High-Frequency Tree CH_4 Flux Measurements Reveal Relationships with Tree Physiology and Environmental Properties

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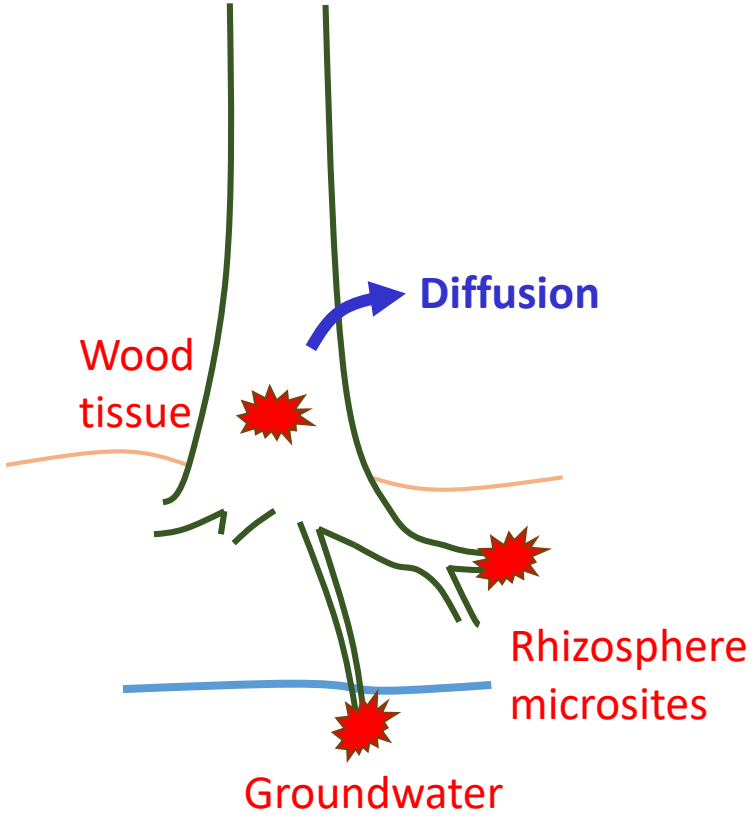
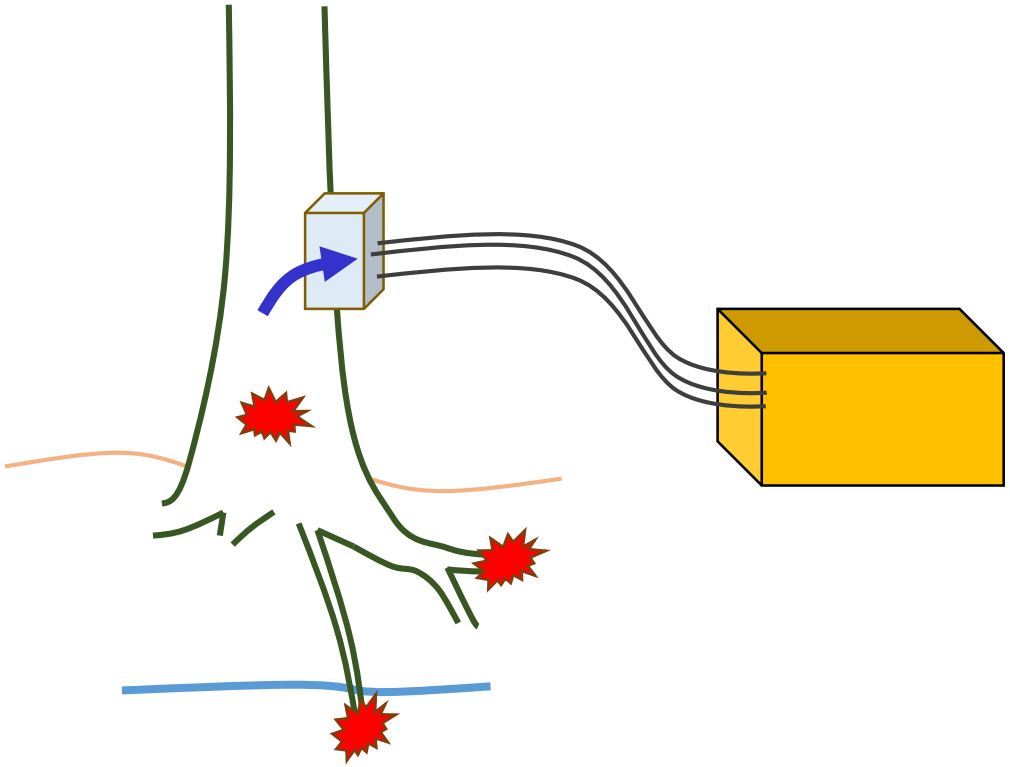
Tree CH_4 process model



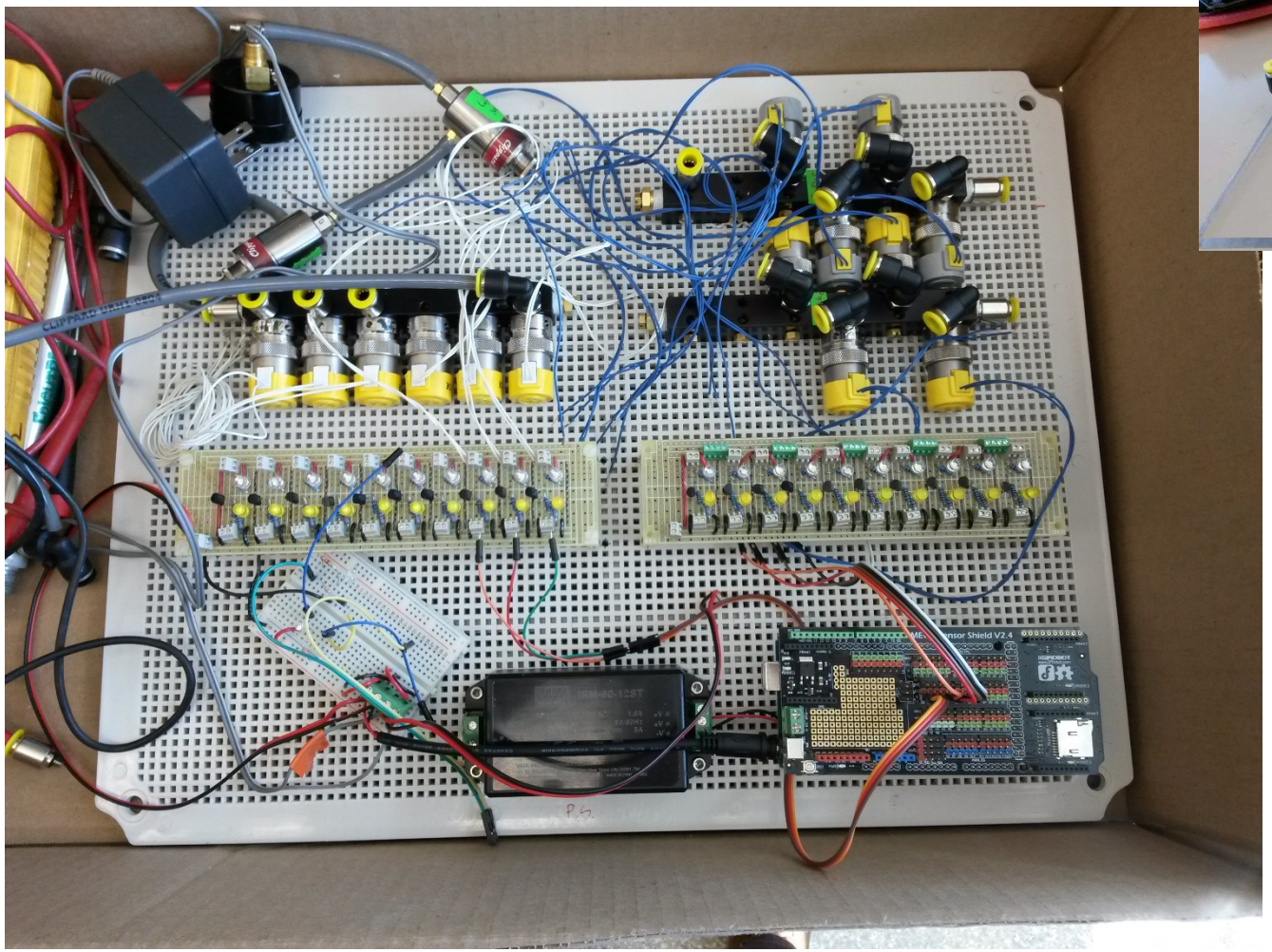
- Temperature increases methanogenic rates.
- Moisture increases anoxia (and potential methanogenesis), but slows gas diffusion.

