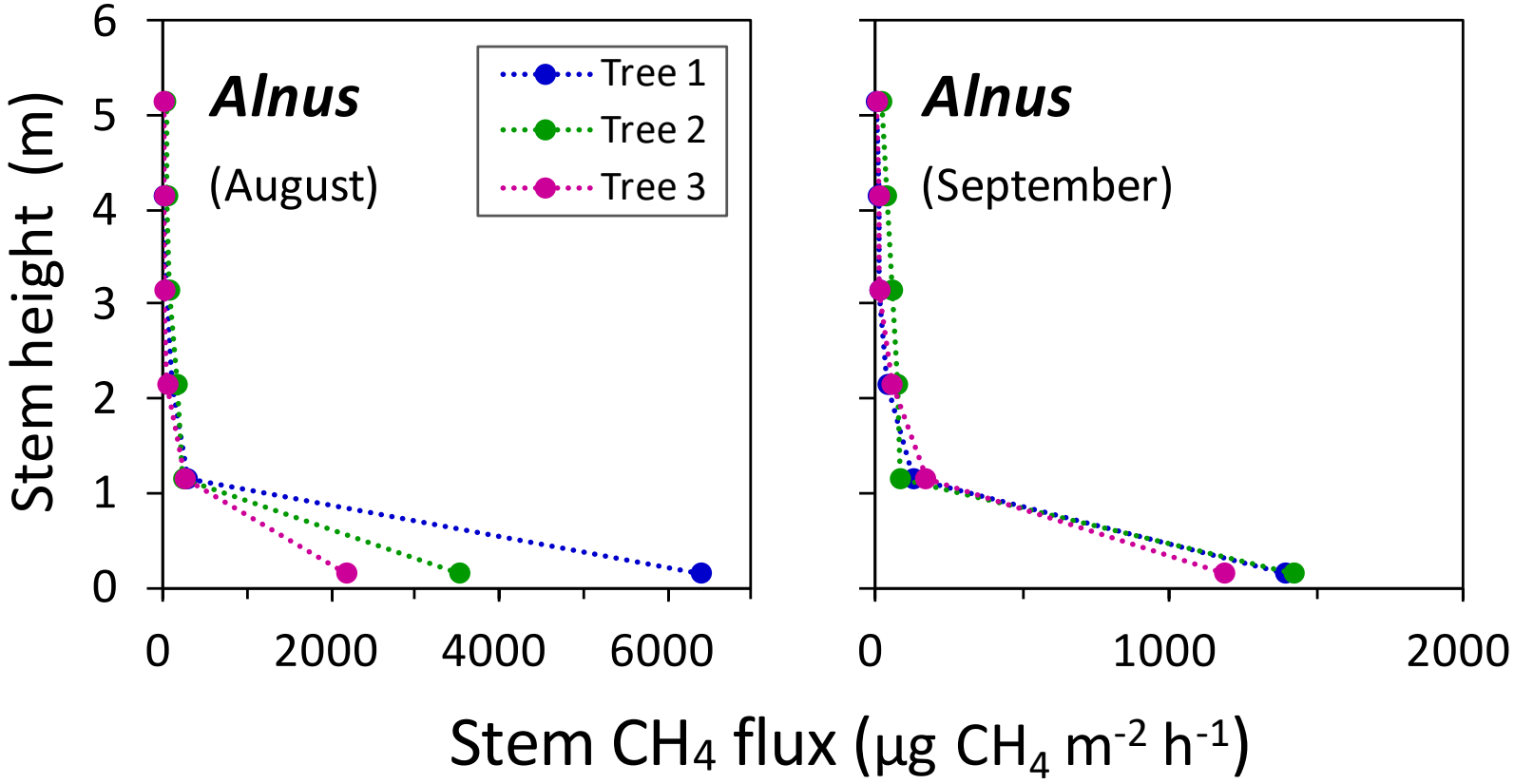
CH_4 flux measurement at 6 heights on a stem.

