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Soil atmosphere CH_4 exchange at the Wombat and Warra flux site

Soil-atmosphere CH_4 fluxes in forest soils

Ecosystem	Region	CH_4 flux ($\mu g\ m^{-2}\ h^{-1}$)	
		Range	Mean
Forest	Boreal	-158 to -1	-65 ± 28
	Temperate	-445 to 1	-44 ± 24
	Sub/ tropical	-116 to 1	-24 ± 16

after Dalal et al. 2008

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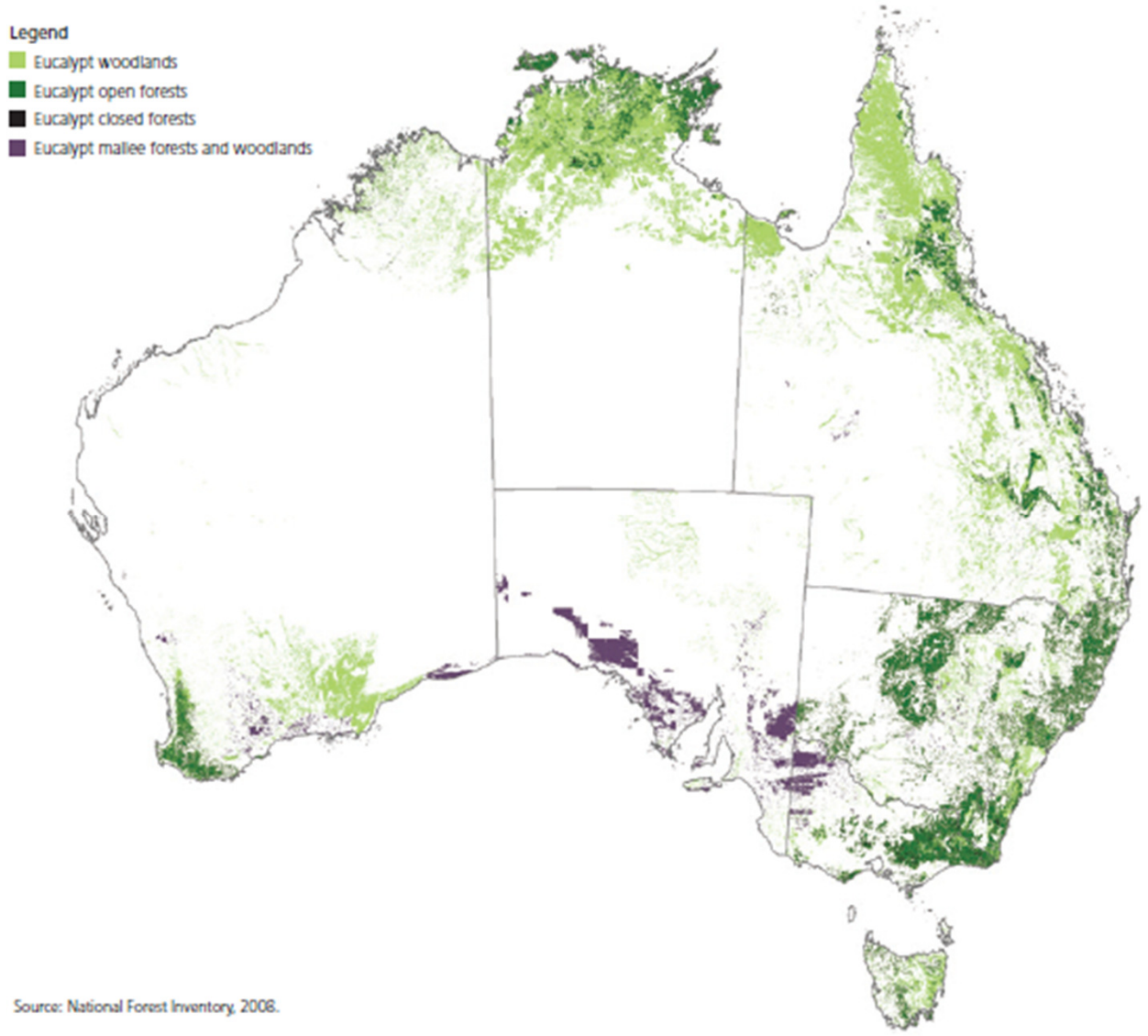
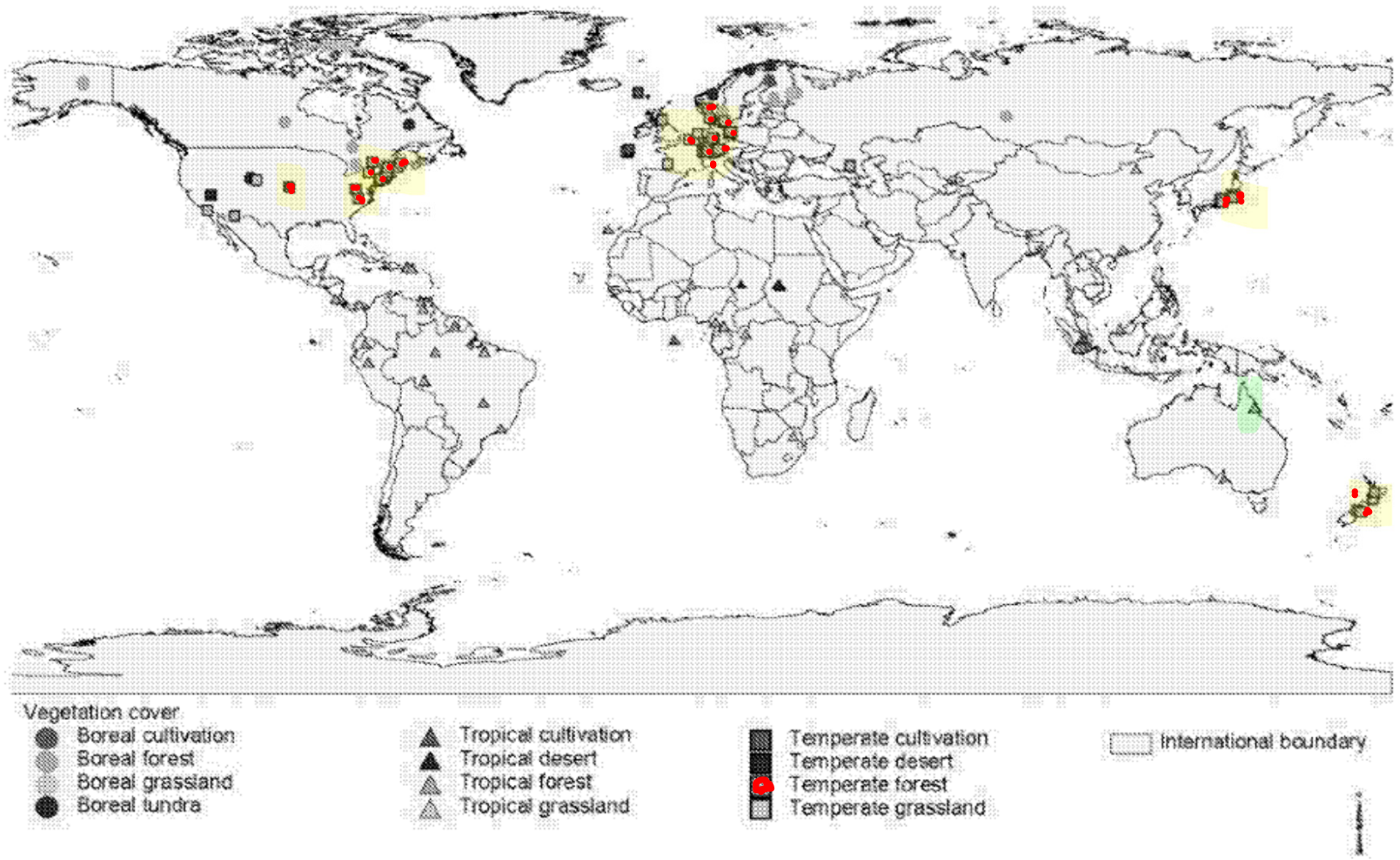
Temperate forests in SE Australia