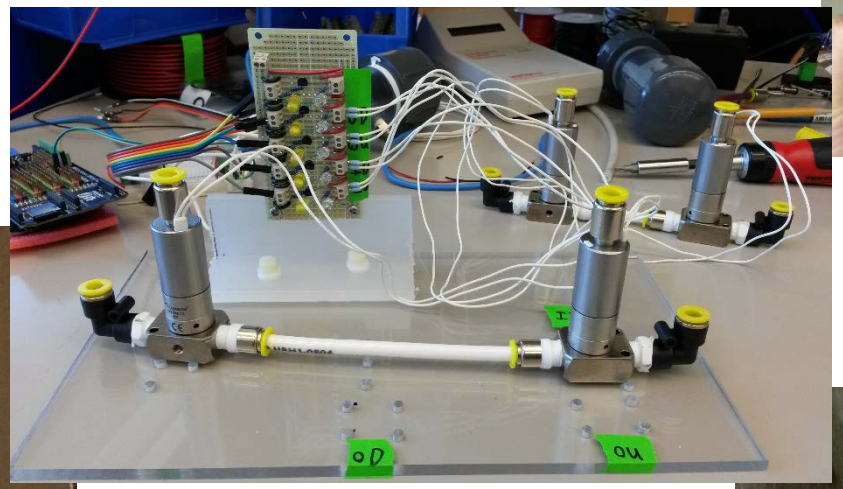
Methods

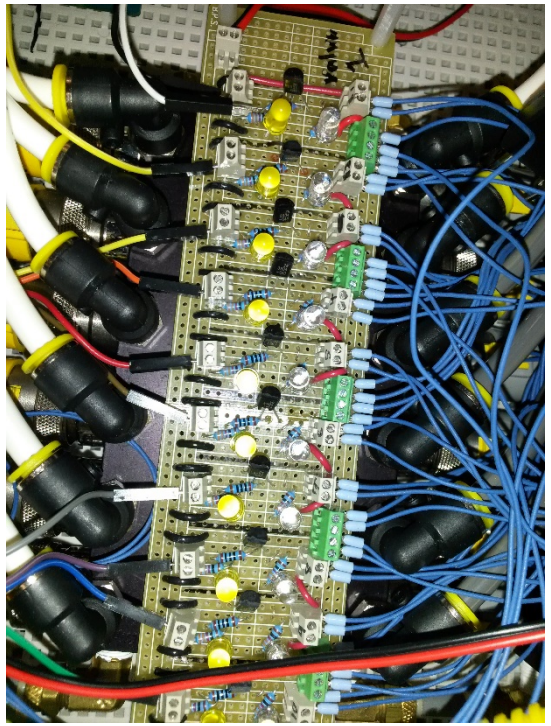


Beech and tulip poplar (4 replicates)
Automated measurements, every 2 hours

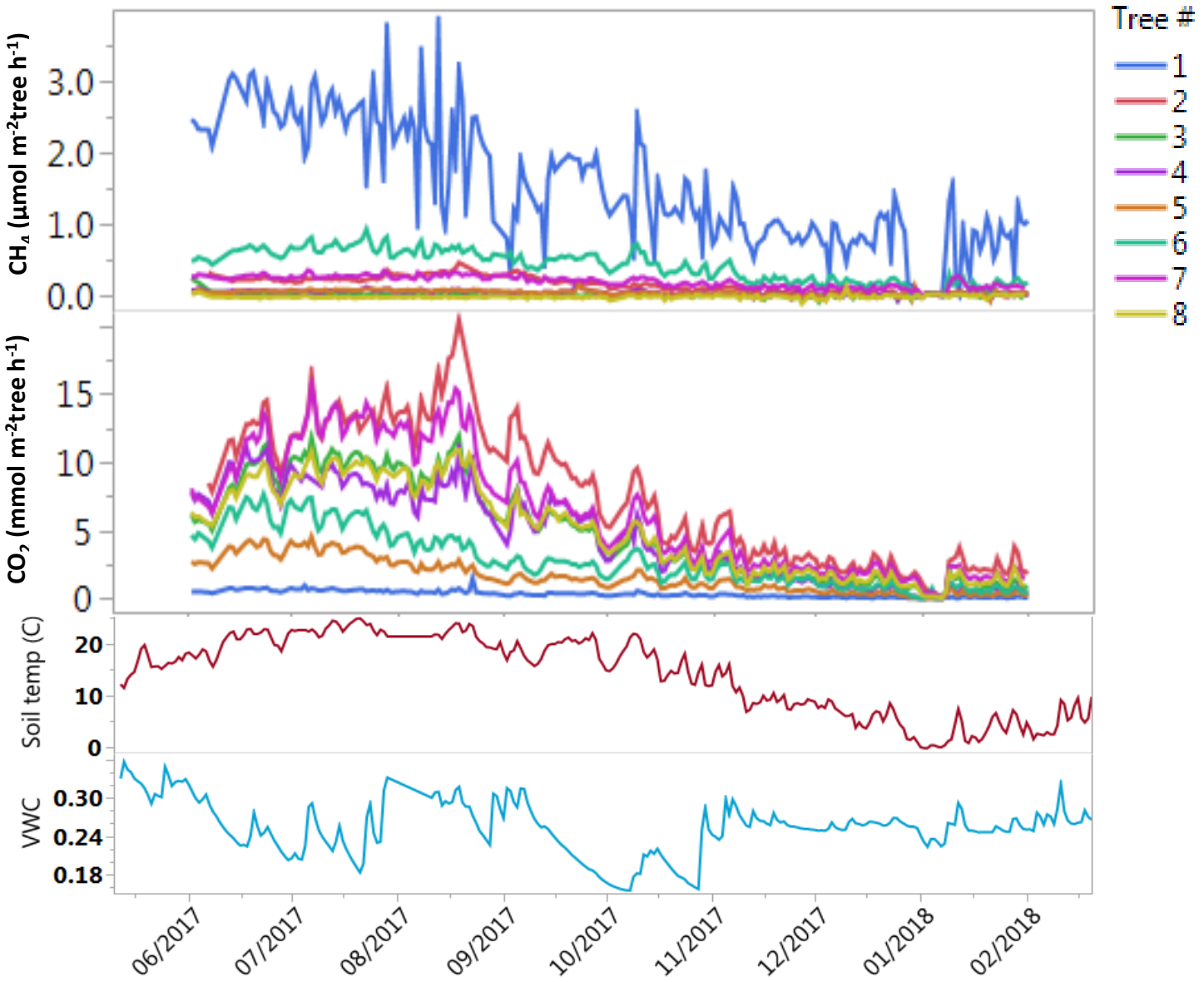
Automated manifolds for high-frequency sampling