Cylindrical chamber for CH_4 flux measurement

* CH_4 concentration analysis: GC/FID

Result: *Vertical profiles of stem CH_4 flux (up to 5m)*

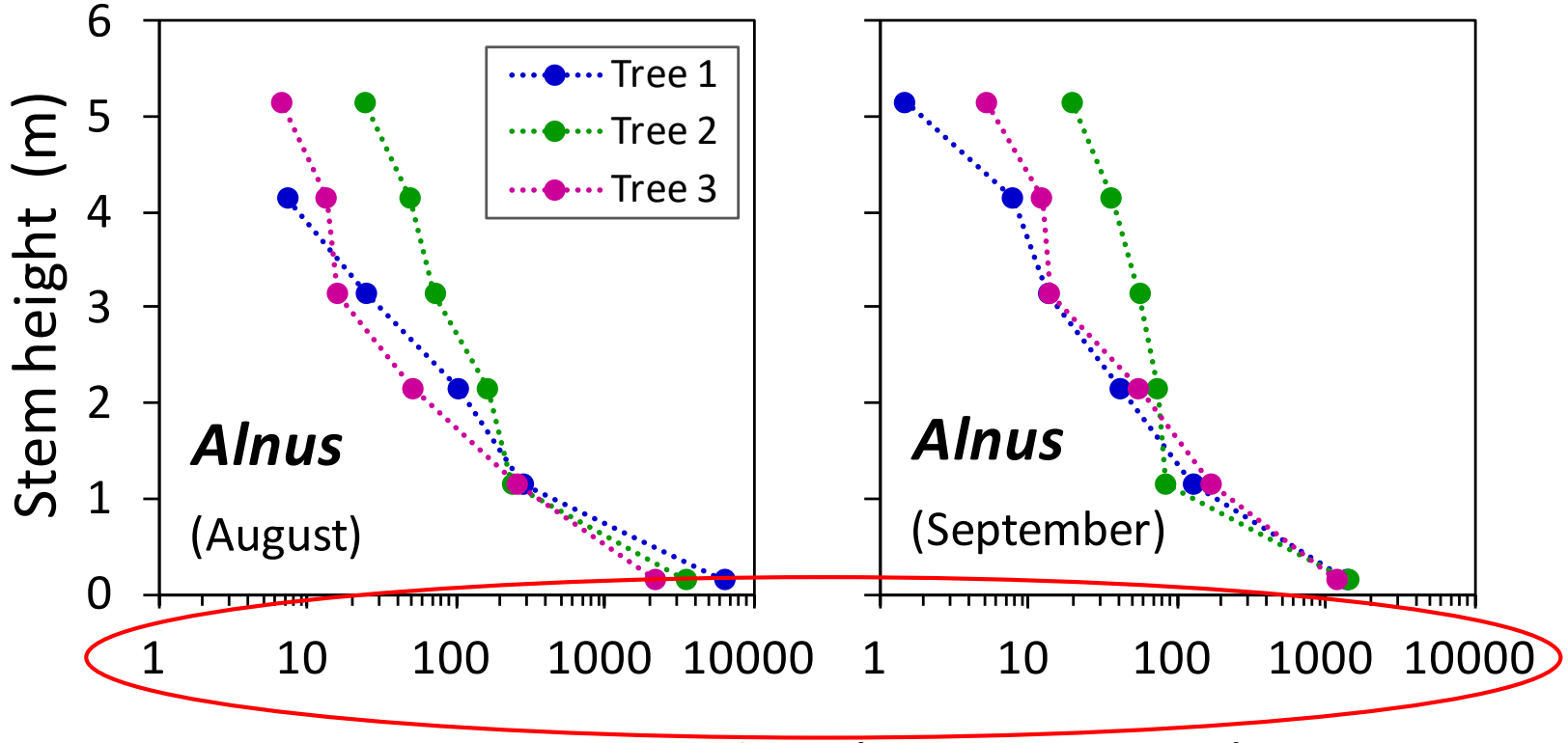
*- For 3 **Alnus** trees -*



- *Largest emissions at the stem bases.*
- *Drastic decrease in CH_4 flux with increasing stem height.*