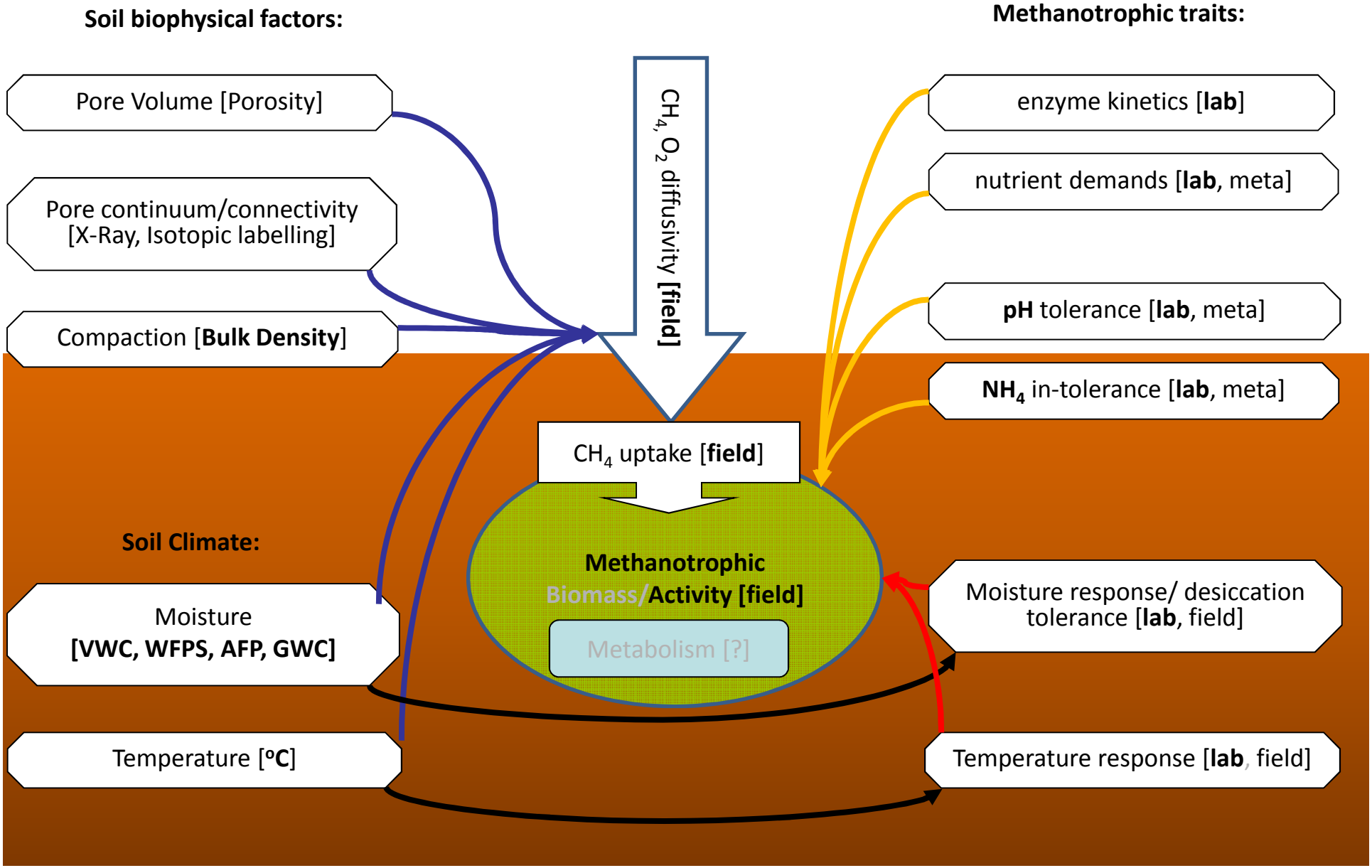
Source: National Forest Inventory, 2008.

Research rationales



after Dutaur and Verchot 2007, Global Biogeochem

Regulators of soil CH_4 uptake and what we measure



Consequences for soil CH_4 uptake

- Warmer and drier conditions

  => drier soil conditions?

- Increased wildfire danger and frequency

  => soil disturbance, stand regeneration, stand water use?

- Higher frequency of planned burning

  => soil disturbance?

Main research objectives

A. Investigation of temporal drivers of soil CH_4 uptake in temperate eucalypt forests of SE Australia

B. Investigation of Fire and Climate Change impact on soil CH_4 uptake in temperate eucalypt forests of SE Australia

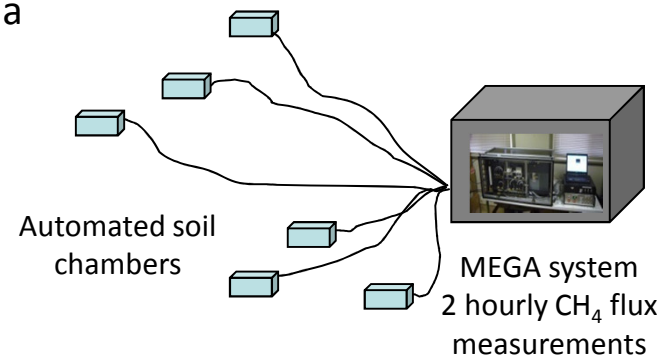
B 1. Assessment of potential wildfire and planned burning effects

B 2. Assessment of simulated climate change impacts

Objective A: temporal regulators

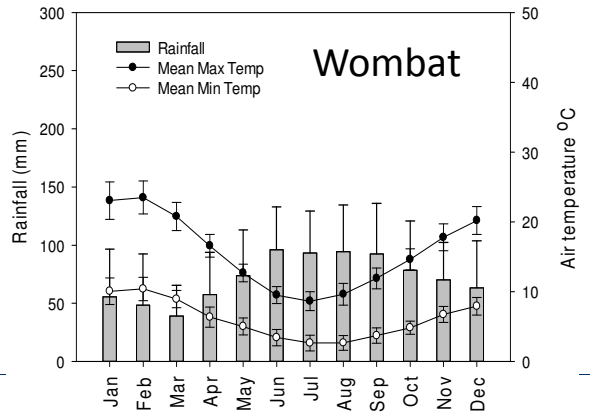
Investigation of temporal controls of soil CH_4 uptake in eucalypt forests of SE Australia

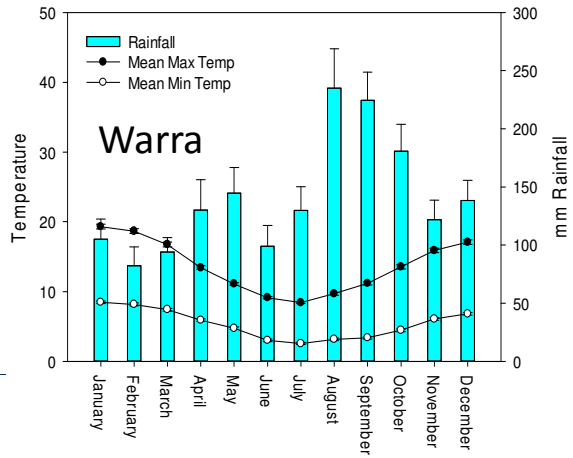
Two automated Chamber systems installed in two Eucalyptus obliqua forests with contrasting yearly precipitation

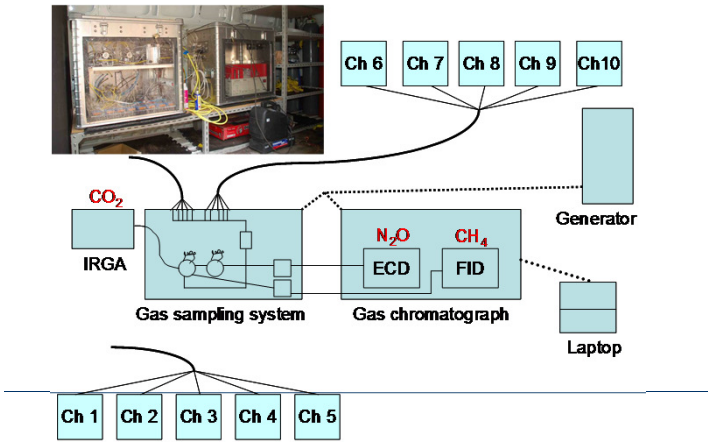


- System A = Wombat State Forest (FTIR, 6 chambers)
  04/2010 – ongoing
- System B = Warra LTER (GC, 10 chambers)
  01/2011 – 01/2012
- Both systems allow CH_4 flux measurements at 1-2 hour frequency

- Soil moisture, soil temperature, and soil inorganic N status was monitored







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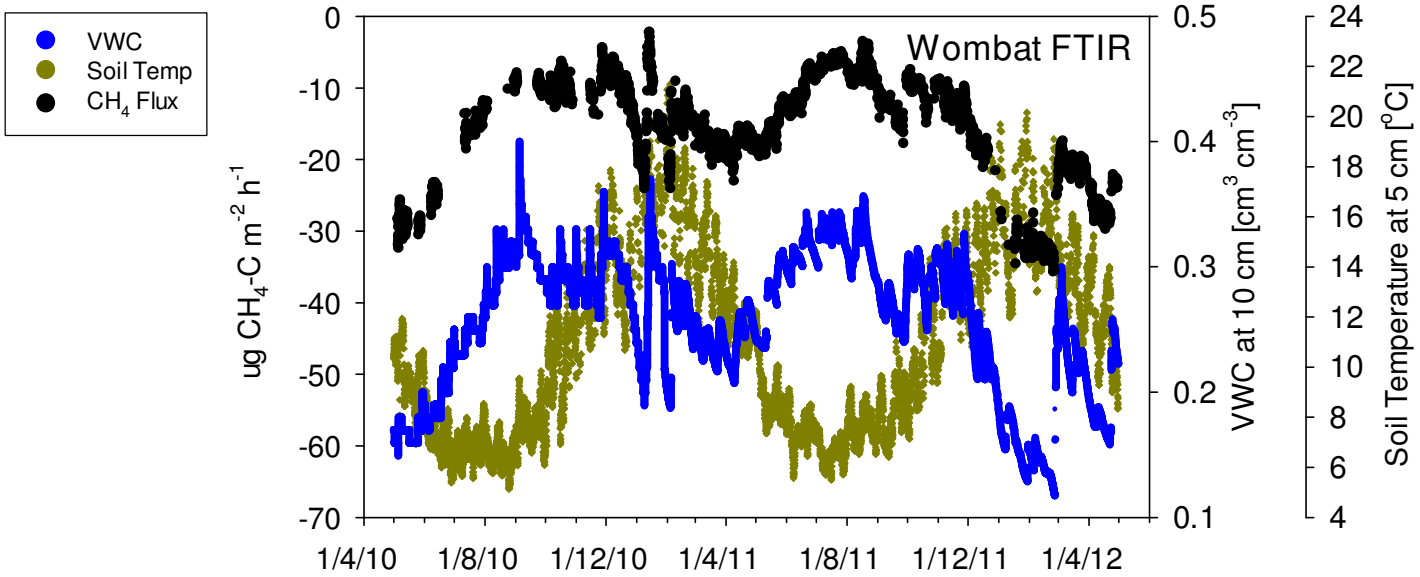
Results A: temporal regulation



