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Automated Measurements of CO_2, CH_4, and N_2O Fluxes from Tree Stems and Adjacent Soils

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New Phytologist

Research

Methane emissions from the trunks of living trees on upland soils

Zhi-Ping Wang[1,2], Qian Gu[1], Feng-Dan Deng[1,3], Jian-Hui Huang[1], J. Patrick Megonigal[4], Qiang Yu[2], Xiao-Tao Lü[2], Ling-Hao Li[1], Scott Chang[5], Yun-Hai Zhang[1], Jin-Chao Feng[6] and Xing-Guo Han[1,2]

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Key words: annual variability, drained soils, heartwood, *in situ* methane (CH_4) flux, poplar (*Populus davidiana*), temperate forest.

Summary

- Upland forests are traditionally thought to be net sinks for atmospheric methane (CH_4). In such forests, *in situ* CH_4 fluxes on tree trunks have been neglected relative to soil and canopy fluxes.
- We measured *in situ* CH_4 fluxes from the trunks of living trees and other surfaces, such as twigs and soils, using a static closed-chamber method, and estimated the CH_4 budget in a temperate upland forest in Beijing.
- We found that the trunks of *Populus davidiana* emitted large quantities of CH_4 during July 2014–July 2015, amounting to mean annual emissions of 85.3 and 103.1 $\mu g\,m^{-2}\,h^{-1}$ on a trunk surface area basis on two replicate plots. The emission rates were similar in magnitude to those from tree trunks in wetland forests. The emitted CH_4 was derived from the heartwood of trunks. On a plot or ecosystem scale, trunk CH_4 emissions were equivalent to *c.* 30–90% of the amount of CH_4 consumed by soils throughout the year, with an annual average of 63%.
- Our findings suggest that wet heartwoods, regardless of rot or not, occur widely in living trees on various habitats, where CH_4 can be produced.

15 papers reporting **CH_4** and/or **N_2O stem emissions** under field conditions in **upland forests**

J. Plant Nutr. Soil Sci. 2017, 000, 1–5
DOI: 10.1002/jpln.201600405

Combining soil and tree-stem flux measurements and soil gas profiles to understand CH_4 pathways in *Fagus sylvatica* forests

Martin Maier[1]*, Katerina Machacova[2], Friederike Lang[1], Kateřina Svobodova[2], and Otmar Urban[2]

Plant Soil (2017) 420:423–434
DOI 10.1007/s11104-017-3416-5

REGULAR ARTICLE

Nitrous oxide emissions from stems of alder, beech and spruce in a temperate forest

Yuan Wen · Marife D. Corre · Christine Rachow · Lin Chen · Edzo Veldkamp

Plant Soil (2016) 398:35–45
DOI 10.1007/s11104-015-2629-8

REGULAR ARTICLE

New Phytologist — Research

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Methane fluxes from tree stems and soils along a habitat gradient

Scott L. Pitz · J. Patrick Megonigal · Chih-Han Chang · Katalin Szlavecz

Global Change Biology (2015) 21, 3889–3900, doi: 10.1111/gcb.12995

TECHNICAL ADVANCE

Nitrous oxide and methane emissions from cryptogamic covers

KATHARINA LENHART[1,2,3], BETTINA WEBER[1], WOLFGANG ELBERT[1], JÖRG STEINKAMP[4], TIM CLOUGH[5],

SCIENTIFIC REPORTS

OPEN

***Pinus sylvestris* as a missing source of nitrous oxide and methane in boreal forest**

Katerina Machacova[1], Jaana Bäck[2], Anni Vanhatalo[2], Elisa Halmeenmäki[2], Pasi Kolari[2],

SCIENTIFIC REPORTS

OPEN

Cryptogamic stem covers may contribute to nitrous oxide consumption by mature beech trees

Katerina Machacova[1], Martin Maier[2], Katerina Svobodova[1], Friederike Lang[2] &

Accepted: 29 September 2017
Published online: 16 October 2017

AGU PUBLICATIONS — JGR

Journal of Geophysical Research: Biogeosciences

RESEARCH ARTICLE
10.1002/2017JG003991

Methane Production Explained Largely by Water Content in the Heartwood of Living Trees in Upland Forests

Zhi-Ping Wang[1], Shi-Jie Han[2], Huan-Long Li[1,3], Feng-Dan Deng[1,3], Yan-Hai Zheng[1], Hai-Feng Liu[1], and Xing-Guo Han[1]

Carbon Dioxide and Methane Fluxes From Tree Stems, Coarse Woody Debris, and Soils in an Upland Temperate Forest

Daniel L. Warner,[1] Samuel Villarreal,[1] Kelsey McWilliams,[2] Shreeram Inamdar,[1] and Rodrigo Vargas[1]*

What we clearly know from these studies?

- Stems can emit CH_4 and exchange N_2O with the atmosphere
- High **spatial** variability within trees and between **trees, species** and **ecosystems**
- High **temporal** variability at seasonal scales

J. Plant Nutr. Soil Sci. 2017, 000, 1–5 DOI: 10.1002/jpln.201600405

Combining soil and tree-stem flux measurements and soil gas profiles to understand CH_4 pathways in *Fagus sylvatica* forests

Martin Maier[1*], Katerina Machacova[2], Friederike Lang[1], Kateřina Svobodova[2], and Otmar Urban[2]

New Phytologist — Research

Methane emissions from the trunks of living trees on upland soils

Global Change Biology — TECHNICAL ...