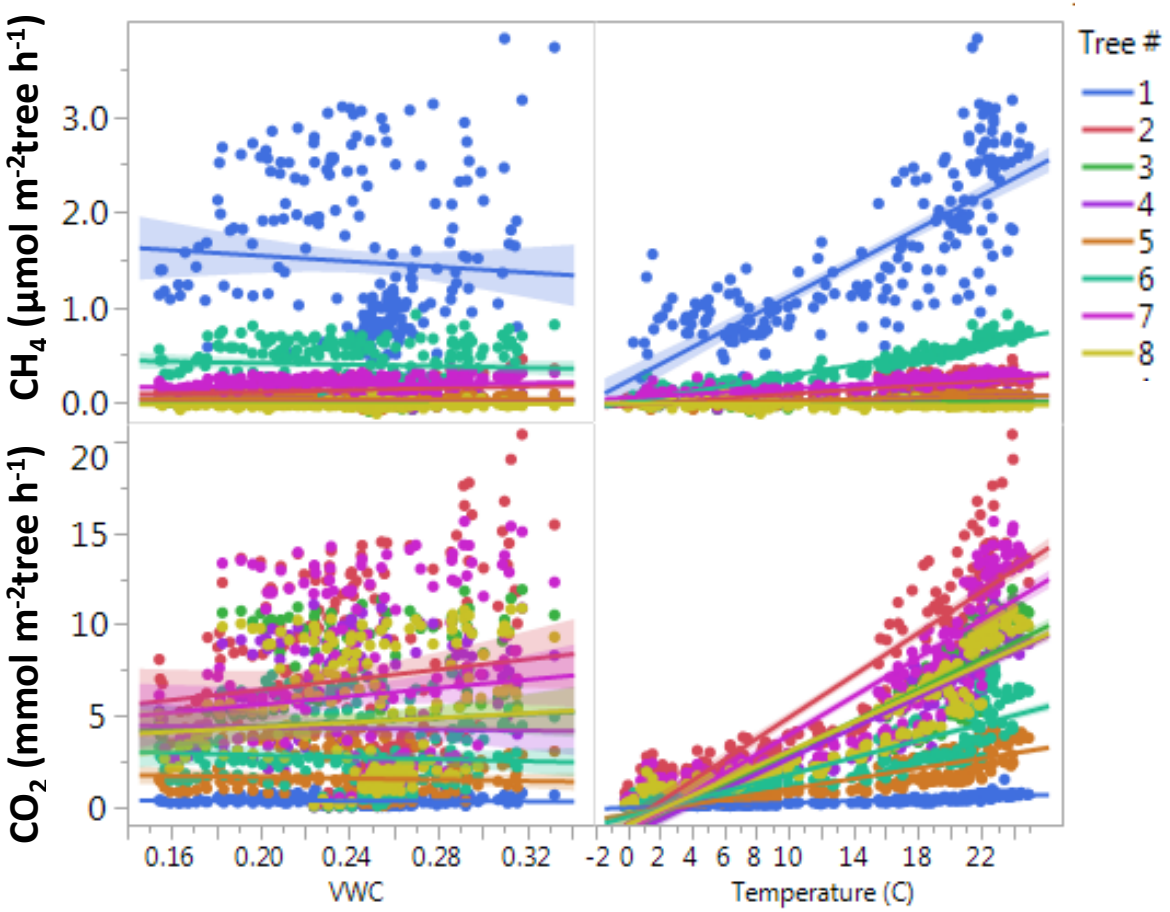




CH_4 and CO_2 daily averages



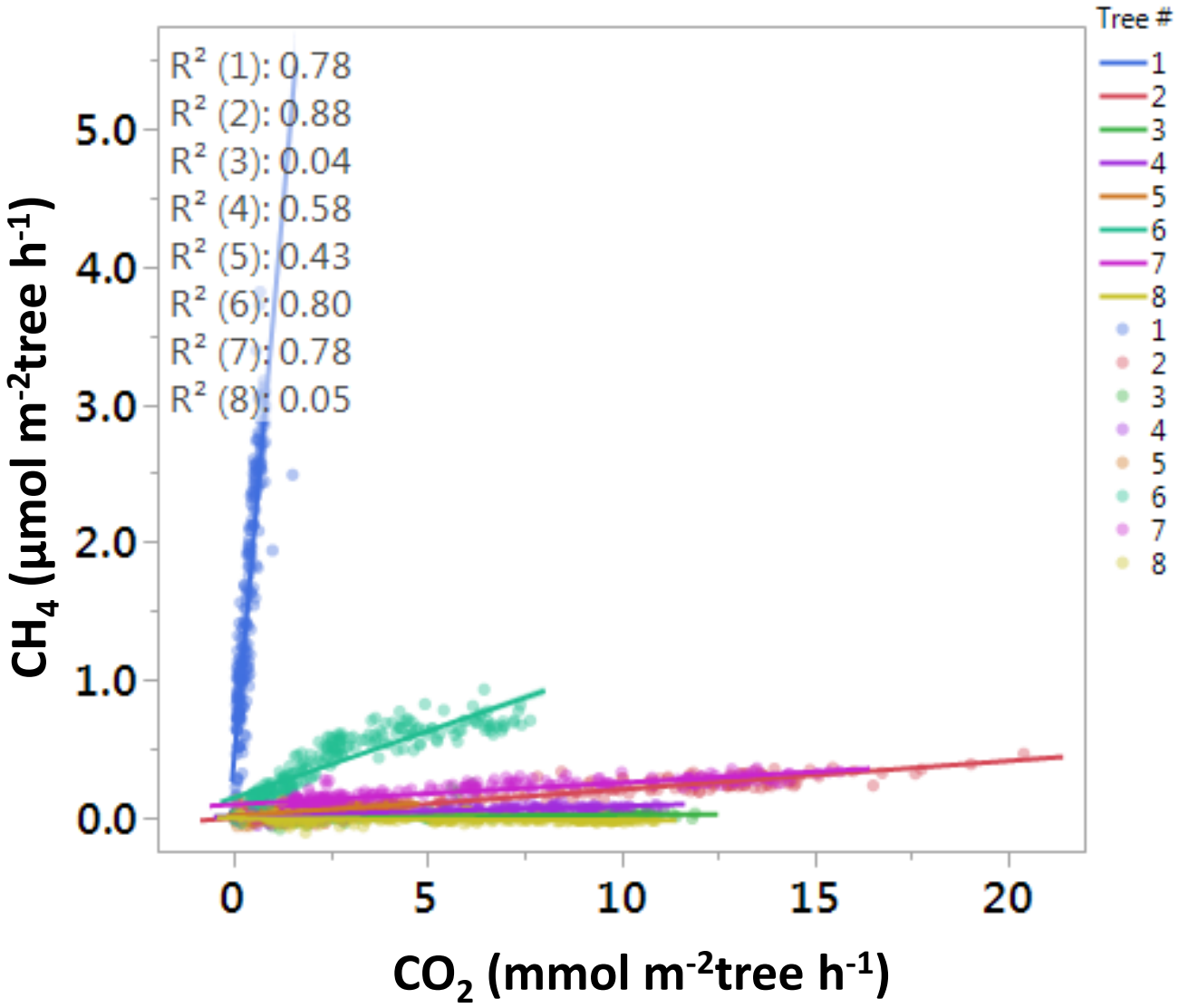
Daily CH_4 and CO_2 over soil moisture and temperature



