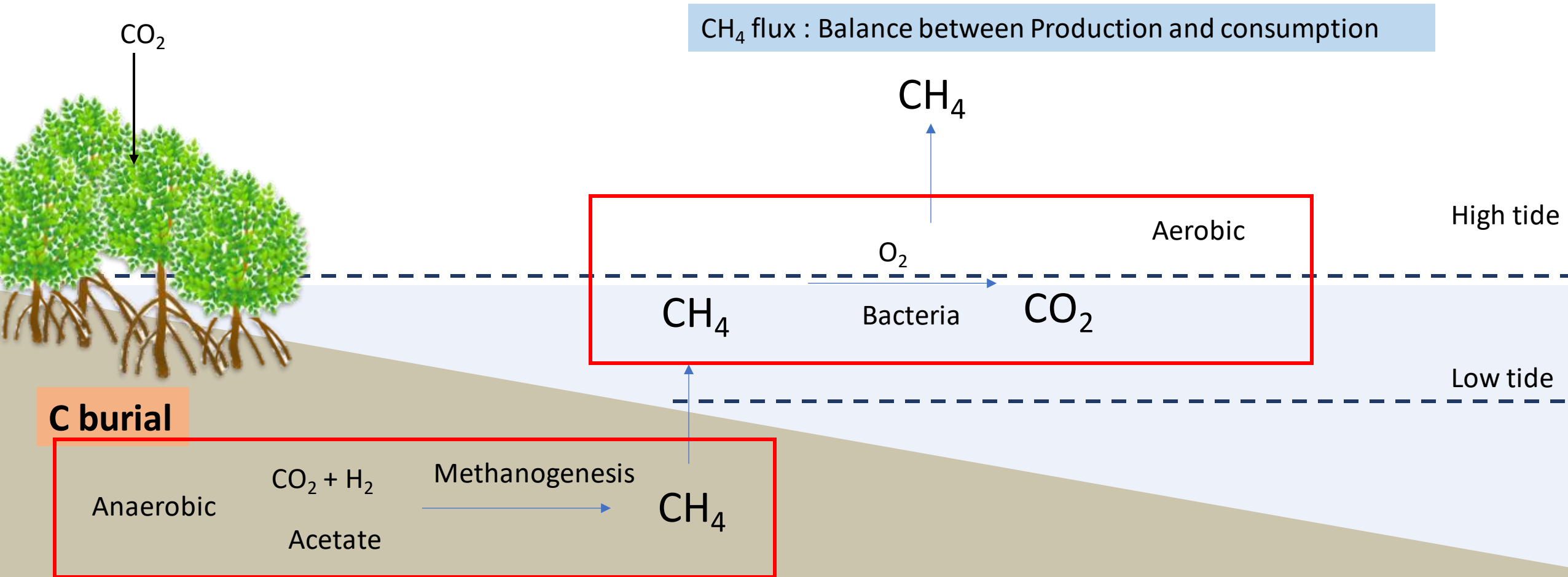




Does CH_4 oxidation reduce CH_4 emissions in mangroves?