Nitrous ... covers

KATHARINA LENHART[1,2,3], BETTINA WEBER[1], WOLFGANG ELBERT[1], JÖRG STEINKAMP[4], TIM CLOUGH[5], ...

OPEN Pinus sylvestris as a missing source of nitrous oxide and methane in boreal forest

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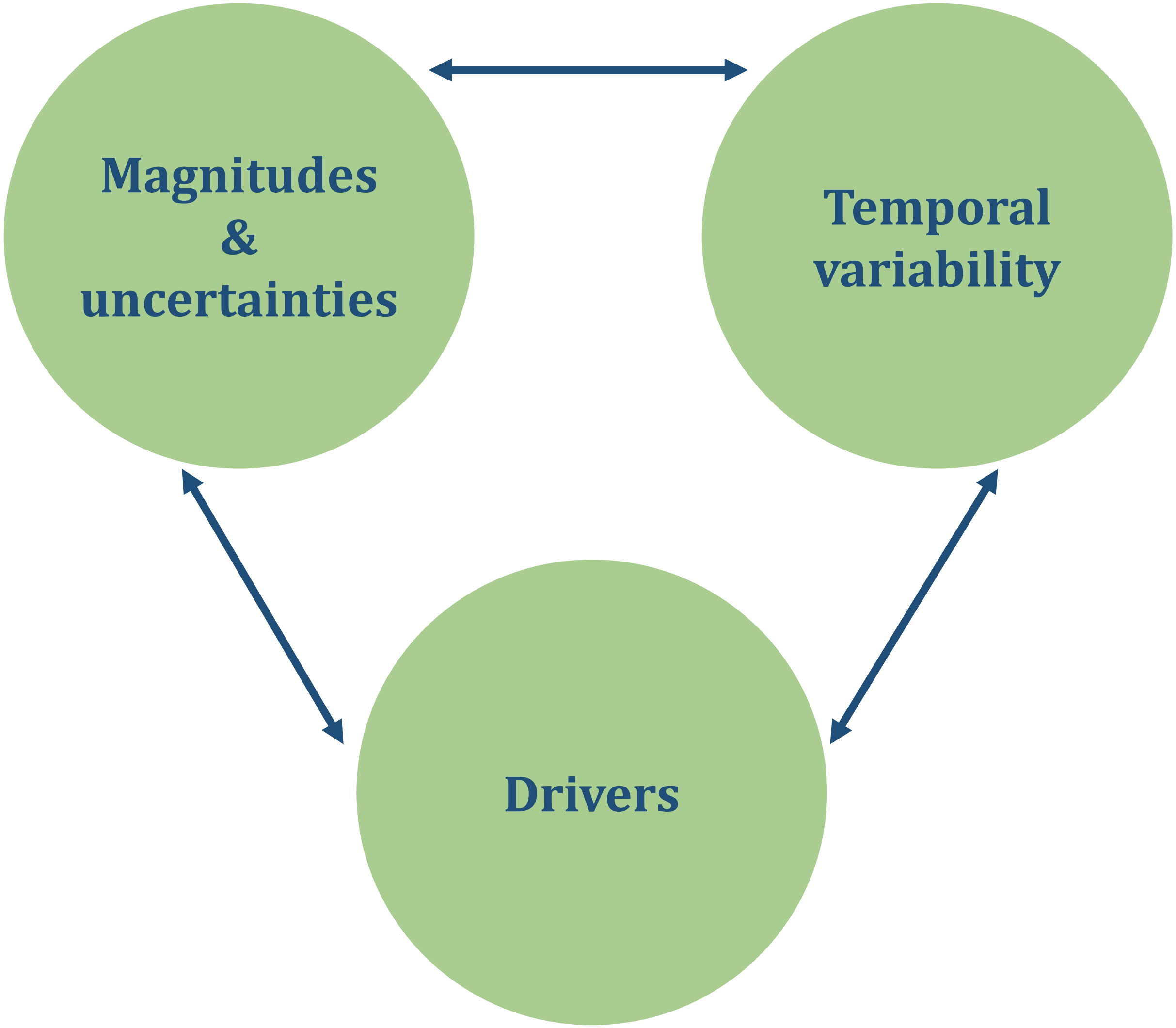
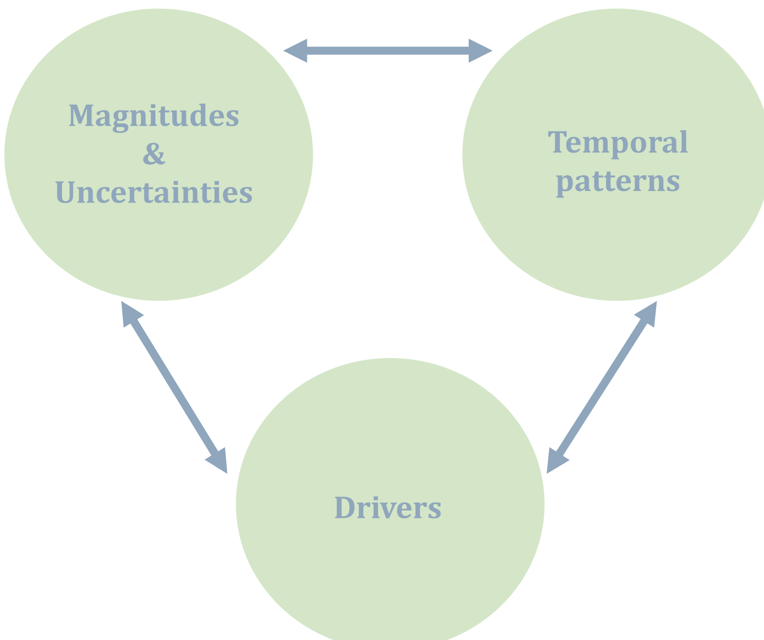
But what is still unclear?