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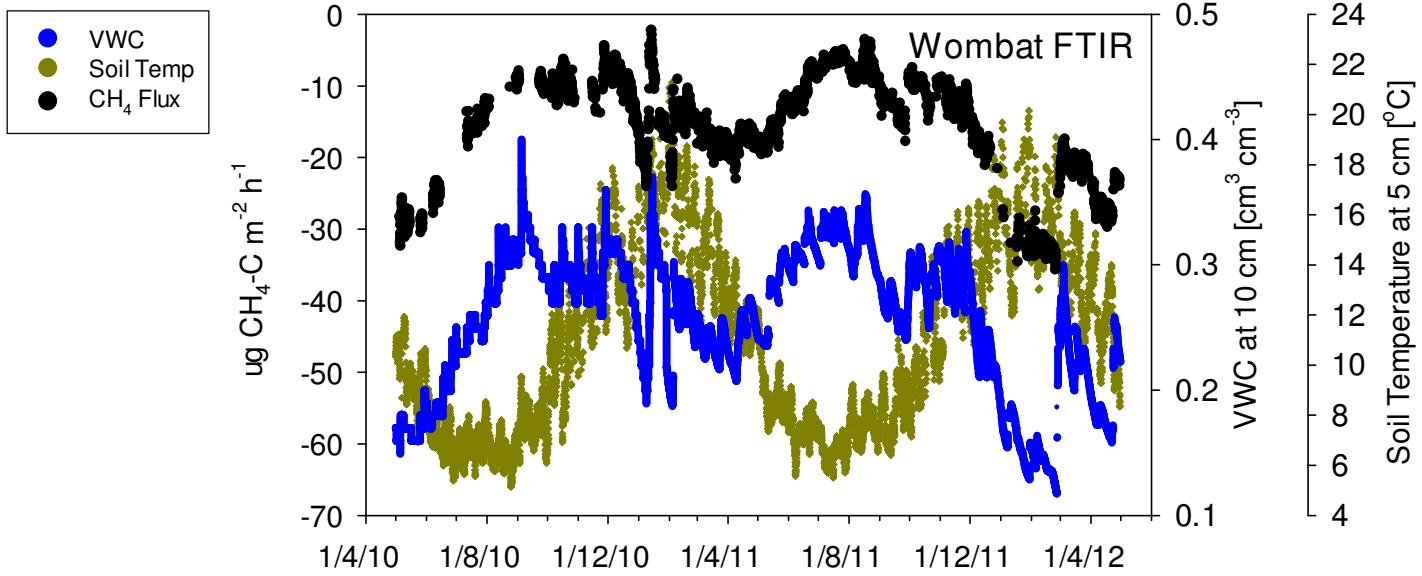
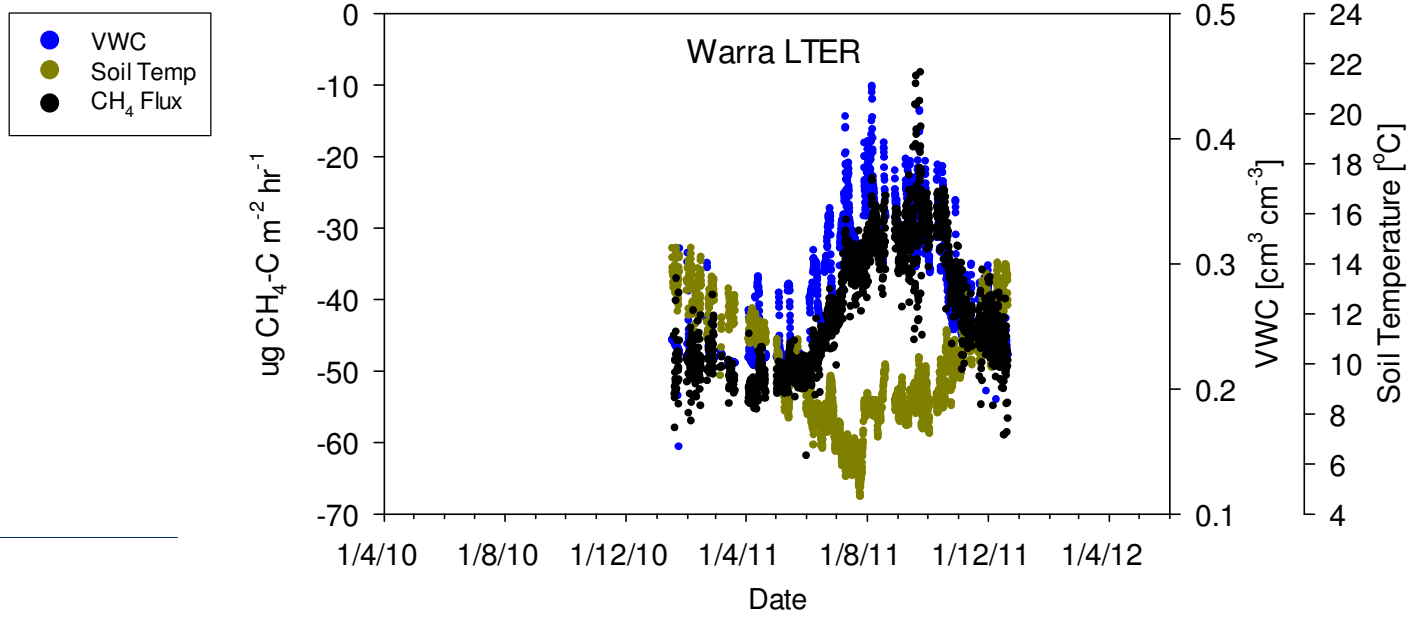
Results A: temporal regulation





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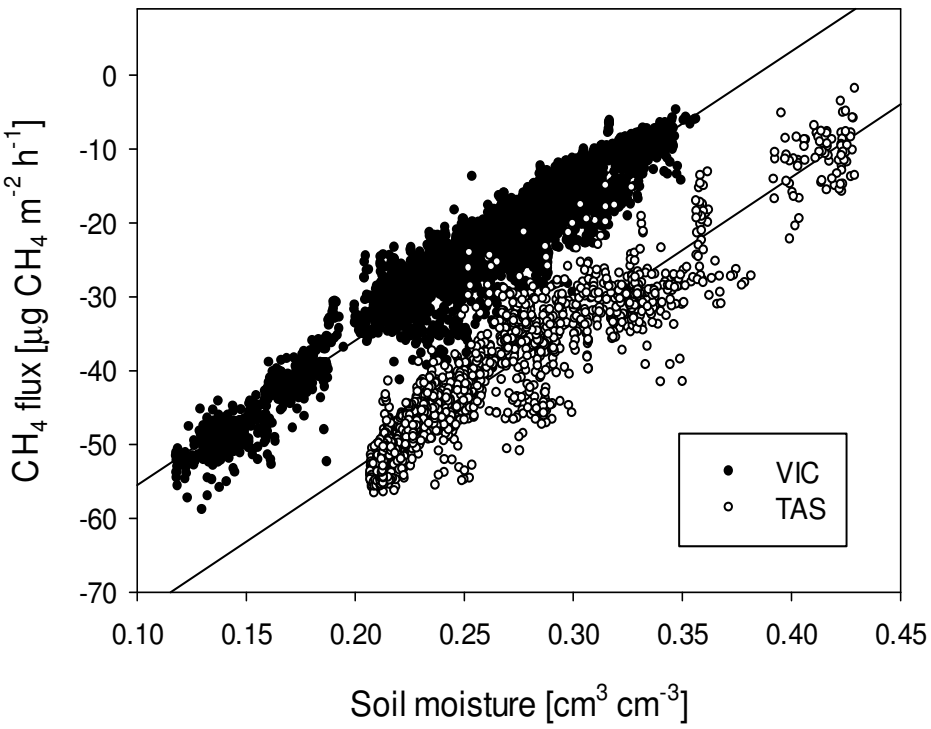
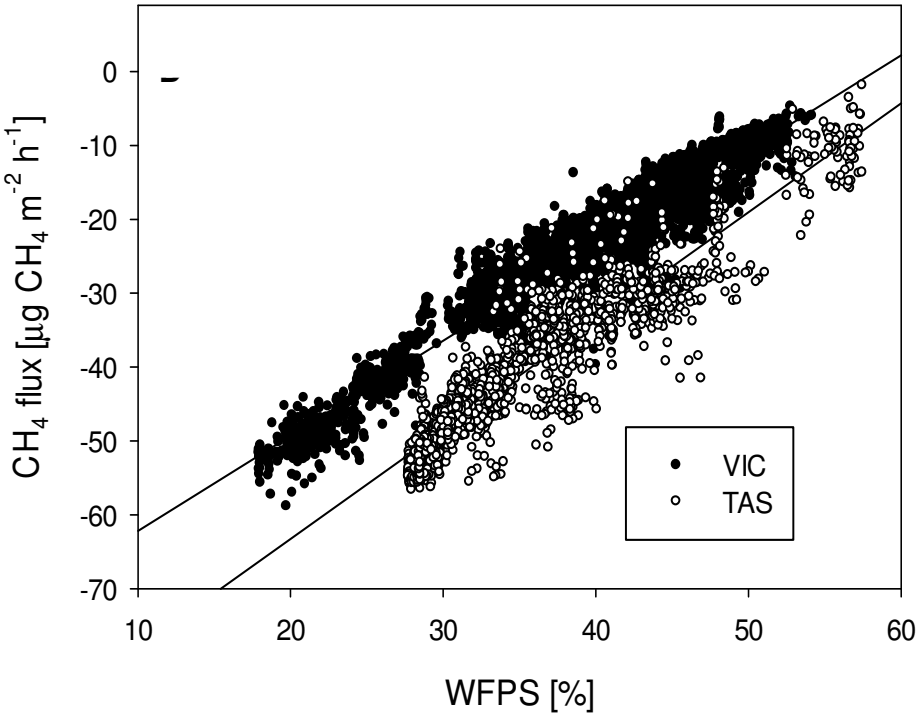
Results A: temporal regulation