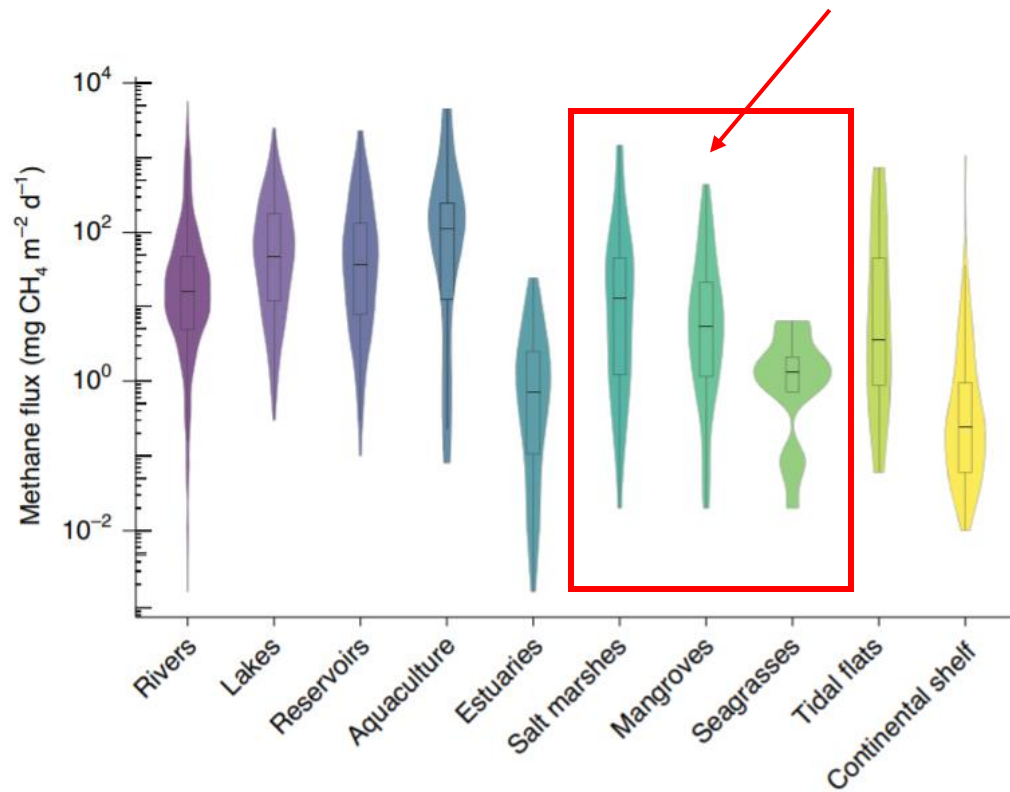
Yvonne Y.Y. Yau, Luiz C. Cotovicz Jr, João Barreira, Gwenaël Abril,
Alberto V. Borges, Cédric Morana, Alex Cabral, Gloria
Reithmaier, Stefano Bonaglia, Alessandra L. Fonseca, Isaac R.
Santos

CH₄ fluxes in Tidal Mangrove



High temporal and spatial variability

Mean: 1.46 Tg CH₄ yr⁻¹



- Lack of continuous and long-term data

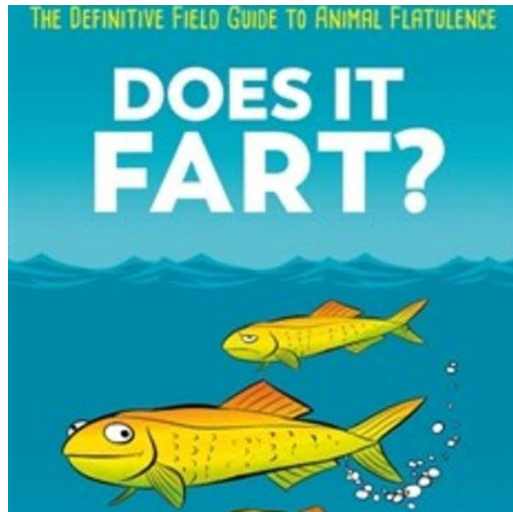
Half of global methane emissions come from highly variable aquatic ecosystem sources

Judith A. Rosentreter^{1,2}, Alberto V. Borges³, Bridget R. Deemer⁴, Meredith A. Holgerson^{5,6,7}, Shaoda Liu^{2,8}, Chunlin Song^{9,10}, John Melack¹¹, Peter A. Raymond², Carlos M. Duarte^{12,13}, George H. Allen¹⁴, David Olefeldt¹⁵, Benjamin Poulter¹⁶, Tom I. Battin¹⁷ and Bradley D. Eyre¹

Atmospheric methane is a potent greenhouse gas that plays a major role in controlling the Earth's climate. The causes of the renewed increase of methane concentration since 2007 are uncertain given the multiple sources and complex biogeochemistry. Here, we present a metadata analysis of methane fluxes from all major natural, impacted and human-made aquatic ecosystems. Our revised bottom-up global aquatic methane emissions combine diffusive, ebullitive and/or plant-mediated fluxes from 15 aquatic ecosystems. We emphasize the high variability of methane fluxes within and between aquatic ecosystems and a positively skewed distribution of empirical data, making global estimates sensitive to statistical assumptions and sampling design. We find aquatic ecosystems contribute (median) 41% or (mean) 53% of total global methane emissions from anthropogenic and natural sources. We show that methane emissions increase from natural to impacted aquatic ecosystems and from coastal to freshwater ecosystems. We argue that aquatic emissions will probably increase due to urbanization, eutrophication and positive climate feedbacks and suggest changes in land-use management as potential mitigation strategies to reduce aquatic methane emissions.