Vertical profiles of stem CH_4 flux (up to 5m)

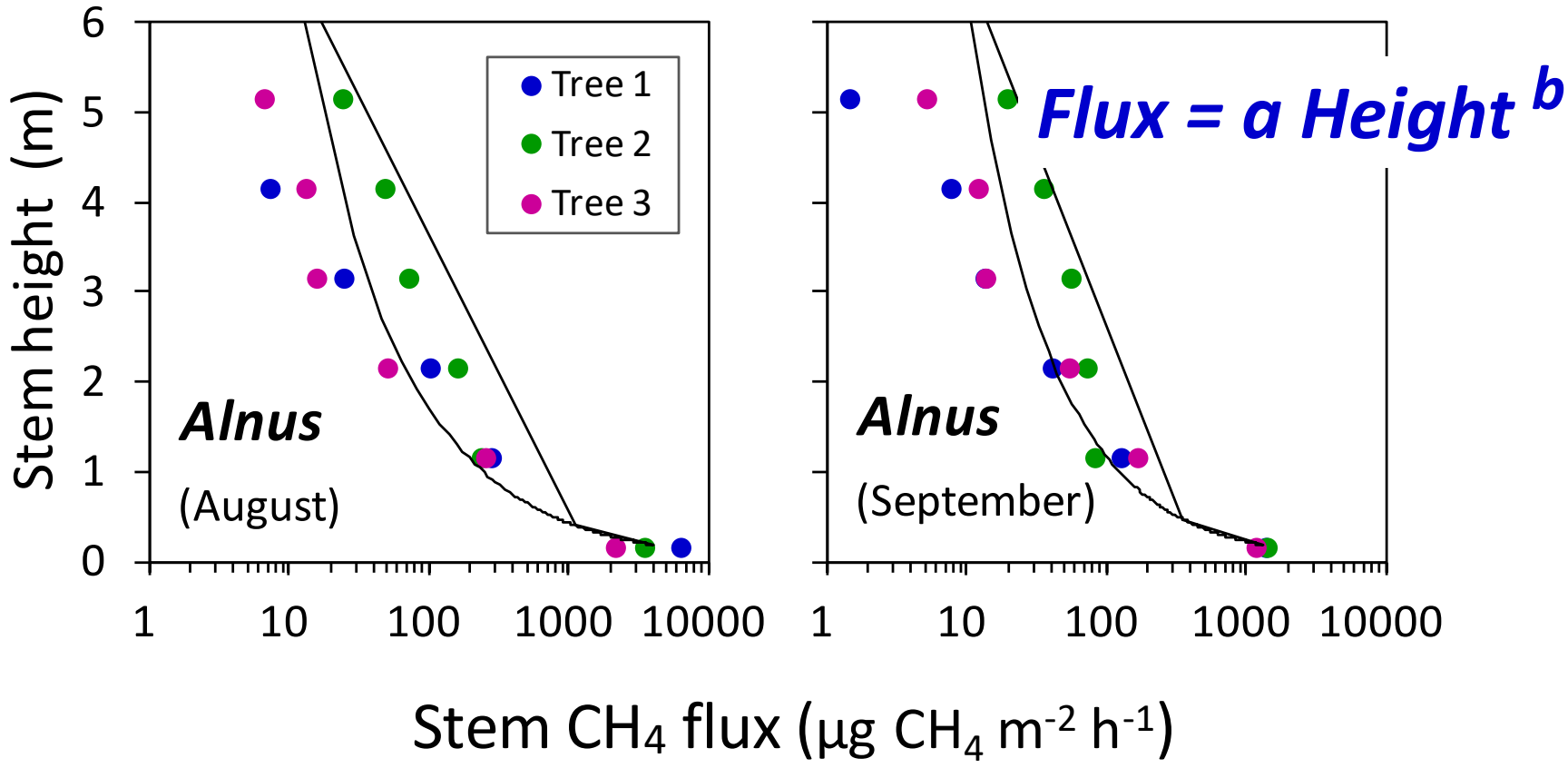
*- For 3 **Alnus** trees -*



- *Continuous upward decrease in CH_4 flux at higher positions.*
- *Detectable CH_4 emissions even at 5m above the ground.*