VIC: $R^2 = 0.924$, $p < 0.001$

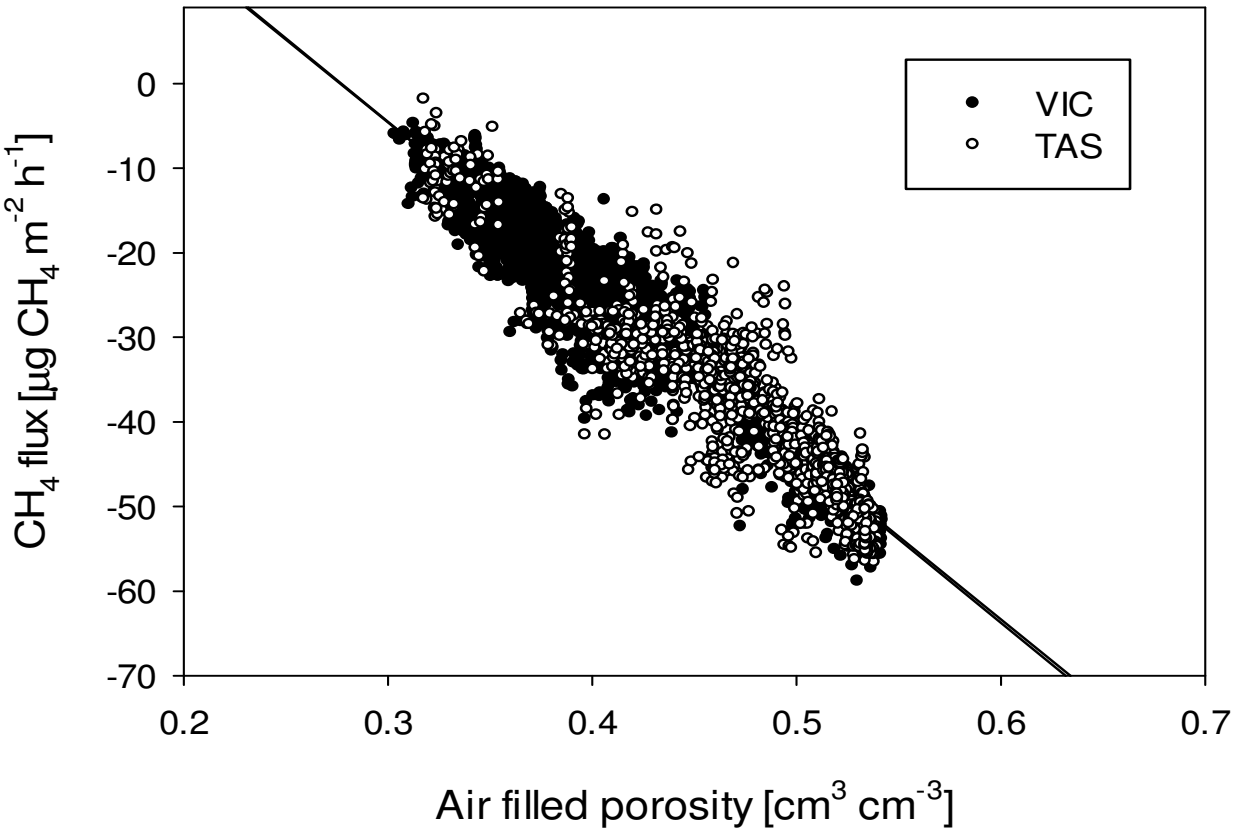




TAS: $R^2 = 0.896$, $p < 0.001$

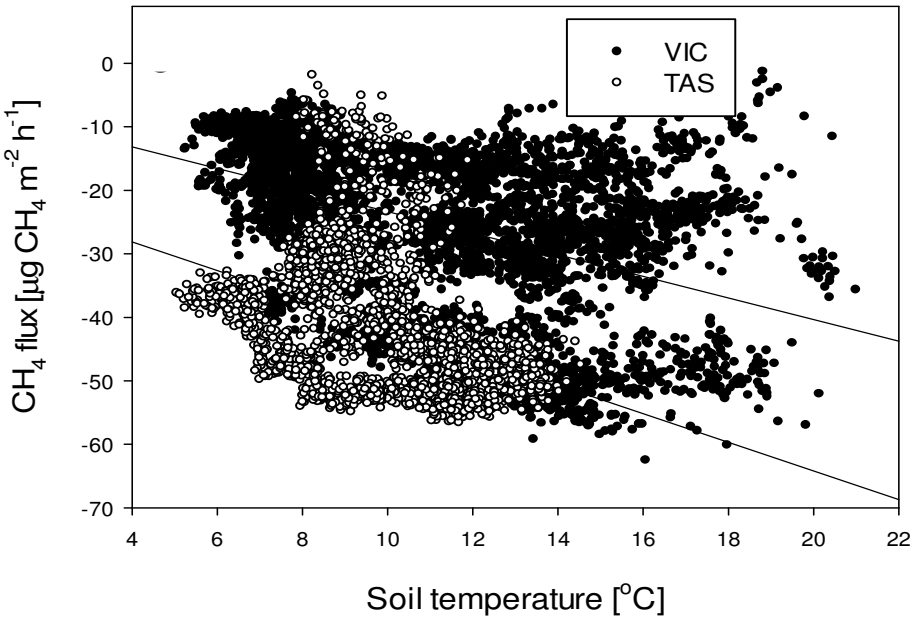
Results A: temporal regulation

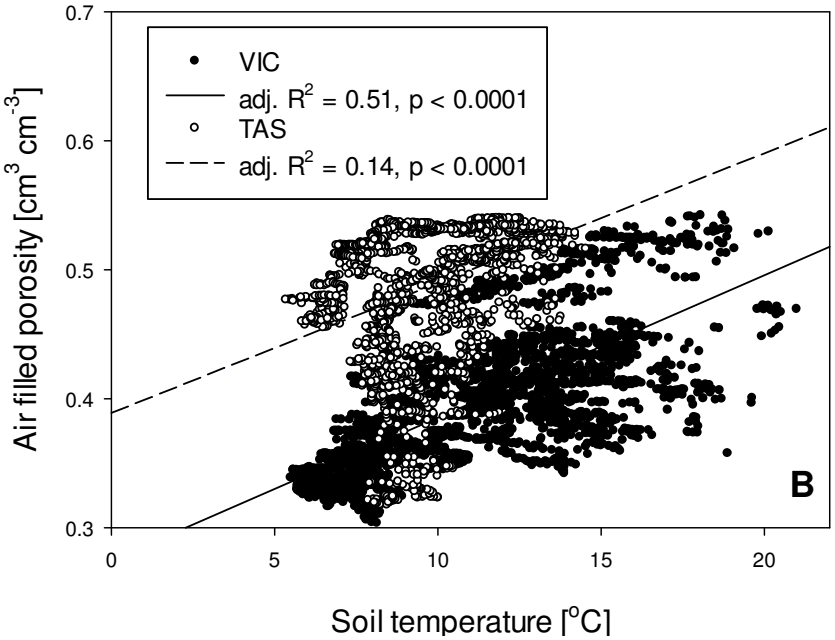
VIC: F_{CH4} = 53.943 – 195.768*AFP; R^2 = 0.924, p< 0.001
TAS: F_{CH4} = 53.640 – 195.378*AFP ; R^2 = 0.896, p< 0.001