Objectives

1. Quantify **air-sea CH₄ flux** in mangrove
2. Potential **drivers** of CH₄ fluxes (groundwater?)
3. Importance of CH₄ **oxidation** in surface water



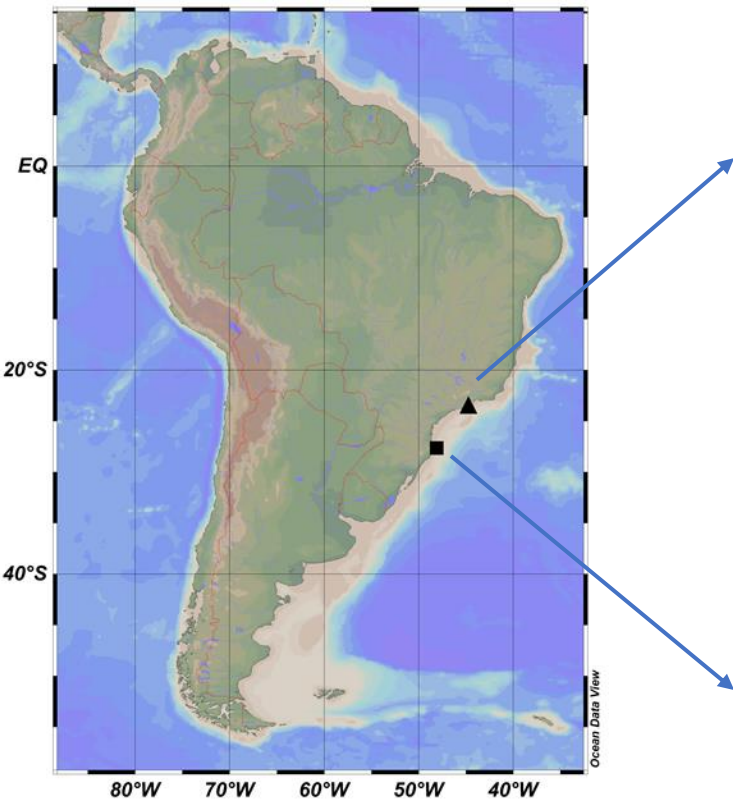
I farted!

My posterior has released a small deposit of methane.



Methodology: Tidal mangrove

Study Site: Brazil



Meso-tidal (Paraty)

- Pristine
- Larger tidal range (1.6 m)

Micro-tidal (Florianópolis)

- Near the city
- Small tidal range (0.9 m)

Methodology

1

Continuous measurements

- CH₄, CO₂, ²²²Rn, DO, Temp, Salinity, depth, current



LICOR, RAD 7

2A

Discrete samples (Spring & neap tide)

- CH₄, δ¹³C-CH₄

Pump

2C Sediment core

2B

Seeps

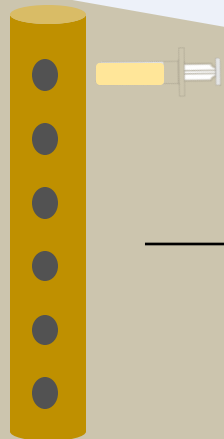
- CH₄, δ¹³C-CH₄

GC/MS → [CH₄]



High tide

Low tide



CH₄ fluxes to the atmosphere

	Meso-tidal Paraty	Micro-tidal Floripa
Air-sea CH ₄ flux (μmol m ⁻² d ⁻¹)	68	179
CH ₄ (nM)	20.2 ± 13	31.6 ± 35.1

Global compiled dataset:

		Mangrove
CH ₄ flux rate (μmol CH ₄ m ⁻² day ⁻¹)	Median	279.17 ^a
	Range	-67.33 to 72,867.83