CH_4 Flux ~ VWC + Temp + VWC x Temp

Tree #	Species	DBH	Model r^2	VWC *p*	Temp *p*	VWC x temp *p*
1	Beech	25.8	0.64	0.071	<0.0001	0.21
2	Tulip poplar	102.5	0.72	<0.0001	<0.0001	<0.0001
3	Tulip poplar	66.2	0.09	0.0063	0.0008	0.66
4	Beech	34.5	0.57	0.414	<0.0001	0.75
5	Beech	32.5	0.48	0.177	<0.0001	0.87
6	Beech	29	0.93	<0.0001	<0.0001	0.11
7	Tulip poplar	74	0.84	<0.0001	<0.0001	0.09
8	Tulip poplar	55.5	0.07	0.49	0.0007	0.7

Daily CH_4 vs CO_2 – A shared control?



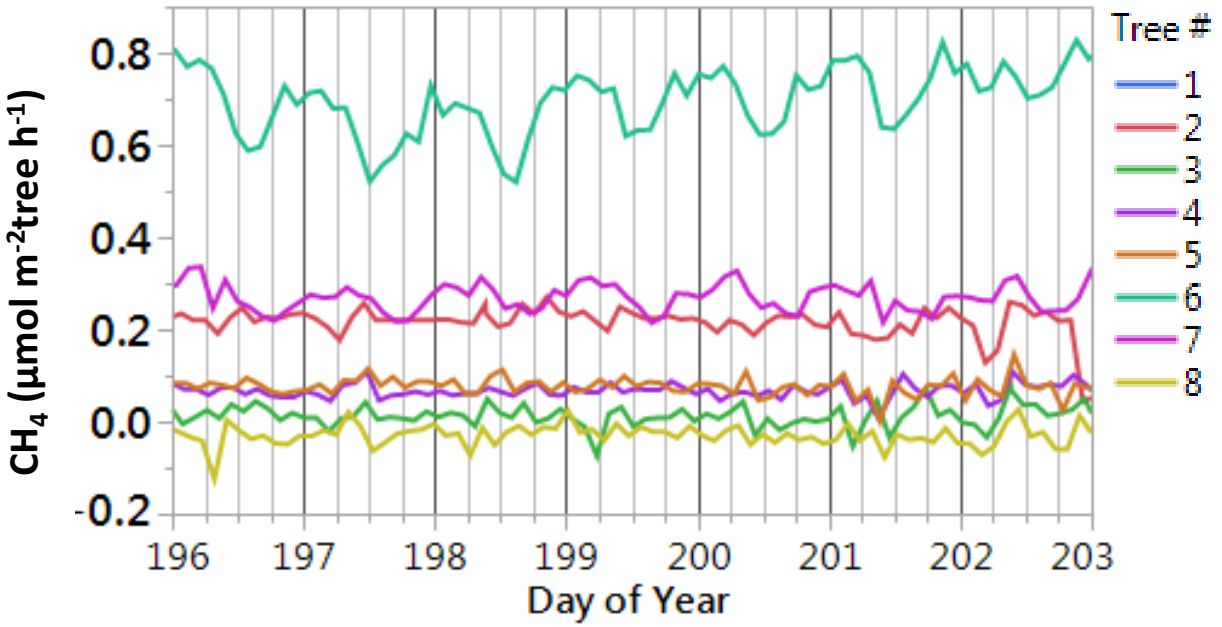
Candidate shared controls:

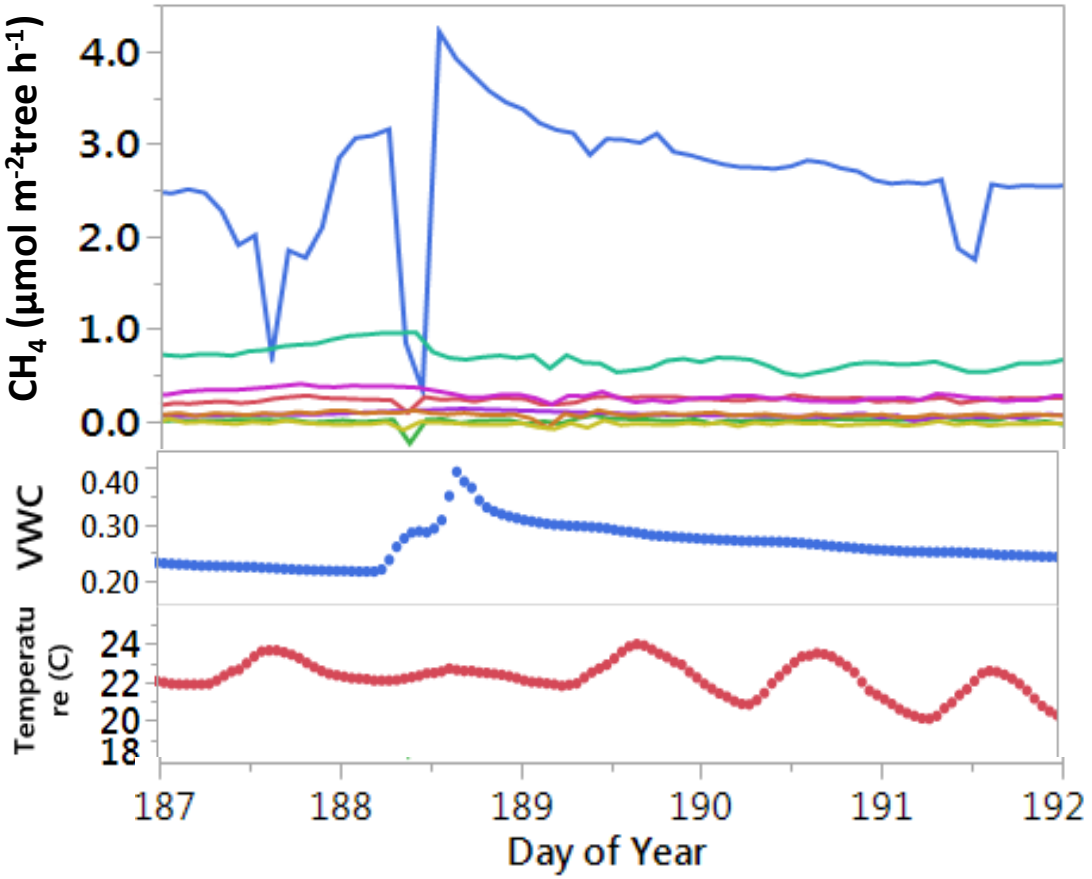
- Temperature
  - Methanogenesis
  - Respiration
  - Diffusion

- Photosynthate
  - Methanogenesis
  - Respiration

Strong correlation indicates it may be possible to use stand respiration to estimate stand CH_4 emissions.