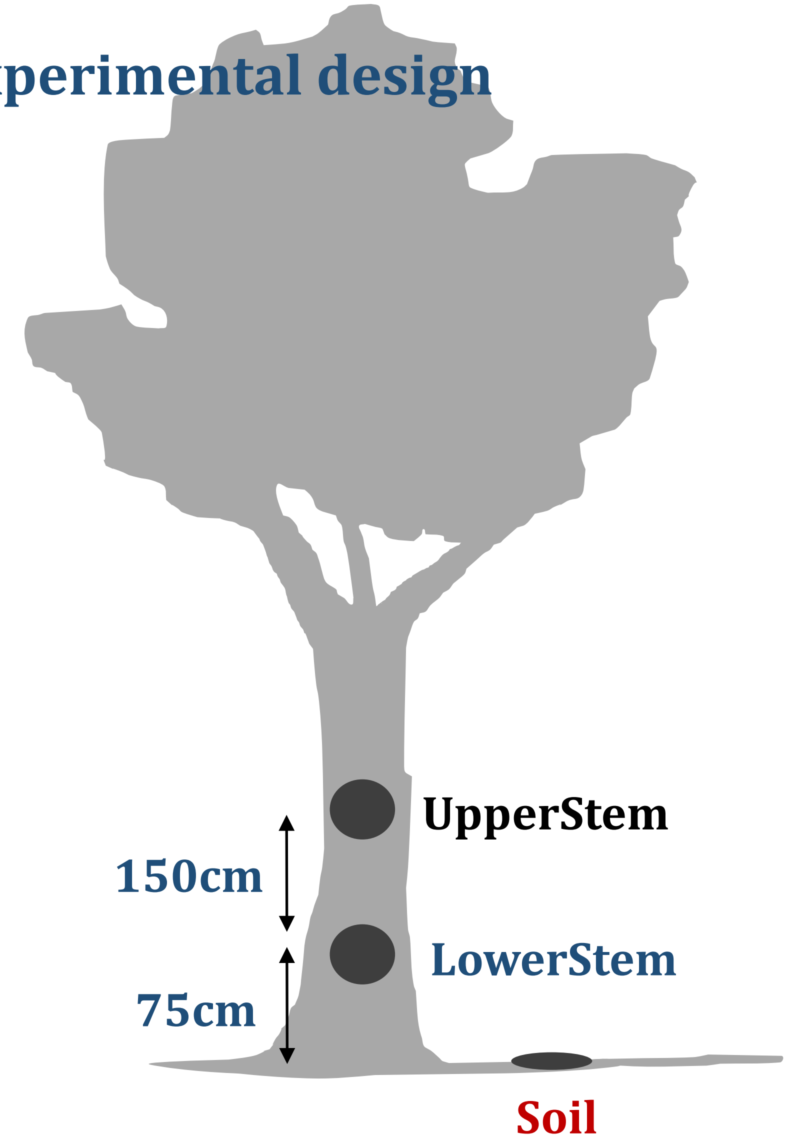
Study aims

Use **AUTOMATIC** measurements of **CO_2**, **CH_4** and **N_2O** to…

- quantify **magnitudes** of emissions
- understand **seasonal** and **diurnal** patterns of emissions
- describe **drivers**
- bring some light on the **origin**