Results A: temporal regulation

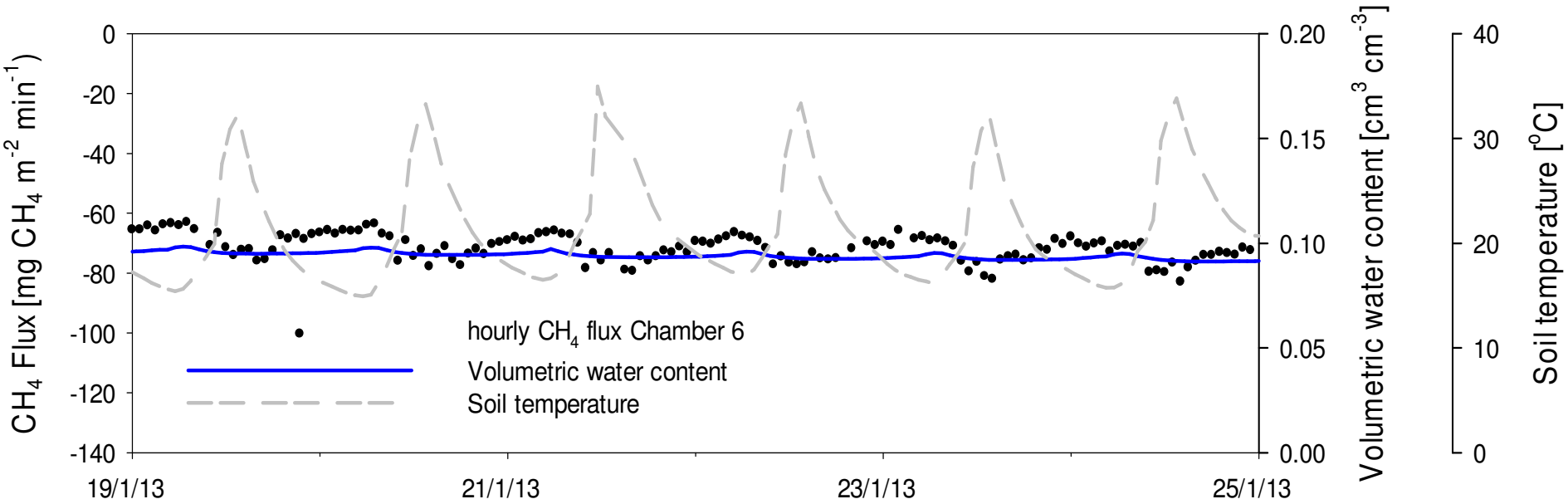
VIC: $R^2 = 0.148$, $p < 0.001$





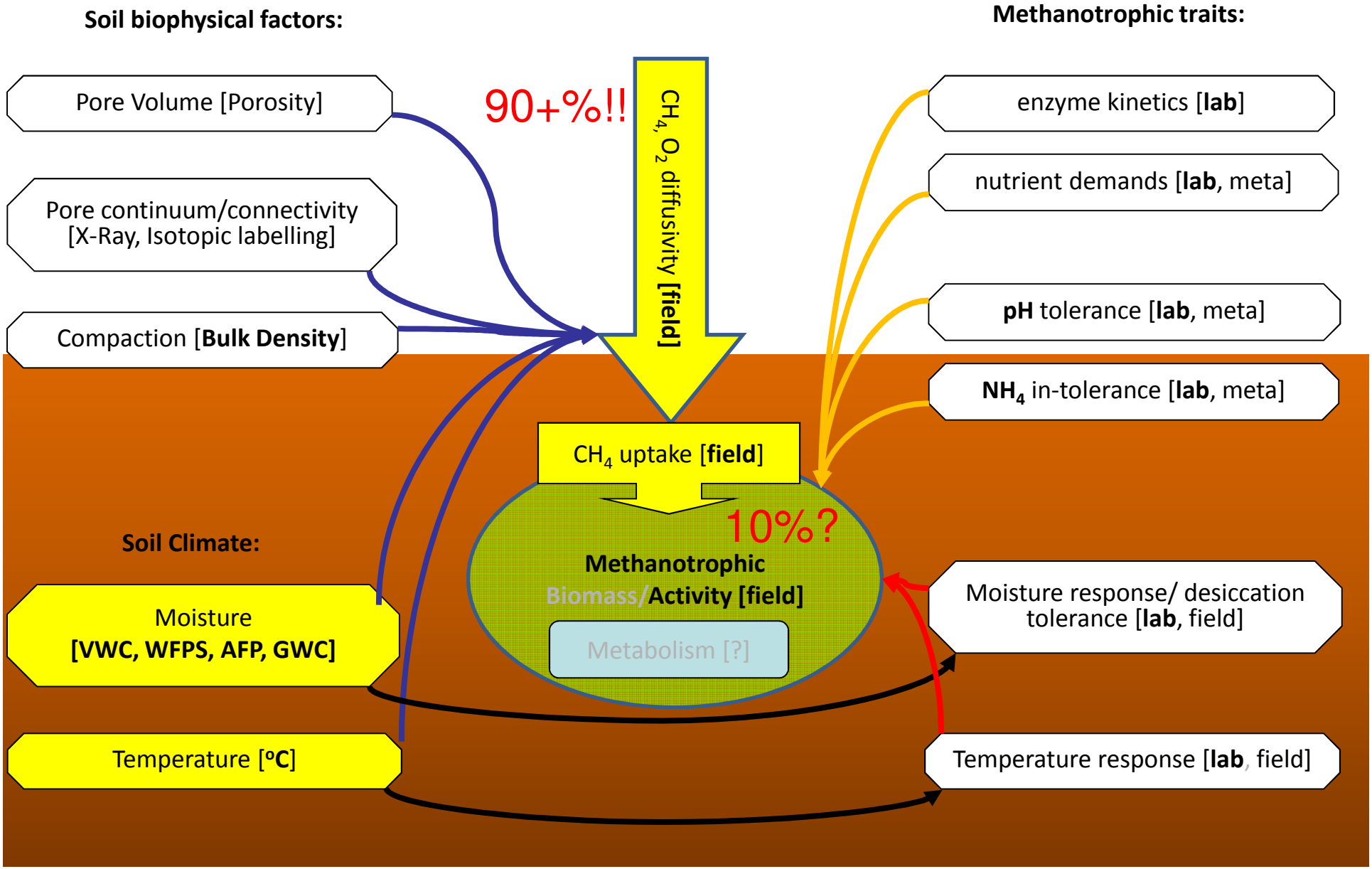
TAS: $R^2 = 0.203$, $p < 0.001$

Results A: temporal regulation



Q_{10} of 1.14 at Wombat Flux site

Regulators of soil CH_4 uptake and what we measure



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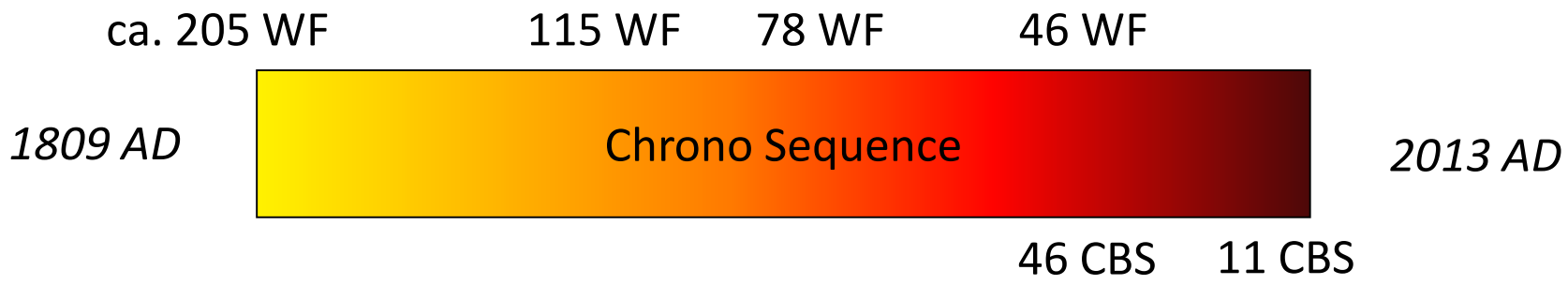
Results A: Temporal Regulation

- Temporal variability in soil CH_4 uptake is predominantly regulated by soil moisture status in both investigated forest systems (90%!!!)
- Soil temperature could only explain a small proportion of the temporal variability in soil CH_4 uptake
- Average soil CH_4 uptake was lower in the Wombat forest (-33.23±0.16 ug CH_4 m^{-2} h^{-1}) compared to the Warra forest (-54.21± 0.22 ug CH_4 m^{-2} h^{-1})
- Average soil bulk density was higher in the Wombat forest (~1.0) compared to the Warra forest (~0.7) => differences in soil porosity and average soil air filled porosity