Hourly dynamics of CH_4



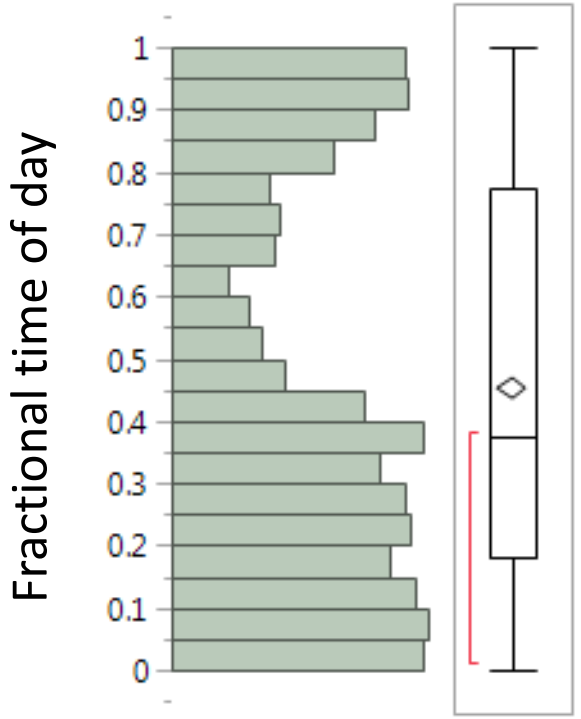


Sampling time of day effect on flux estimates

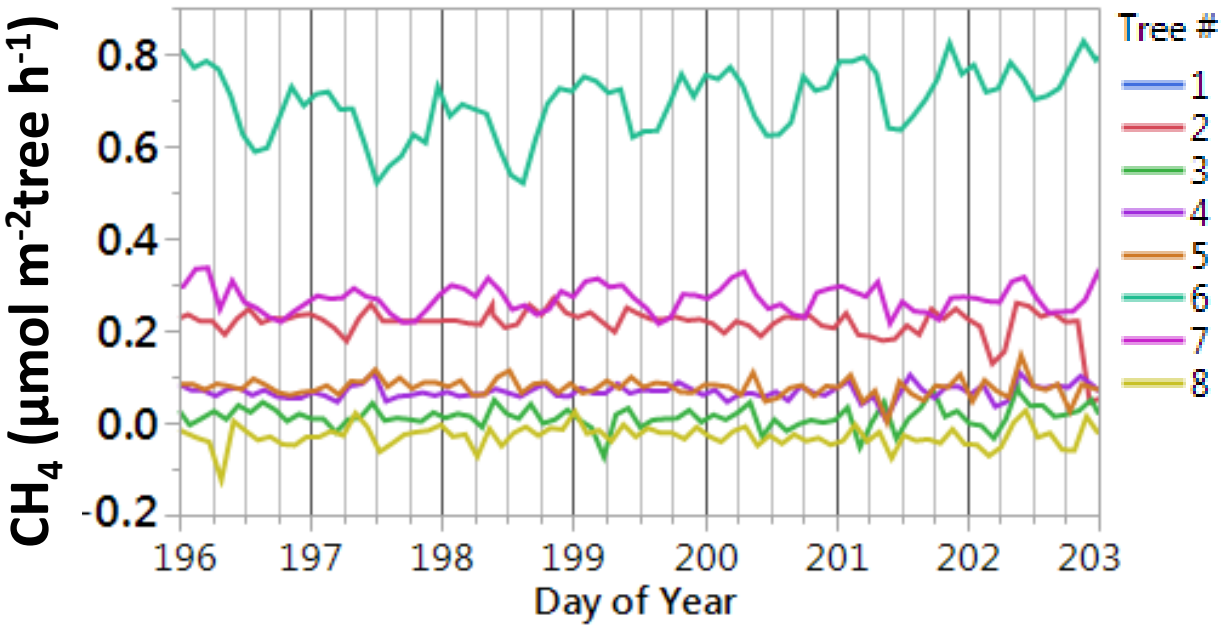
Sampling period	10:00-12:00	17:00-19:00	Full day
Tree 1			
Summer	2.06	2.36	2.47
Fall	1.15	1.37	1.42
Winter	0.70	0.79	0.73
Tree 6			
Summer	0.60	0.63	0.64
Fall	0.46	0.46	0.45
Winter	0.20	0.20	0.16

Fluxes in CH_4 (µmol m^{-2}tree h^{-1})

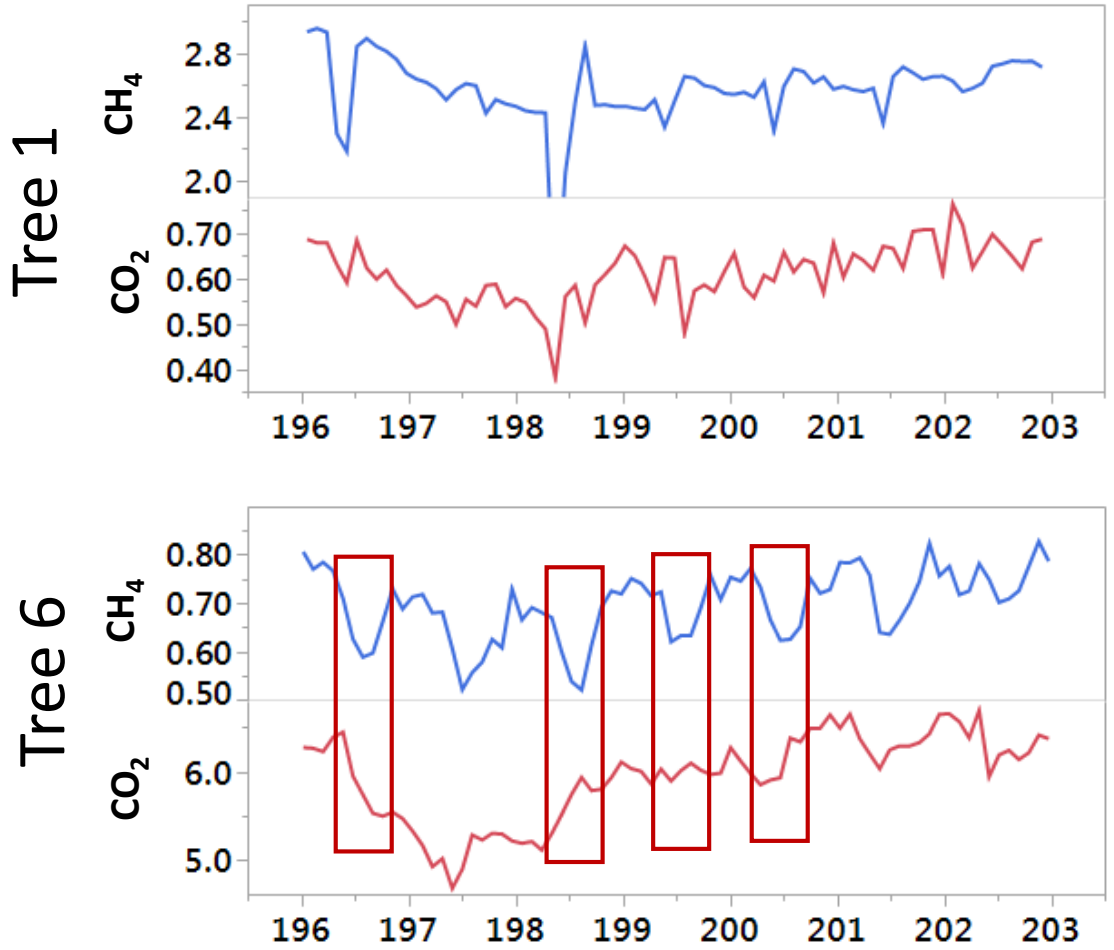
Distribution of negative fluxes over time of day (winter)