Experimental design



Carya cordiformis

CO_2, CH_4 and N_2O

Every hour for 100 days

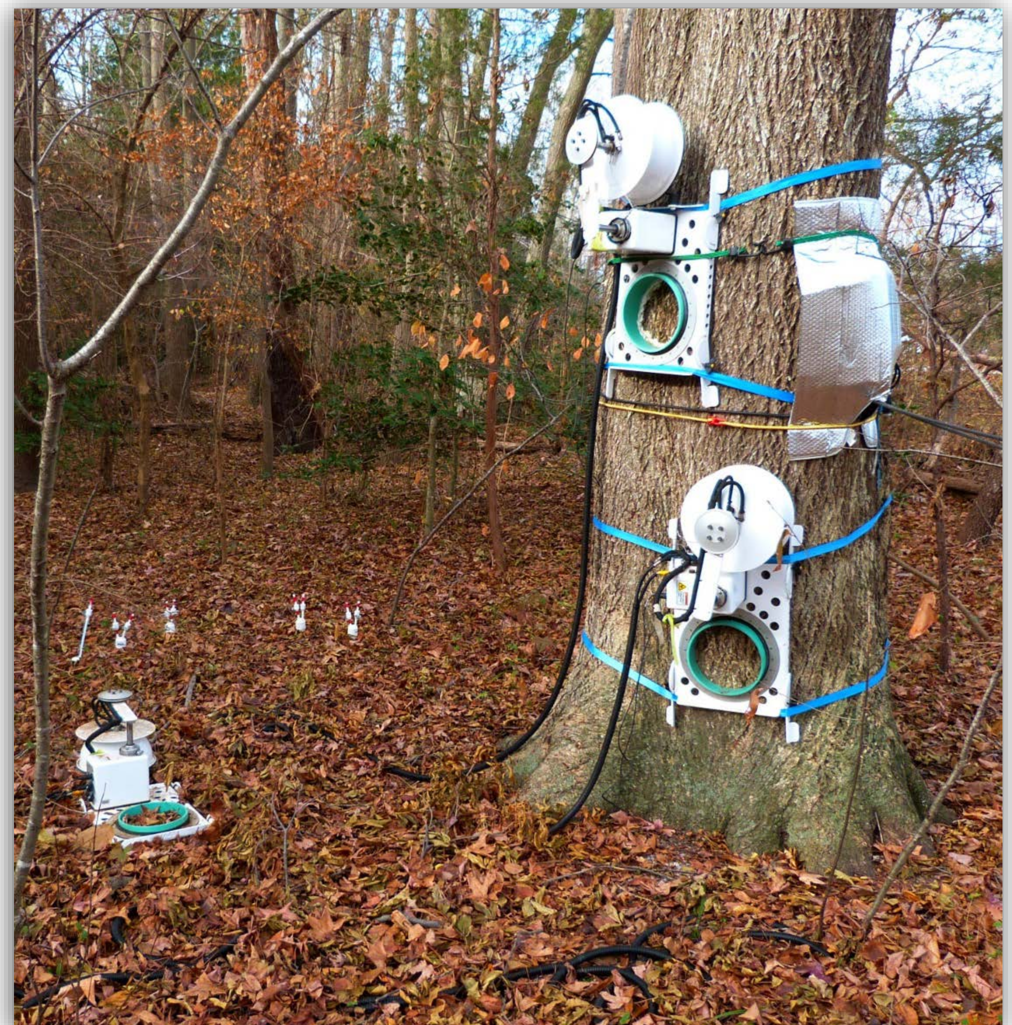
(April – July 2017)

7200 measurements

- Sap flow
- Stem temperature
- Soil temperature
- Soil water content
- Meteorological variables