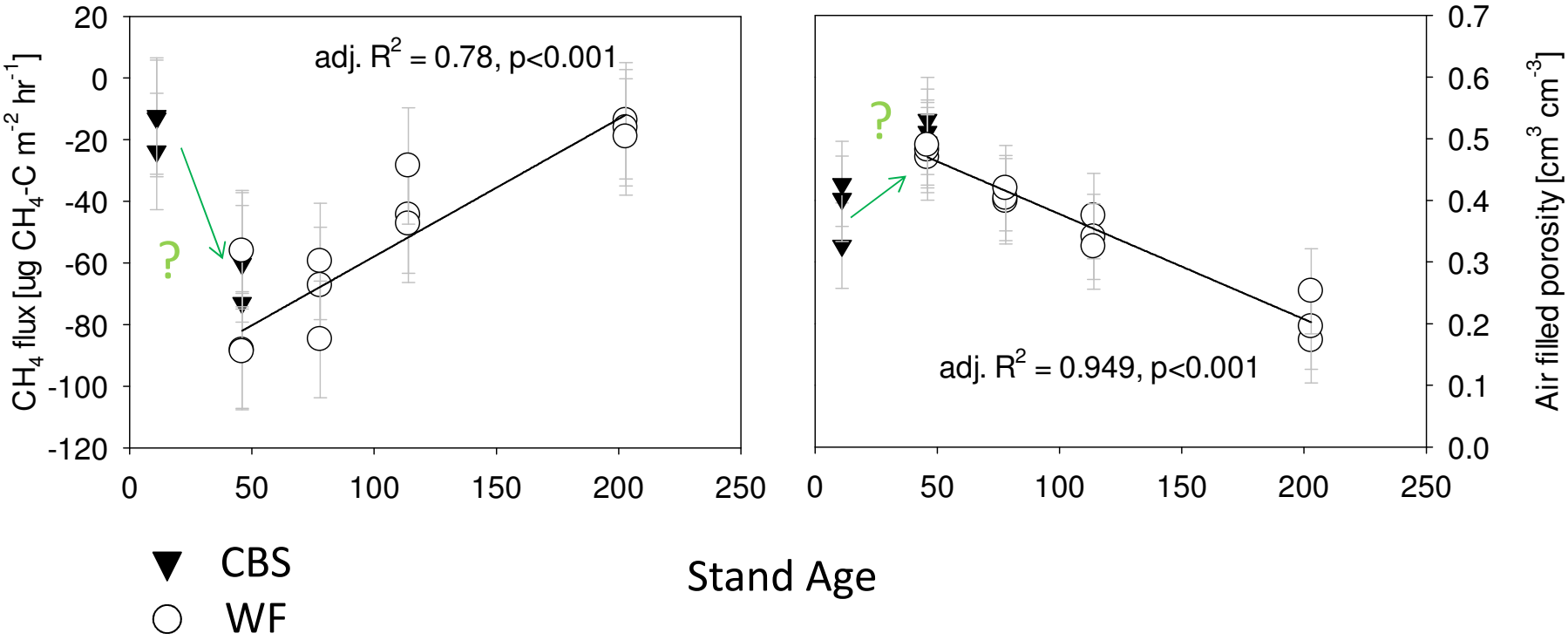
Objective B 1: Wildfire Effects

Assessment of potential wildfire effects on soil CH_4 uptake in eucalypt forests

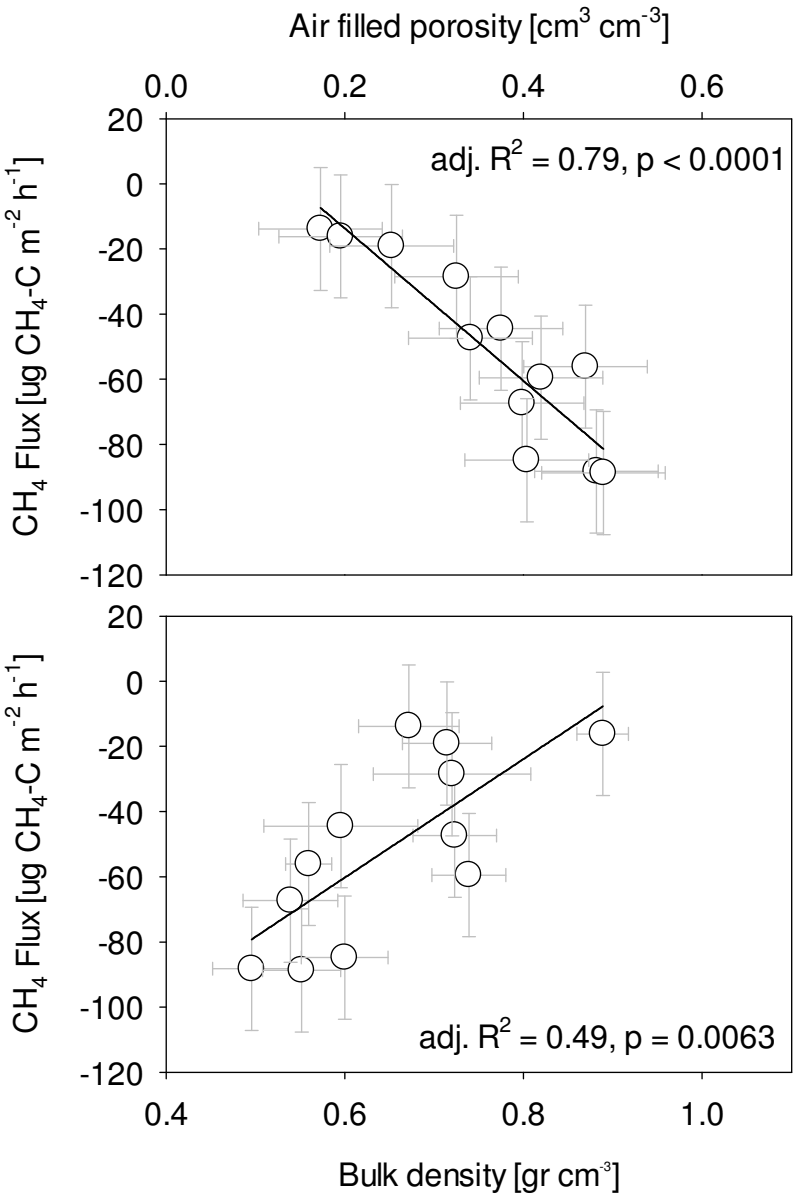
- Warra LTER, Tasmania, Chrono Sequence
  - (WF = Wild Fire, CBS = Clear fell, Burn, Sow)
  - 6 x Age/Disturbance classes x 3 sites x 5 chambers
- 6 sampling campaigns between 03/2009 and 02/2011
- Static manual chamber incubations (CH_4 flux/diffusivity/activity)