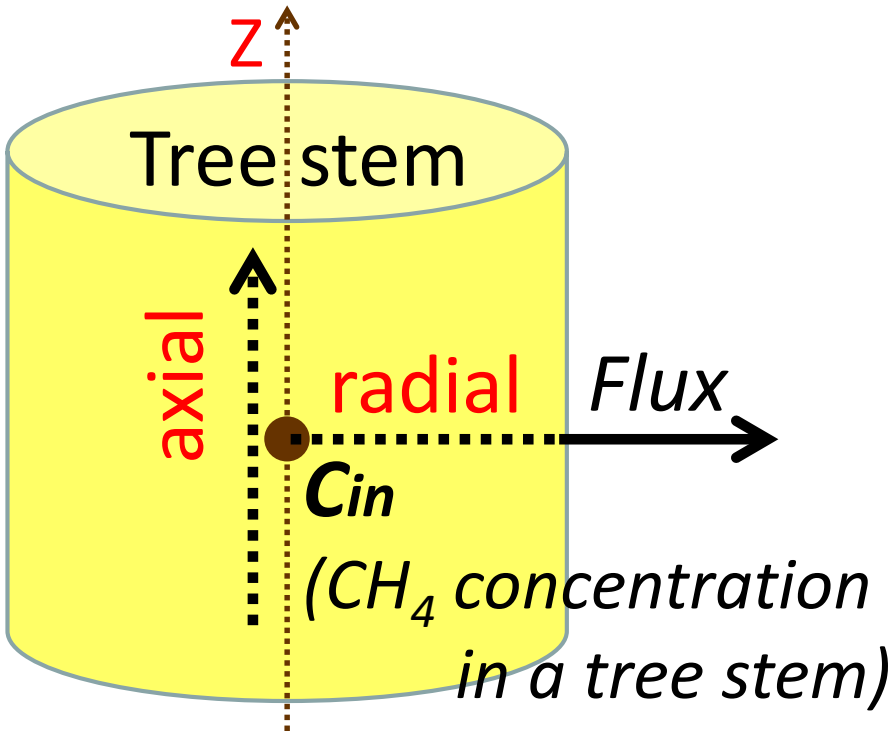
Vertical profiles of stem CH_4 flux (up to 5m)

*- For 3 **Alnus** trees -*



- *Vertical patterns can be regressed by a power function.*

Vertical profiles of stem CH_4 flux
*- **A simple diffusion model** for **Alnus** -*



Assumption 1

- $Flux = -D_{radial}\,(C_{in} - C_{atmosphere})$ ⋯ *Fick's law*

  D_{radial} → *Radial gas diffusivity in a tree stem*

Assumption 2

- C_{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 CH_4 flux
*- **A simple diffusion model** for **Alnus** -*