Upland forested area, St Jones Reserve, DE

Experimental design



Li-8100A

Li-8150 Multiplexer

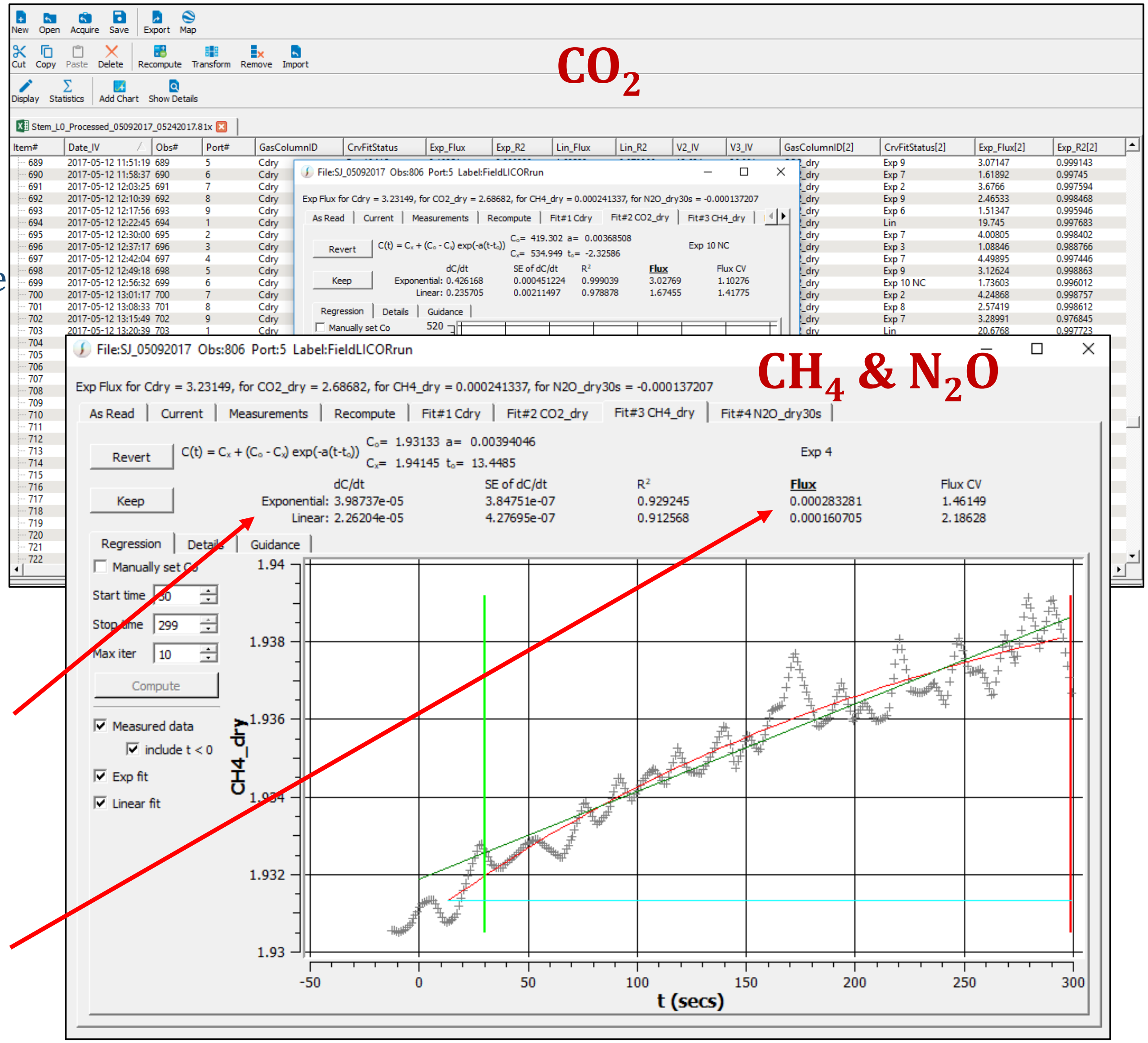
Li-8100 IRGA

Picarro G2508

SoilFluxPRO™

Flux calculation

LI-COR
Version SoilFluxPro™
Soil Gas Flux Software



Exponential
Linear

Exp: 0.28 nmols m^{-2} s^{-1}
Lin: 0.16 nmols m^{-2} s^{-1}

Statistical analysis

- **DIURNAL** patterns and drivers → **Wavelet coherence analysis**

  (hourly data)

- **SEASONAL** patterns and drivers → Mixed-effects models

  (daily averaged data)

  (interactions and temporal autocorrelation)