Al-Haj and Fulweiler et al., 2020

Mostly freshwater mangrove

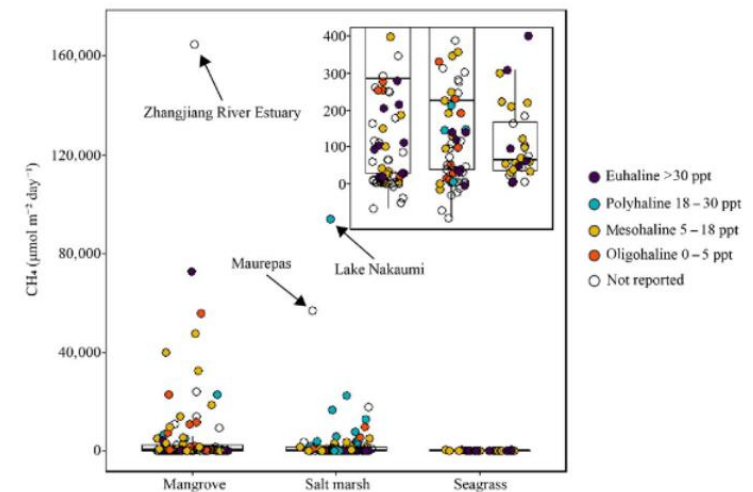
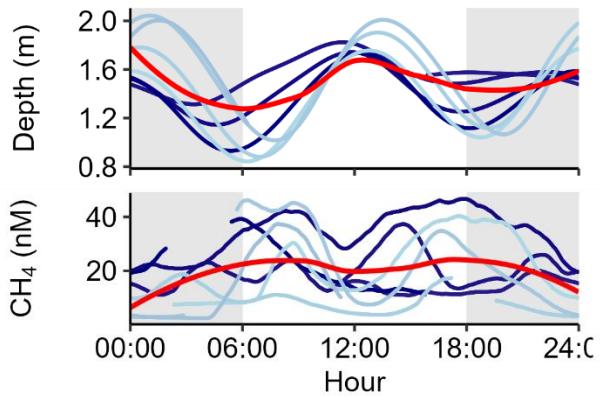


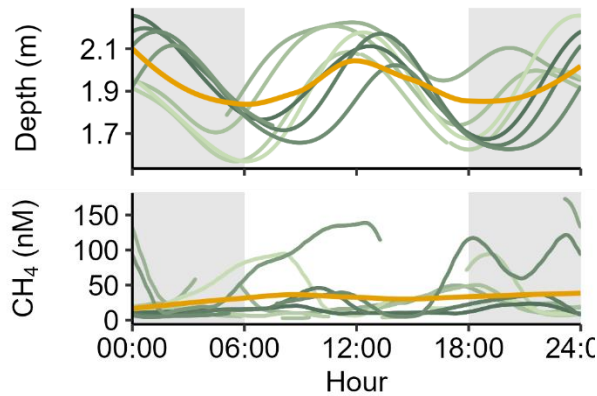
FIGURE 2 Mean CH₄ fluxes for each vegetated ecosystem type binned by salinity. Several studies did not report salinity. We name the several sites exhibiting high CH₄ fluxes. The Yang et al. (2018) Zhangjiang River Estuary observation was not included in further analysis

Tidal trend - daily and biweekly

Meso-tidal (Paraty)



Micro-tidal (Floripa)



Tidal trend

High tide:

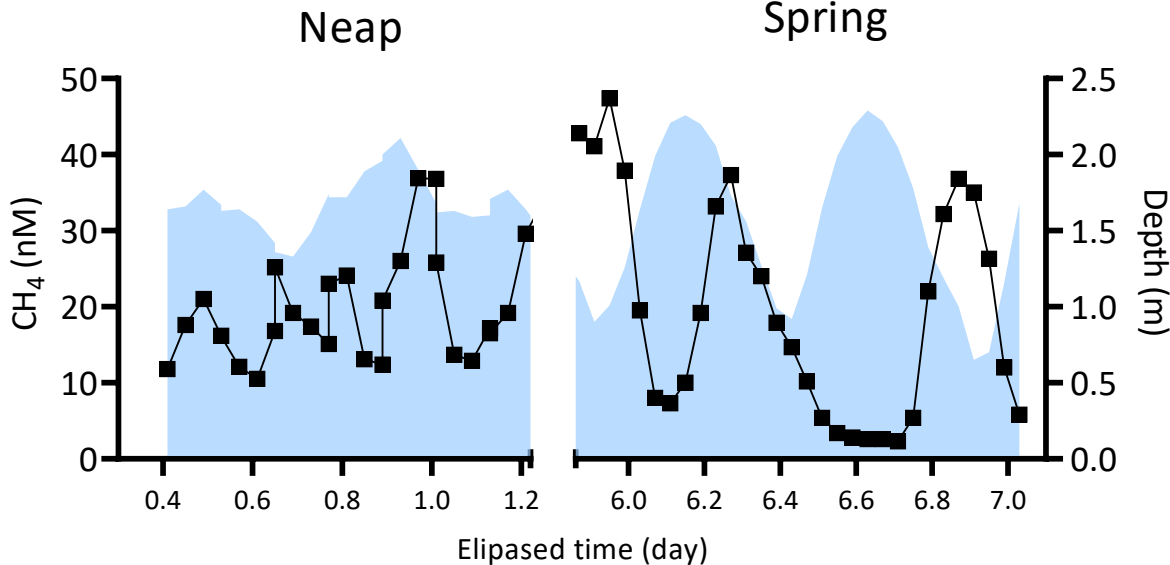
- High DO sat, salinity
- Low CH₄ and ²²²Rn