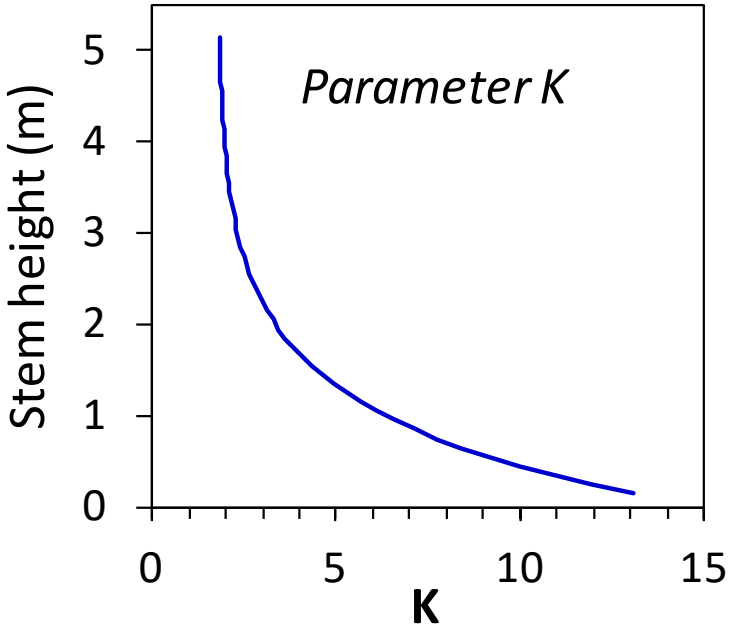
Diffusion equation

$$\partial^2 C_{in} / \partial Z^2 = K\, C_{in}$$

Z: stem height

$$C_{in} = A \cosh \sqrt{K}\, Z + B \sinh \sqrt{K}\, Z$$

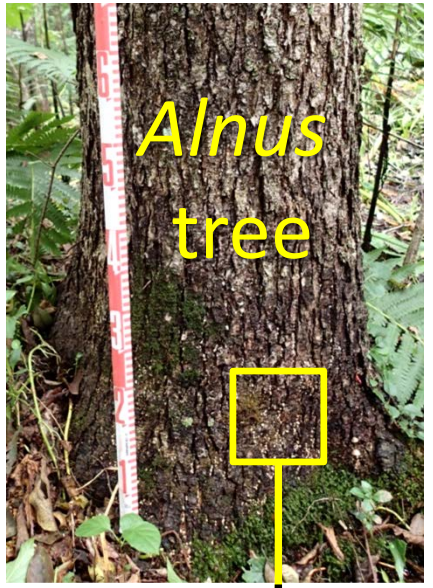
(Hyperbolic function)