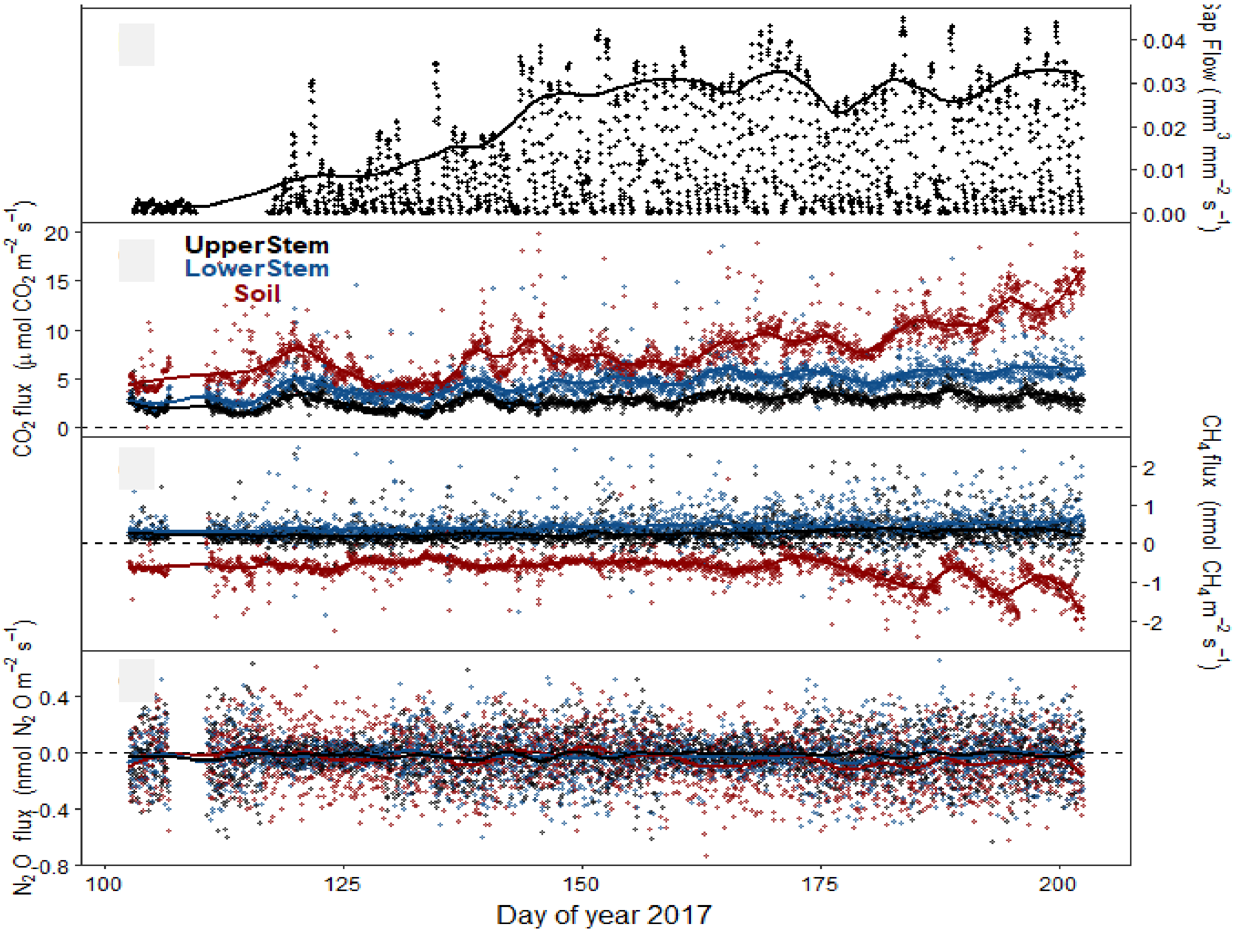
Results – SEASONAL TRENDS

Sap Flow

CO_2

CH_4

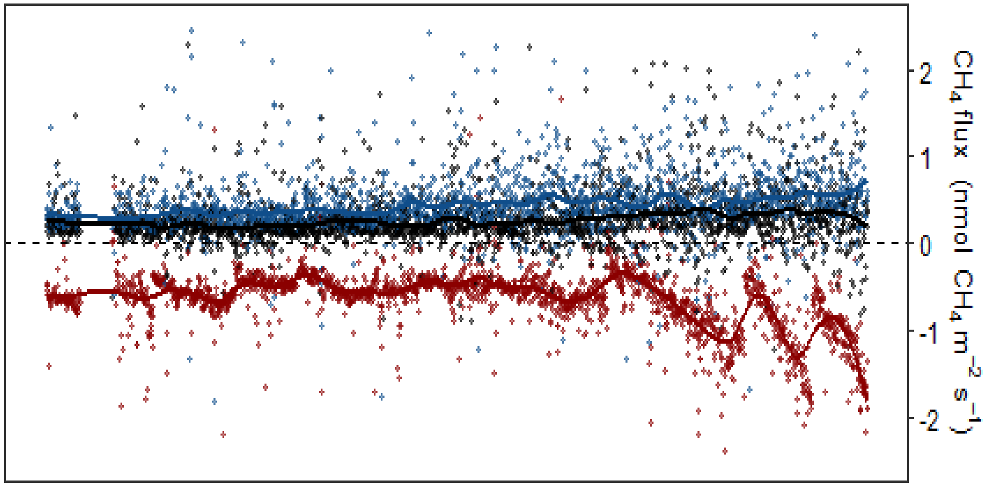
N_2O



Seasonal course of sap flow per unit sapwood area (SF) and CO_2, CH_4 and N_2O fluxes associated with **UpperStem**, **LowerStem** and **Soil** chambers. Points are hourly means taken from Day of the Year 102 to 202.

Results – SEASONAL TRENDS

CH_4



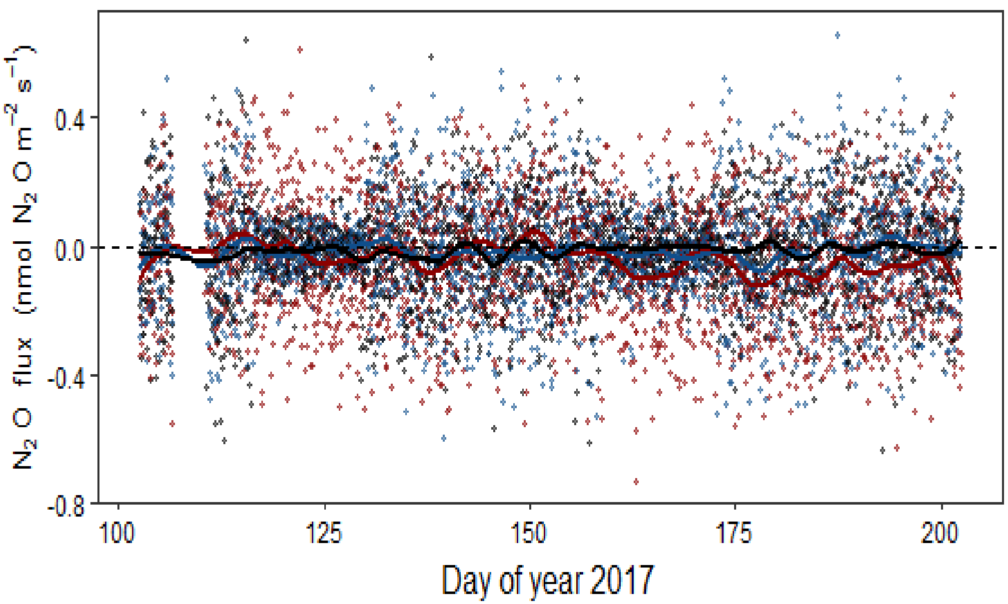
UpperStem: 0.28 ± 0.02

LowerStem: 0.46 ± 0.03

Soil: -0.66 ± 0.06

(nmol CH_4 m^{-2} s^{-1})

N_2O



UpperStem: -0.014 ± 0.006

LowerStem: -0.017 ± 0.008

Soil: -0.046 ± 0.011

(nmol N_2O m^{-2} s^{-1})

Results – SEASONAL PATTERNS – mixed-effects model

(daily data)

CO_2

MODEL	Variables
UpperStem	Temperature
adjR2 = 0.93	SWC
$p < 0.001$	SF
	Temp*SF
	SWC*SF
LowerStem	Temperature
adjR2 = 0.92	SWC
$p < 0.001$	SF
	Temp*SWC
	Temp*SF
Soil	Temperature
adjR2 = 0.99	SWC
$p < 0.001$	SF
	Temp*SWC