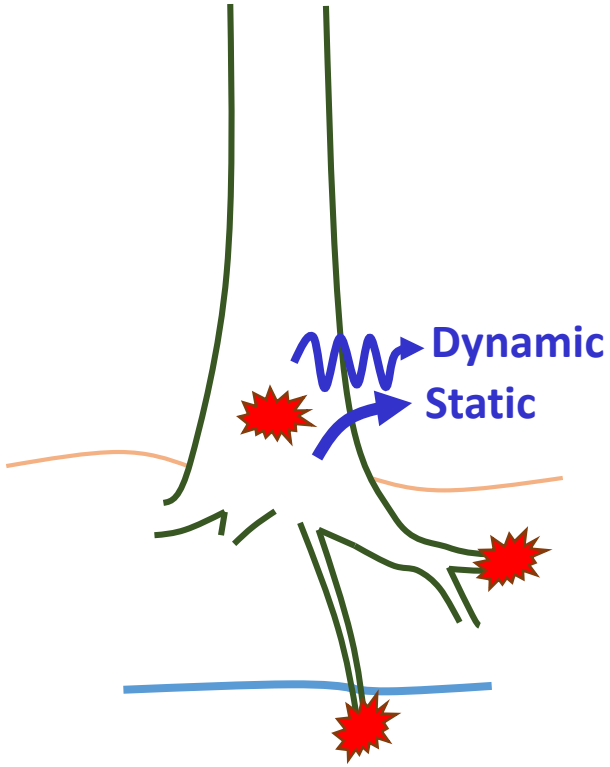
Hourly CH_4 and CO_2 fluxes – out of sync

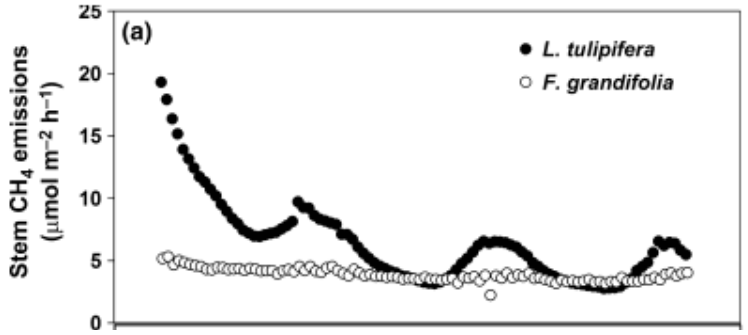


Tree	r² Daily mean fluxes	r² Hourly fluxes
1	0.58	0.07
6	0.88	0.31



Adding dynamic fluxes to process models





Pitz and Megonigal, 2017 New Phytologist

- Choice of sampling time or day may significantly affect stand CH_4 flux estimates.
- Hourly dynamics show physiology affects fluxes of CH_4 and CO_2 differently.
- Daily correlation between CO_2 and CH_4 indicates a shared physical (temperature) or physiological (photosynthate) control.