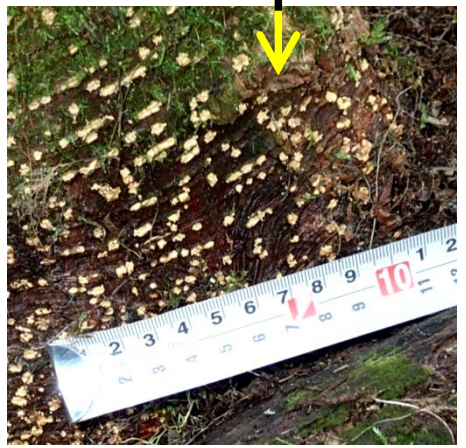


***K* = *f* (*Radial* gas diffusivity / *Axial* gas diffusivity)**

Assumption 4

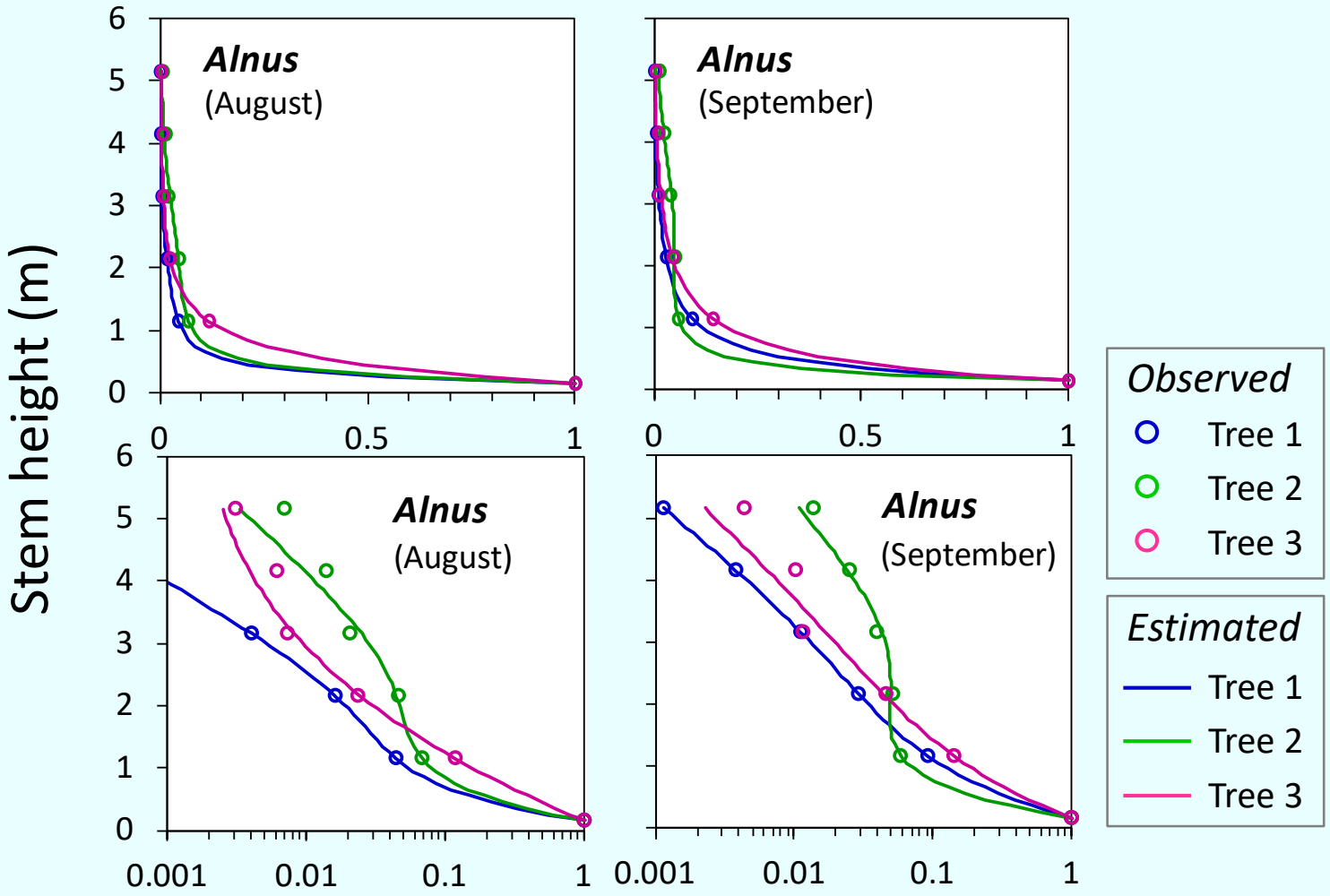
*Parameter **K** decreases with increasing stem height.*





Hypertrophied (well-developed) lenticels at the stem base.

Vertical profiles of stem CH_4 flux
*- **Application of the diffusion model** for **Alnus** -*