CH_4

MODEL	Variables
UpperStem	Temperature
adjR2 = 0.40	SF
$p < 0.001$	
LowerStem	Temperature
adjR2 = 0.33	SWC
$p < 0.001$	
Soil	Temperature
adjR2 = 0.92	SWC
$p < 0.001$	Temp*SWC

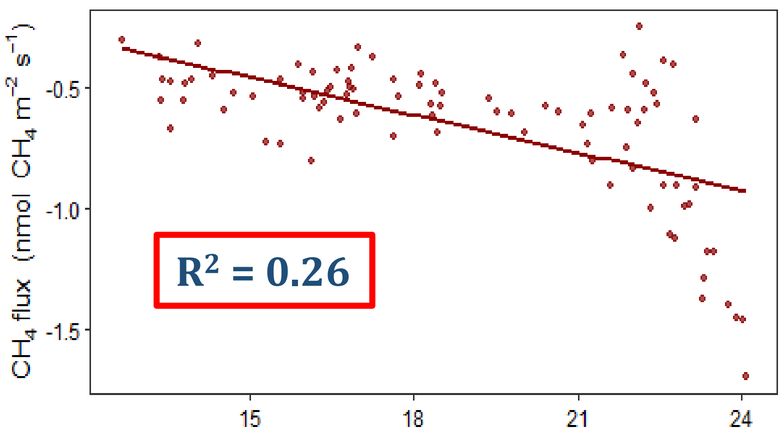
N_2O

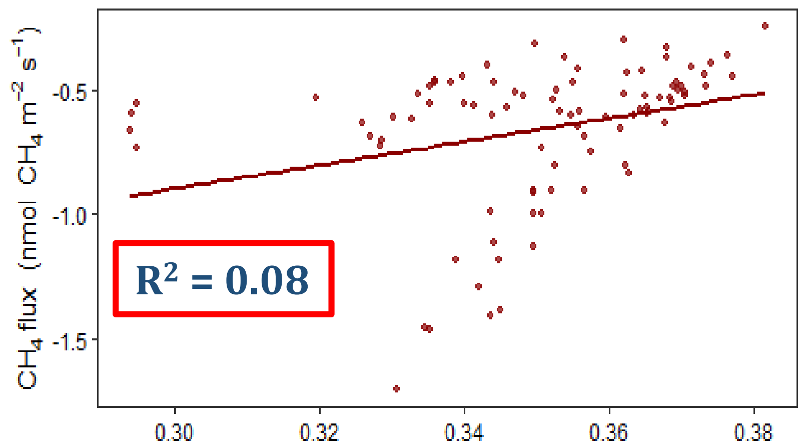
MODEL	Variables
UpperStem	Temperature
adjR2 = 0.10	SWC
$p = 0.032$	SF
LowerStem	
p = n.s.	
Soil	Temperature
adjR2 = 0.22	
$p = 0.001$	

Results – SEASONAL PATTERNS – mixed-effects model

(daily data)