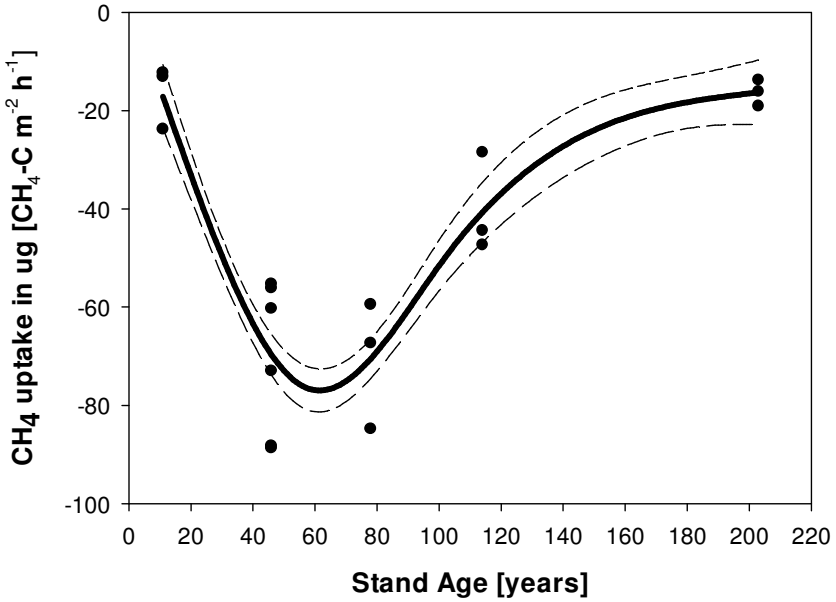
Results B 1: wildfire effects



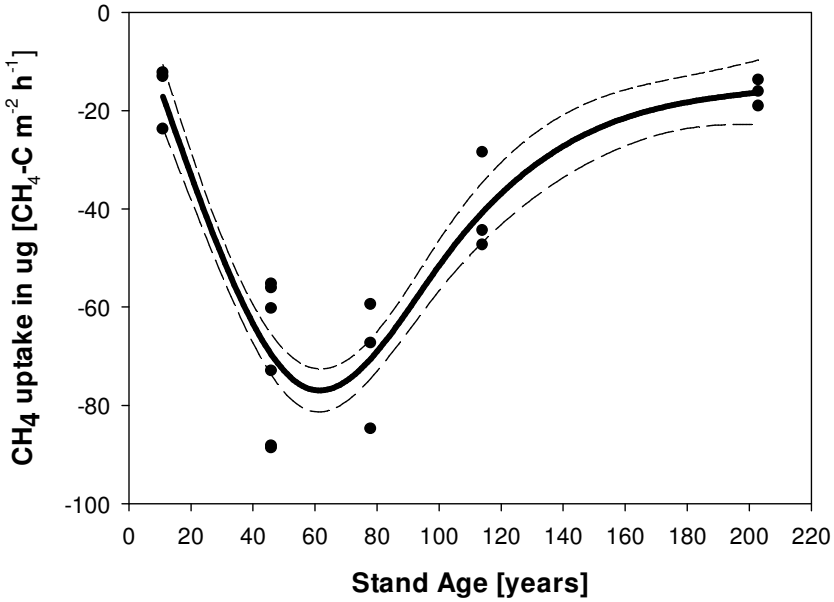
Results B 1: wildfire effects

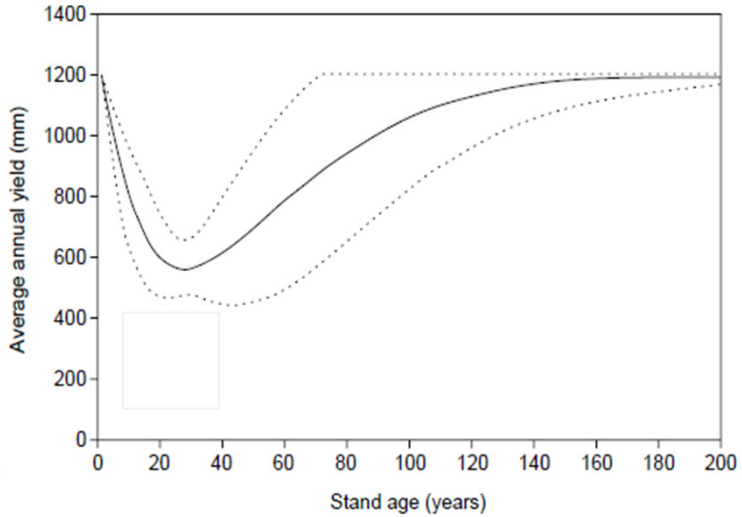


Applications



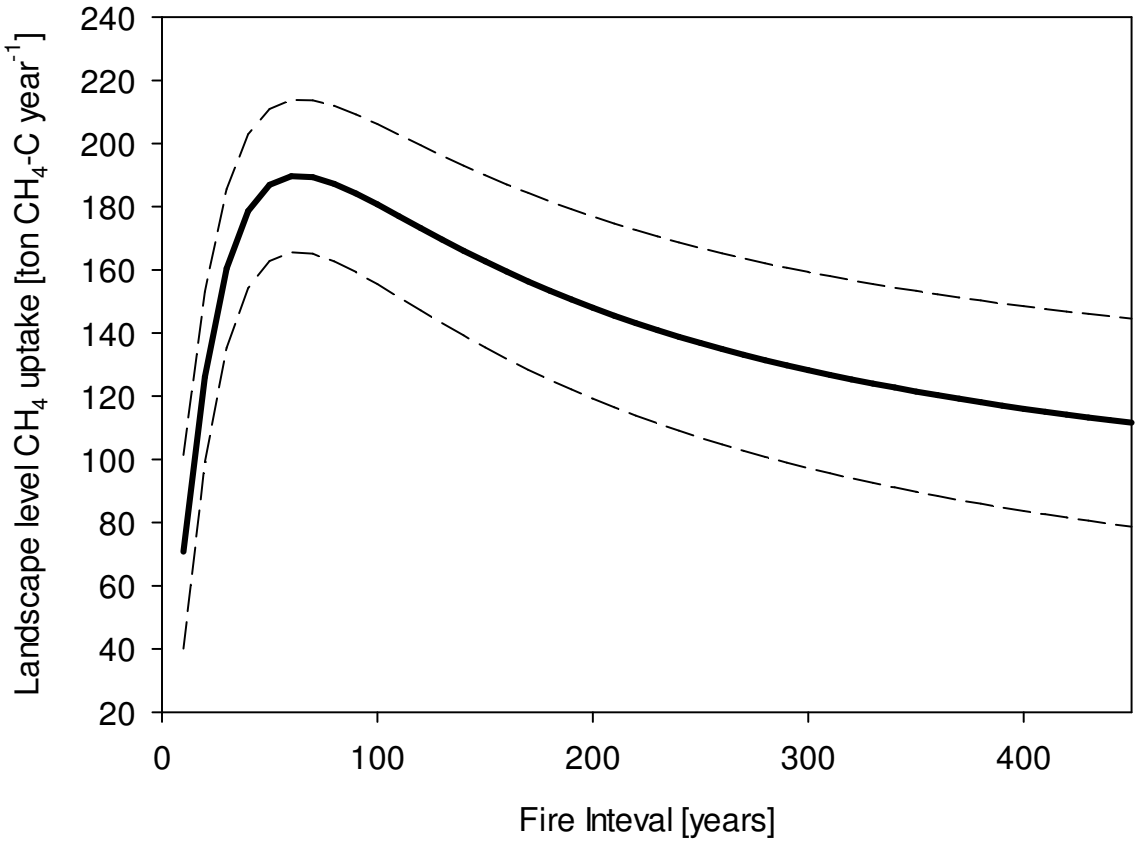
Applications





Kuczera??

Applications

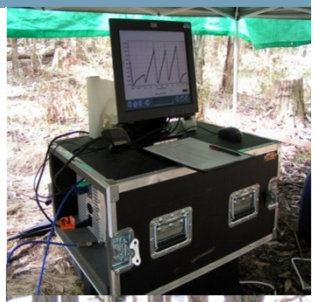


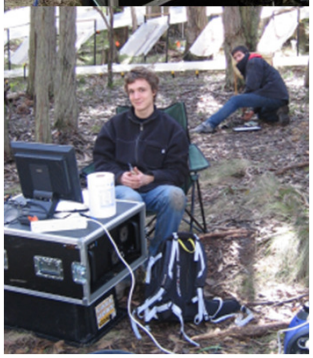
Results B 1: Wild Fire

- Stand replacing wild fire showed strong effect on soil CH_4 uptake magnitude
- CH_4 uptake decreased with time since last fire, this effect was also reflected in soil parameters linked to diffusivity (increasing soil moisture levels with stand age)
- Stand development related changes in stand water use could be a potential explanation for this and would allow modelling of spatial variability in soil CH_4 uptake across a landscape mosaic of different aged stands
- Increase in fire intervals in association with climate change will most likely not reduce landscape level soil CH_4 uptake

Objective B 2: Climate Change Impact

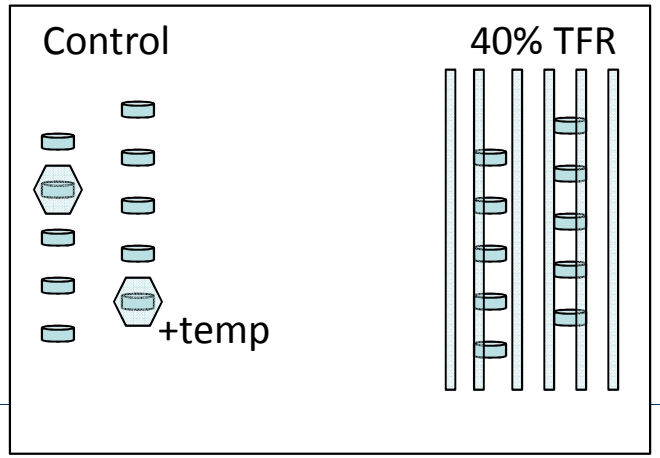
Assessment of simulated climate change impact on soil CH_4 uptake in eucalypt forests





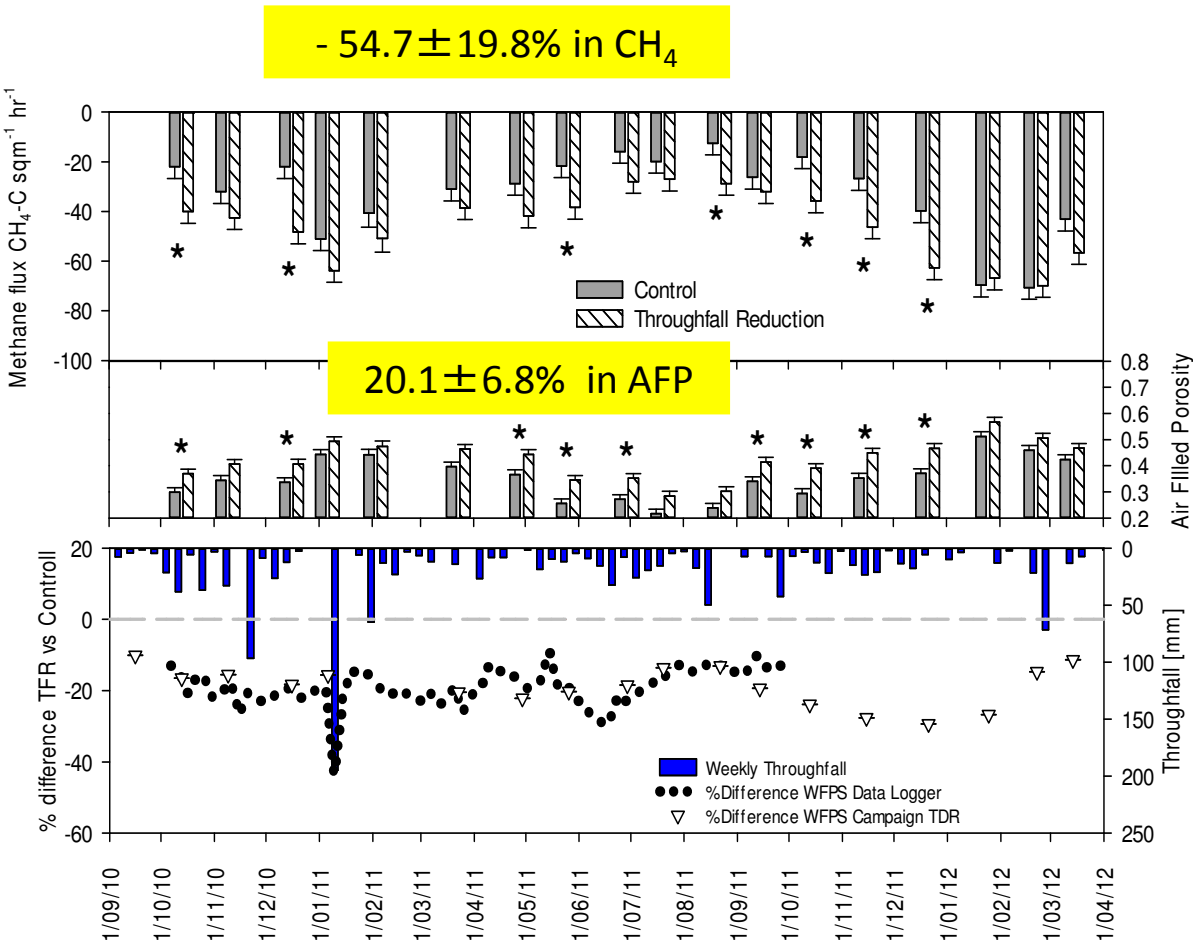
- Wombat State Forest, Victoria, Australia
  - 3 Sites x 2 Treatments x 10 chambers
- FGGA through flow online flux measurements (closed dynamic)
- Monthly measurements 2/2010 – 3/2012