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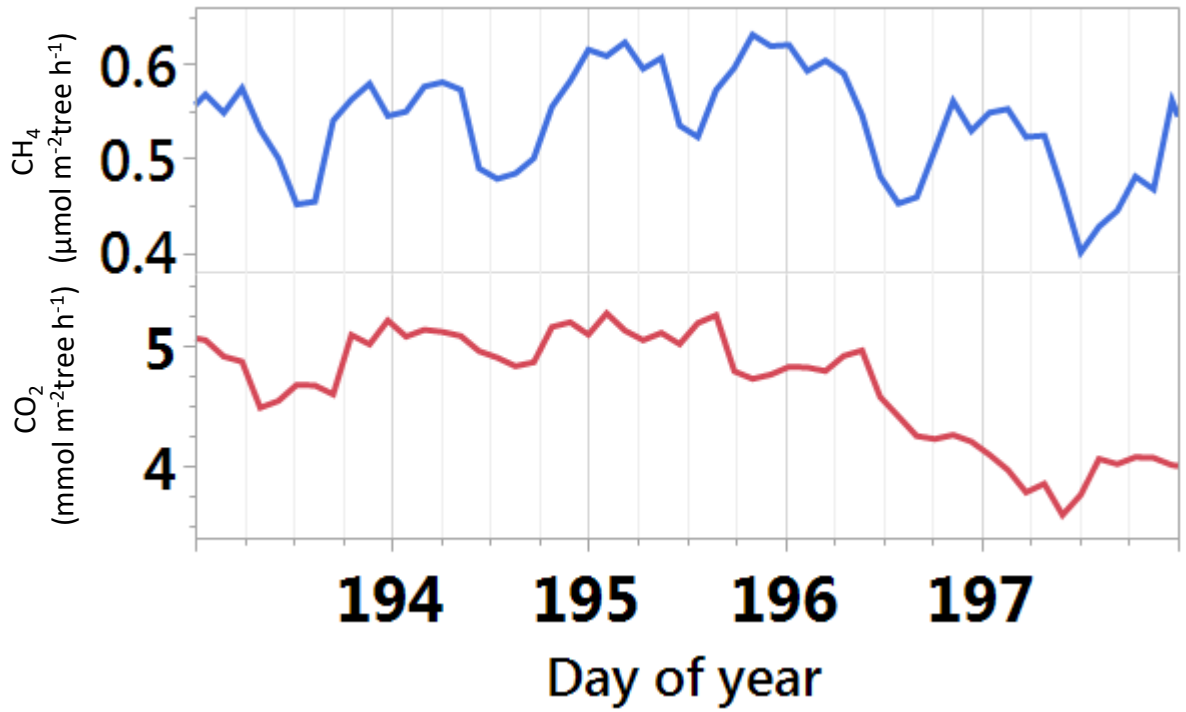
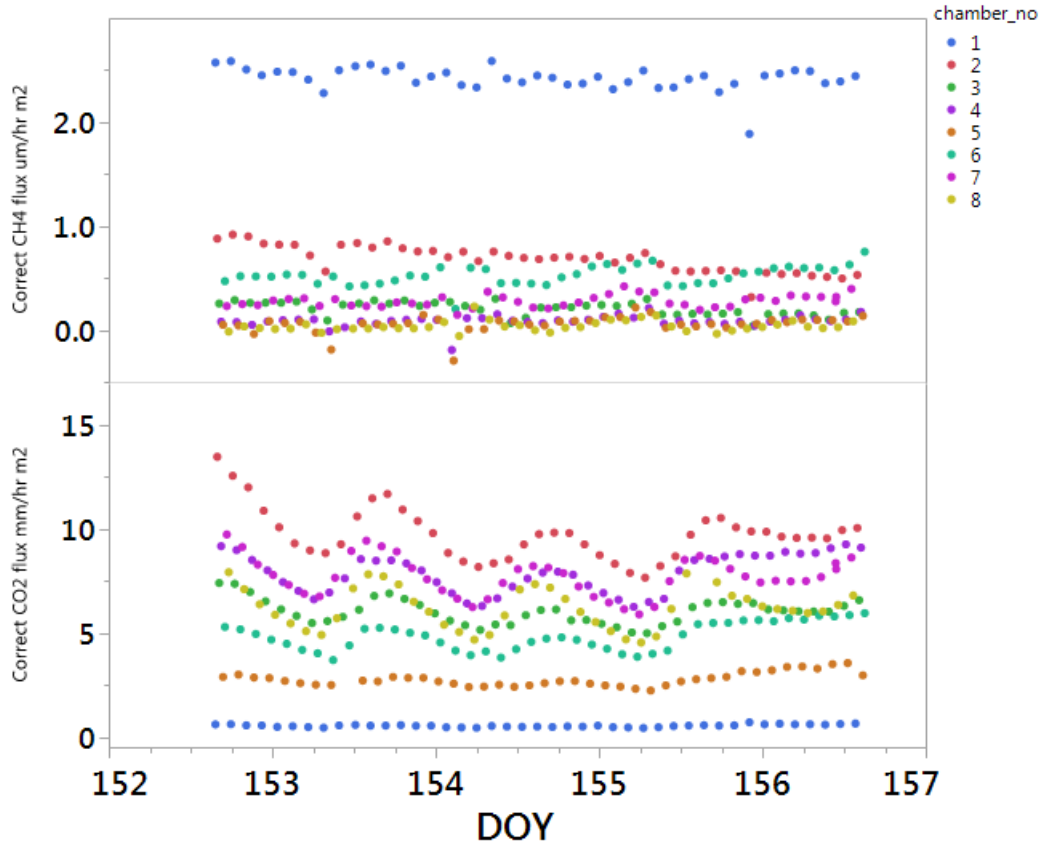
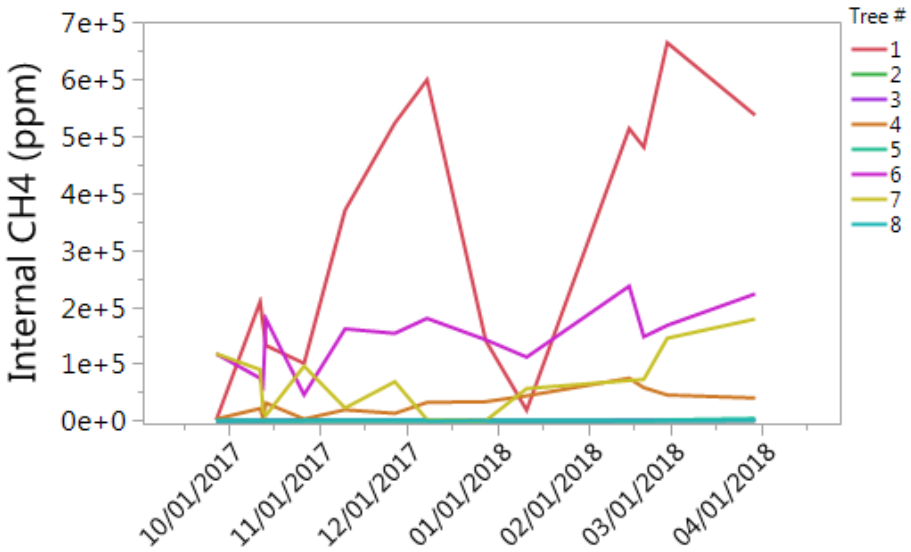
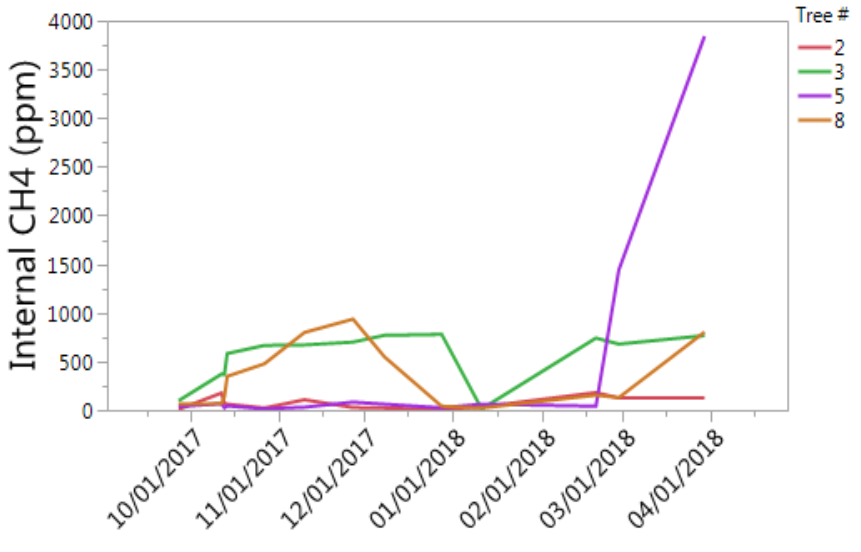

CH_4 (µmol m^{-2}tree h^{-1})
CO_2 (mmol m^{-2}tree h^{-1})
0.6
0.5
0.4
5
4
194
195
196
197
Day of year

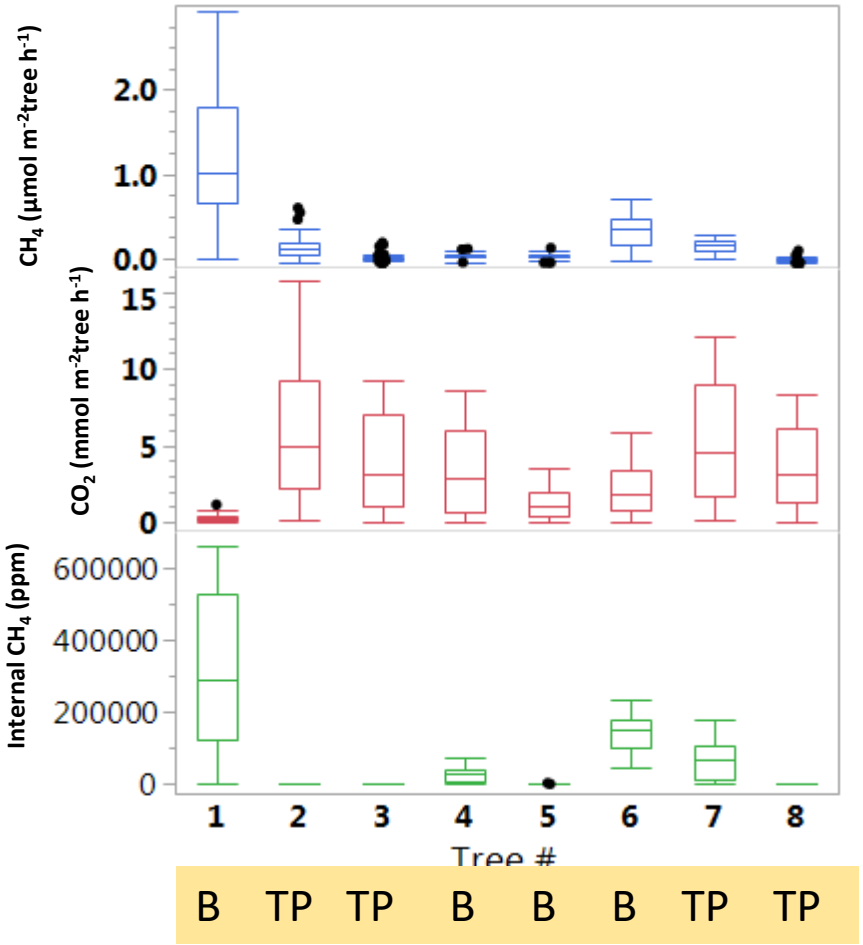

chamber_no
1
2
3
4
5
6
7
8
Correct CH4 flux um/hr m2
2.0
1.0
0.0
Correct CO2 flux mm/hr m2
15
10
5
0
152
153
154
155
156
157
DOY