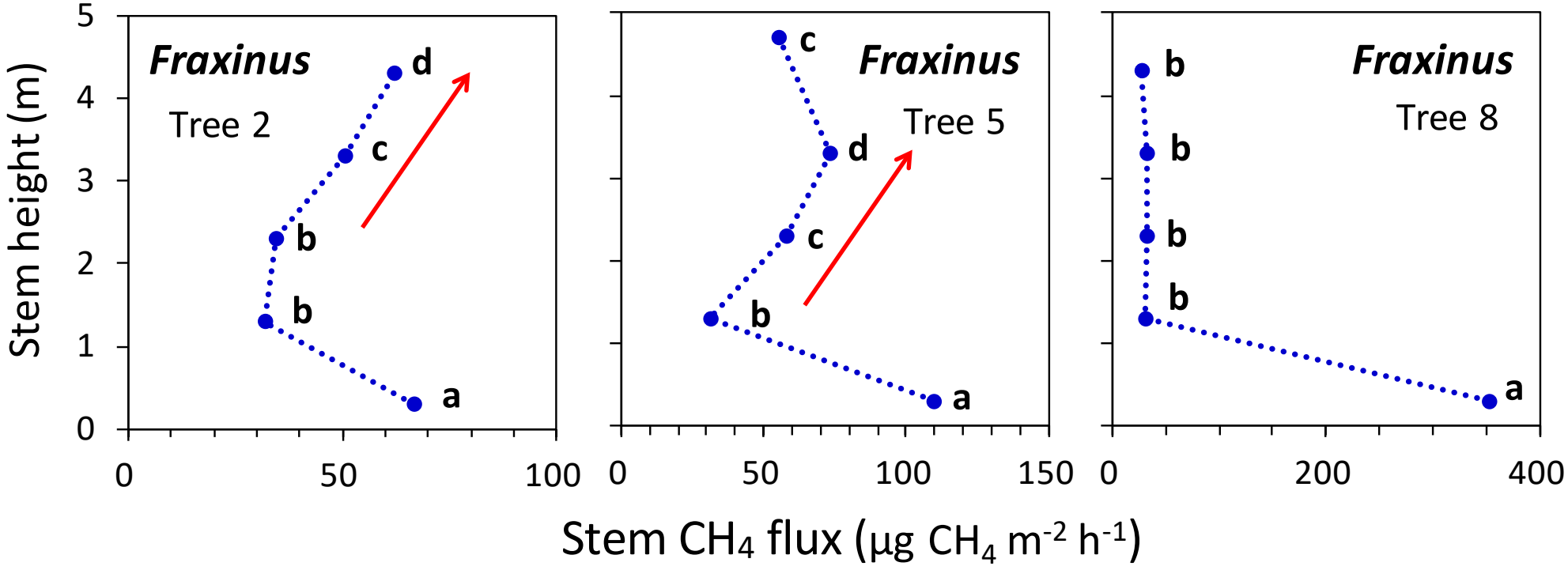
Stem CH_4 flux (Relative value to flux at 0.15m)

(Upper: normal scale, Lower: log-scale)

- *Good fit between observed values and model estimation.*
- *Suggesting that **CH_4 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 -*



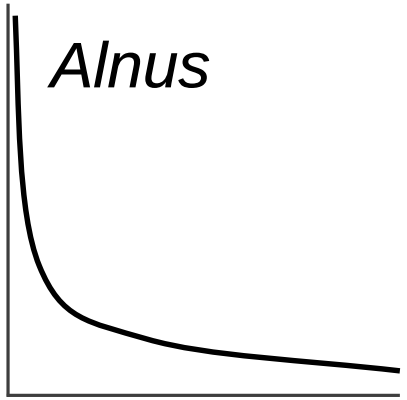
Different alphabets *indicate the* ***statistical differences*** *in flux between heights within each tree.*

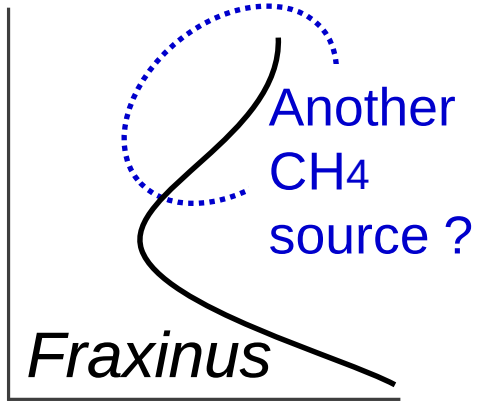
- *Irregular vertical patterns in stem CH_4 flux*
- *Higher CH_4 emissions at higher stem positions,*

suggesting ***potential CH_4 sources in the tree stem****?*

Summary

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.