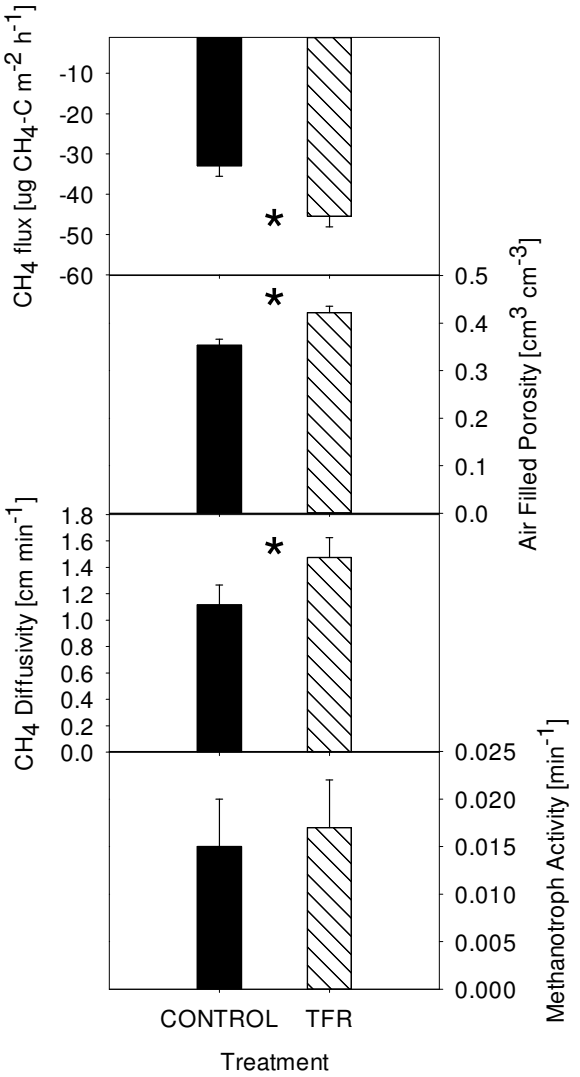
passive warming OTC



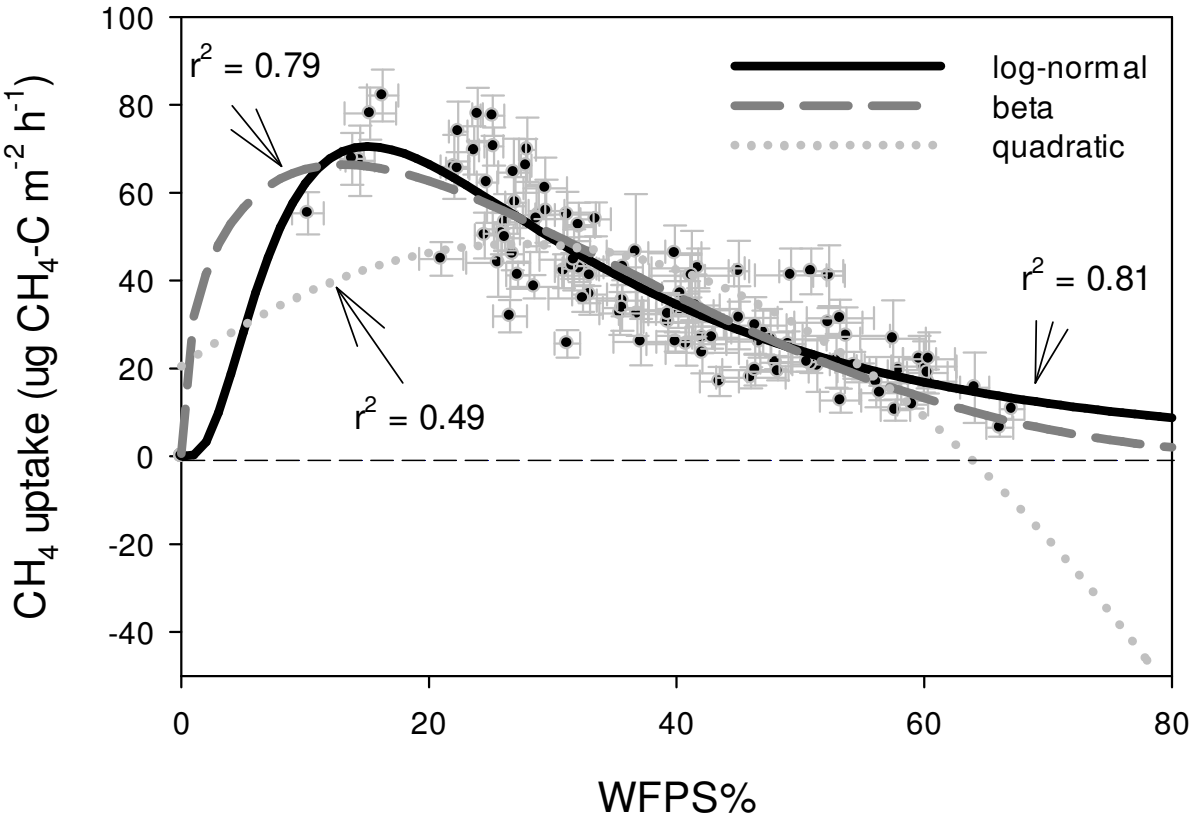
40% passive throughfall reduction

Results B 2: climate change impact





Results B 2: climate change impact



Results B 2: climate change impact

- A throughfall reduction of 40% resulted in an soil moisture reduction of 19.8± 6.8% WFPS or 20.1±6.8% in AFP and this lead to an increase in CH_4 uptake of 54.7 ± 19.8%

- An increase of 0.6 C in temperature had no significant effect on CH_4 uptake

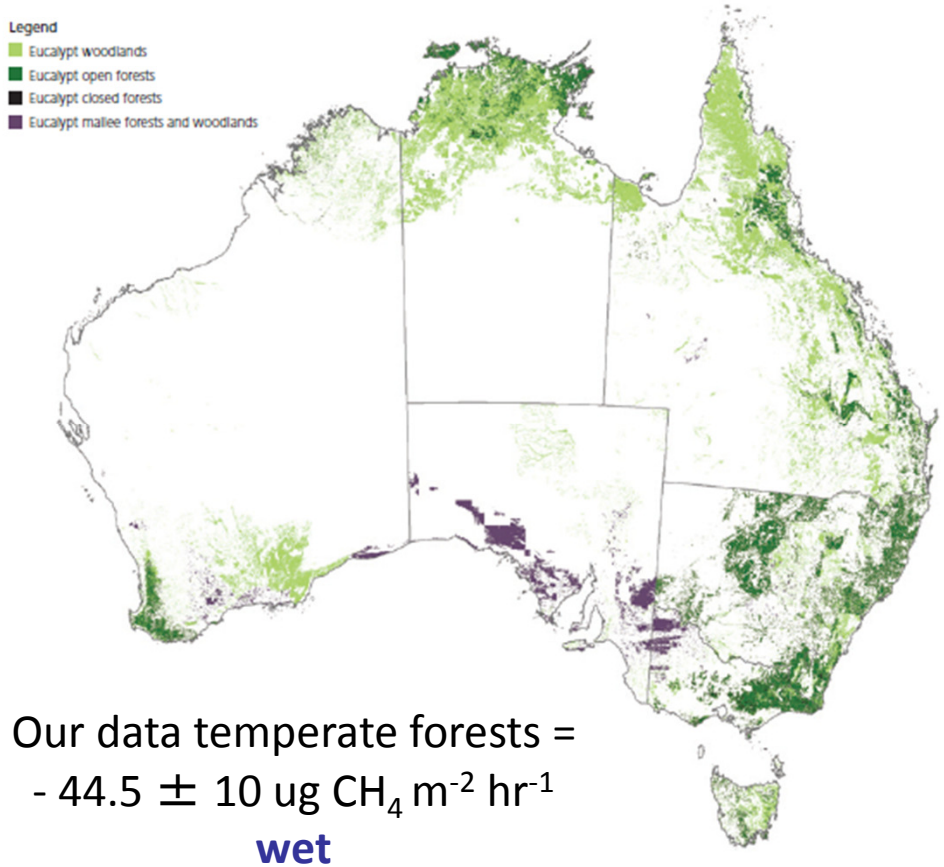
- Soil WFPS was above the optimum for soil CH_4 diffusivity therefore limiting soil CH_4 uptake

Conclusions

- Soil moisture/diffusivity is the main temporal control of soil methane uptake in SE Australian's temperate eucalypt forests explaining **up to 90%** of temporal variability
- Soil temperature has probably only an apparent control over soil CH_4 uptake due to the fact that soil temperature and soil moisture are often auto correlated
- Spatial differences in CH_4 uptake magnitude among sites can be attributed to differences in mean soil moisture status (air filled porosity). These can be linked to physical soil properties that determine soil porosity
- Stand replacing wild fire show the potential to substantially alter soil CH_4 uptake by affecting soil properties linked to diffusivity (**soil moisture and structure, stand development**)
- CH_4 uptake will likely increase as a response to a drier and warmer climate based on a decrease in soil moisture and consequently an increase in CH_4 diffusivity
- Climate change in the medium to long term is unlikely to lead to a reduction in CH_4 uptake from desiccation stress

Why bother?

Ecosystem	Region	CH_4 flux ($\mu g\ m^{-2}\ h^{-1}$)	
		Range	Mean
Forest	Boreal	-158 to -1	-65 ± 28
	Temperate	-445 to 1	-44 ± 24
	Sub/ tropical	-116 to 1	-24 ± 16



Our data temperate forests =
- 44.5 ± 10 ug $CH_4\ m^{-2}\ hr^{-1}$
wet

Approximately 28 million hectare of temperate forests

potential offset of 3.6 ±1.8% of Australians CH_4 emissions

All forests = 147 million hectare

potential offset of 18.9 ±8.5% of Australians CH_4 emissions

Rangelands = 550 million hectare with approximately 24±14 $CH_4\ m^{-2}\ hr^{-1}$

Potential offset of 38.5 ±22.4 % of Australians CH_4 emissions

=> 57.4 ±30.9 % of Australians CH_4 emissions

Acknowledgements

Many thanks to:

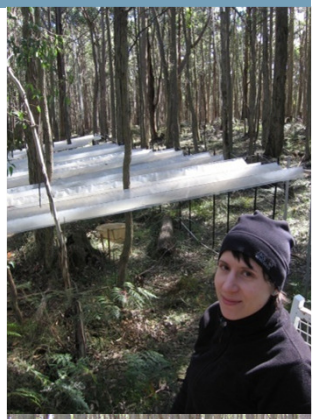
Stefan Arndt and Steve Livesley

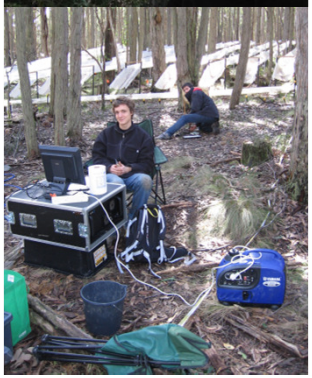
Nina Hinko-Najera, Julio Najera-Umana, Markus Loew

the whole Creswick campus team and students

A whole bunch of French interns

Tim Wardlaw, Joseph von Fischer, David Griffith, Hizbullah Jamali, Jason Beringer





Thank you for your attention

contact: bfest@unimelb.edu.au

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