CO_2 | CH_4 | N_2O





adjR2 = 0.92

p < 0.001 SF

Temp*SWC

Temp*SF

Soil Temperature

adjR2 = 0.99 SWC

p < 0.001 SF

Temp*SWC

Soil Temperature

$adjR^2 = 0.92$ SWC

p < 0.001 Temp*SWC

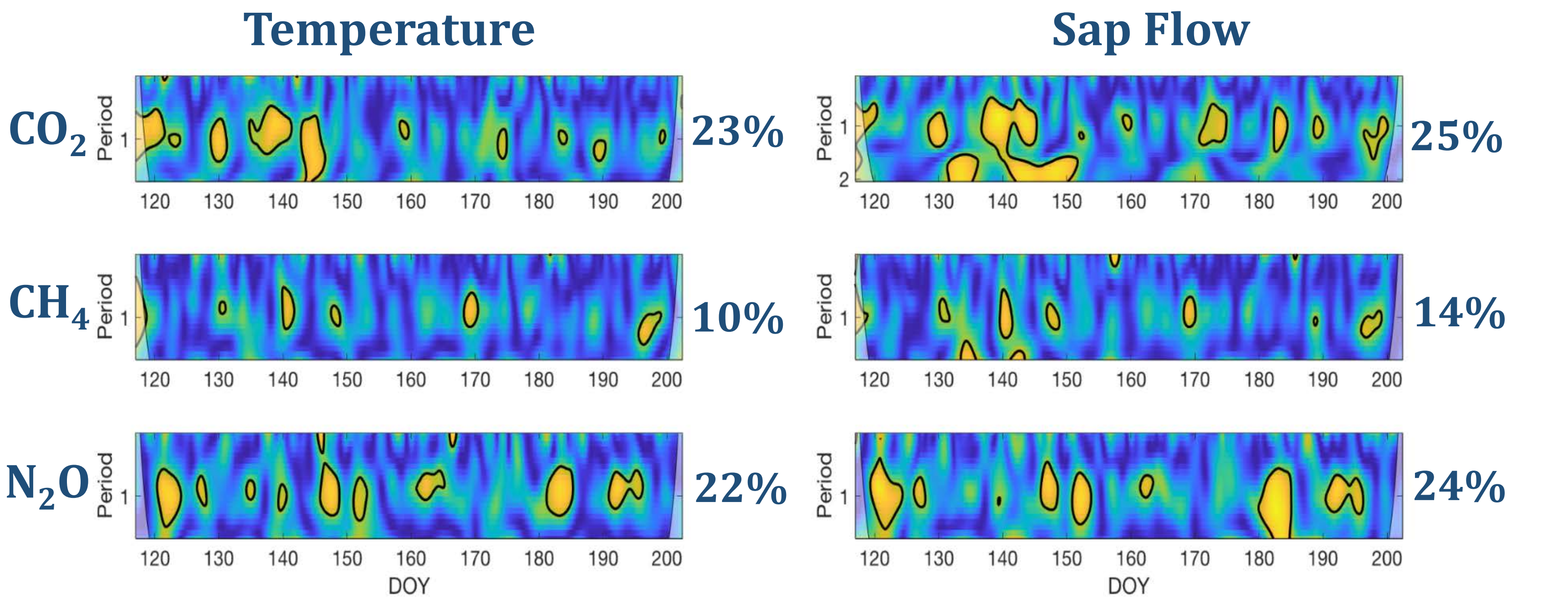
Soil Temperature

adjR2 = 0.22

p = 0.001

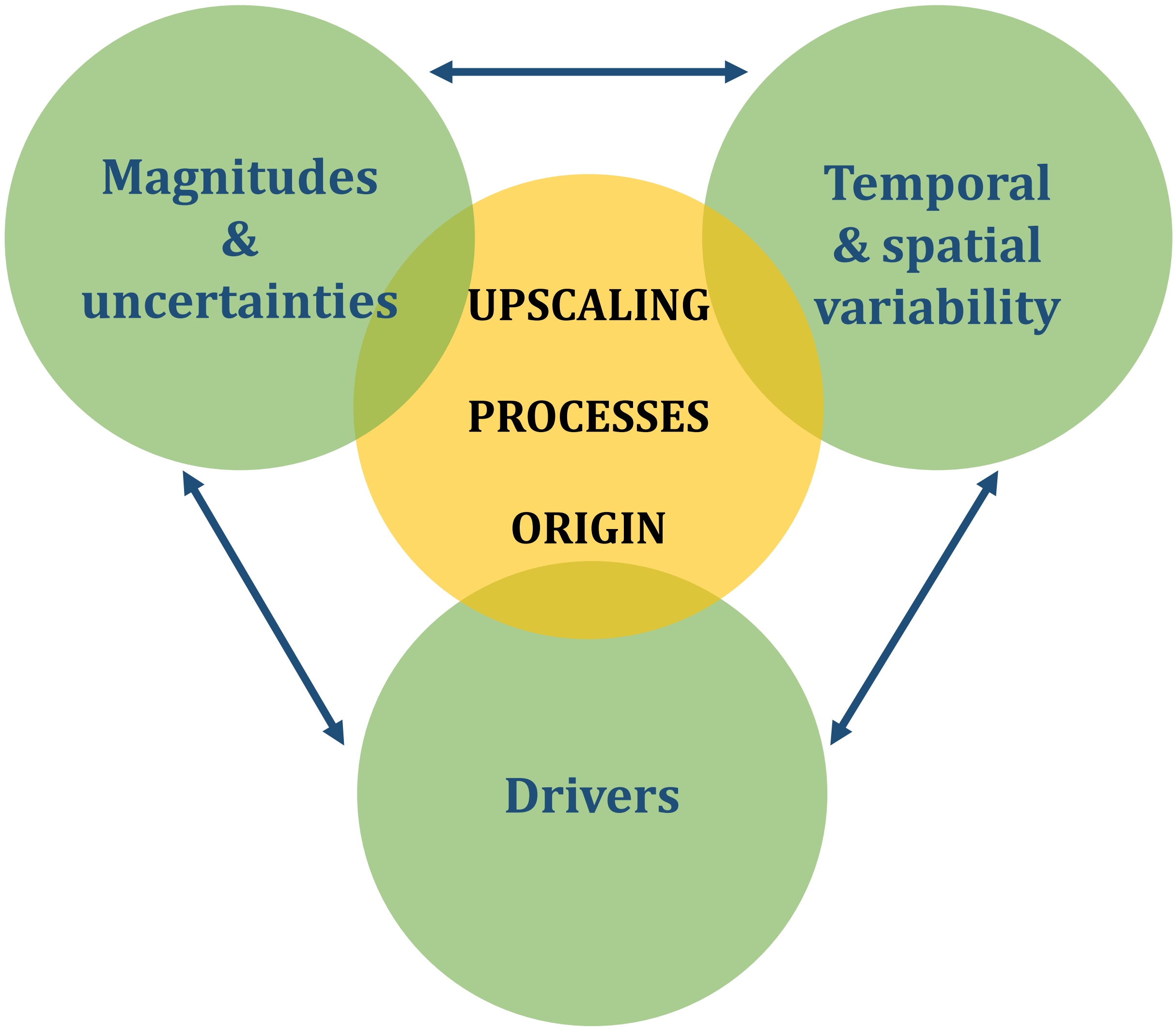
Results – DIURNAL PATTERNS – Wavelet coherence analysis

(hourly data)



Wavelet coherence analyses output and the percentage of days with significant correlations between CO_2, CH_4 and N_2O of the LowerStem with Temperature (left panels) and SF (right panels) using hourly data. Yellow color indicates significant temporal correlations ($p<0.05$).

Conclusions




Thanks