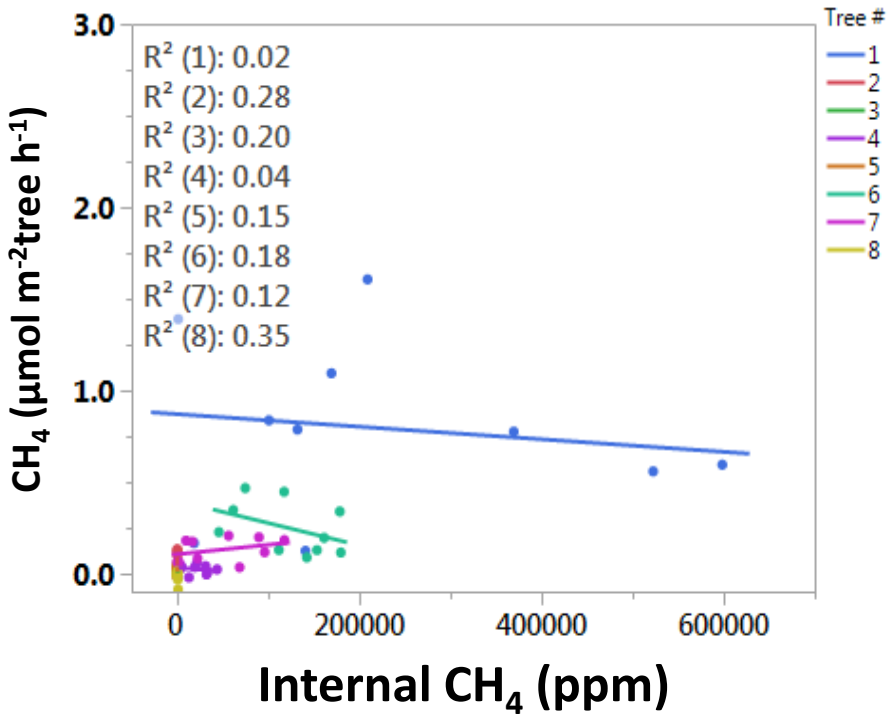
Internal CH_4 – Fall and Winter



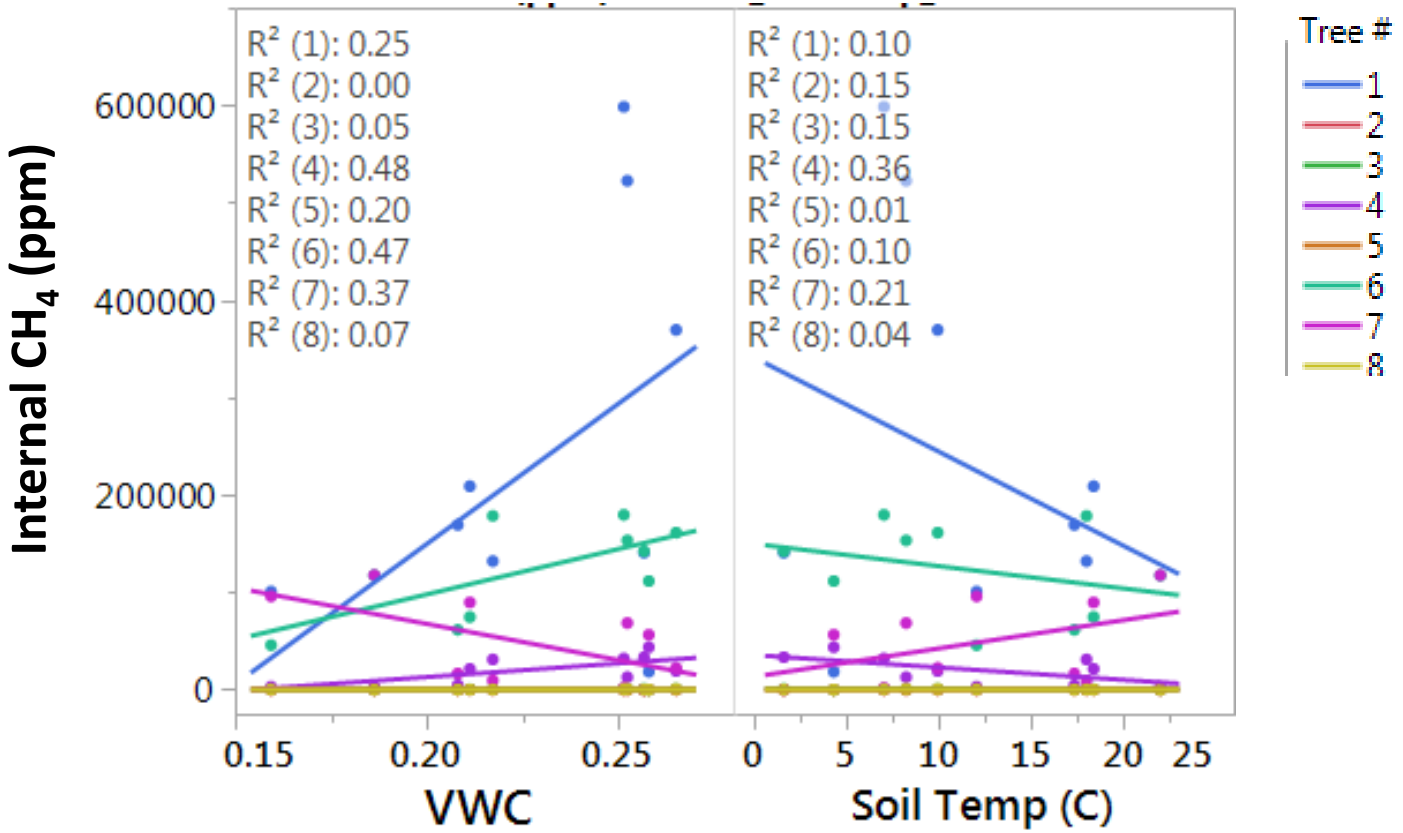


Internal CH_4 vs CH_4 fluxes





Internal CH_4 - moderate relationships with moisture and temperature



Conclusions

- CH_4 emission has a positive relationships with temperature, but low or negative relationship with VWC
- Beech trees appear more likely to host high CH_4 emissions compared to tulip poplar

- CH_4 emission also has very strong relationships with CO_2 in individual trees
- Low correlation of flux with internal CH_4
  - Thus emission appears to be controlled by transport processes on the day-week timescale

- Internal CH_4 may be strongly influenced by moisture