Low tide:

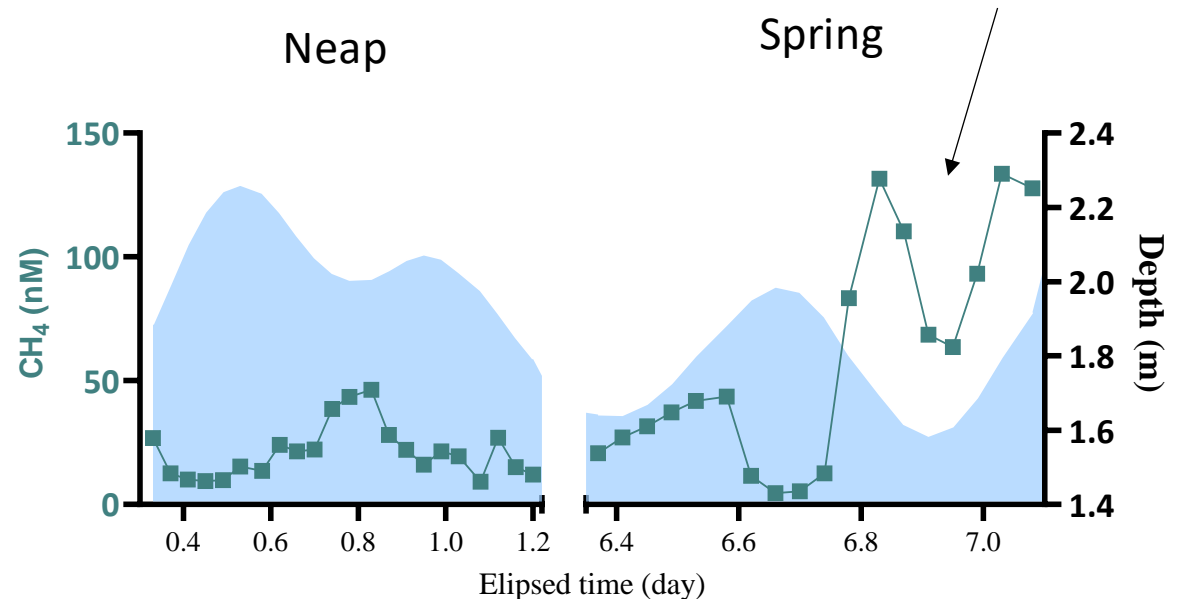
- High CH₄ (58 nM)

Spring: 3 times higher than in neap tide

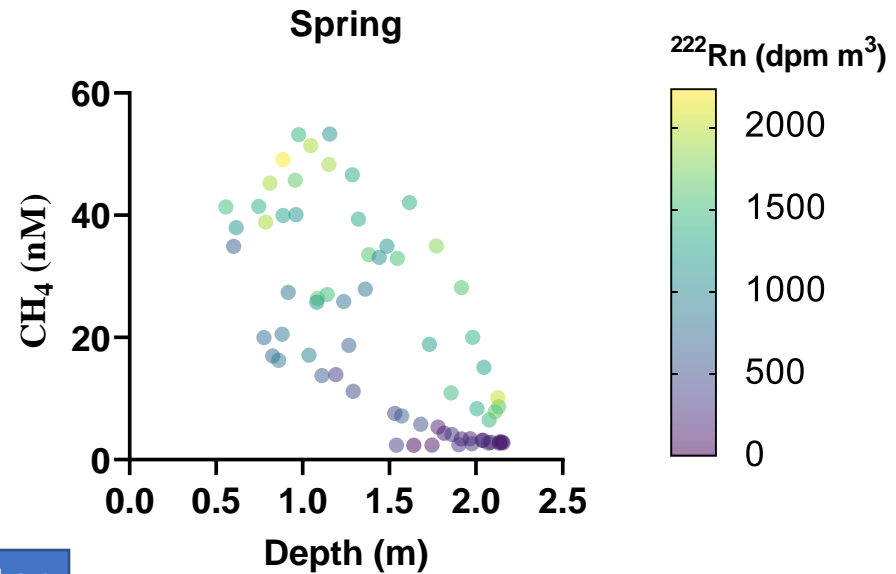
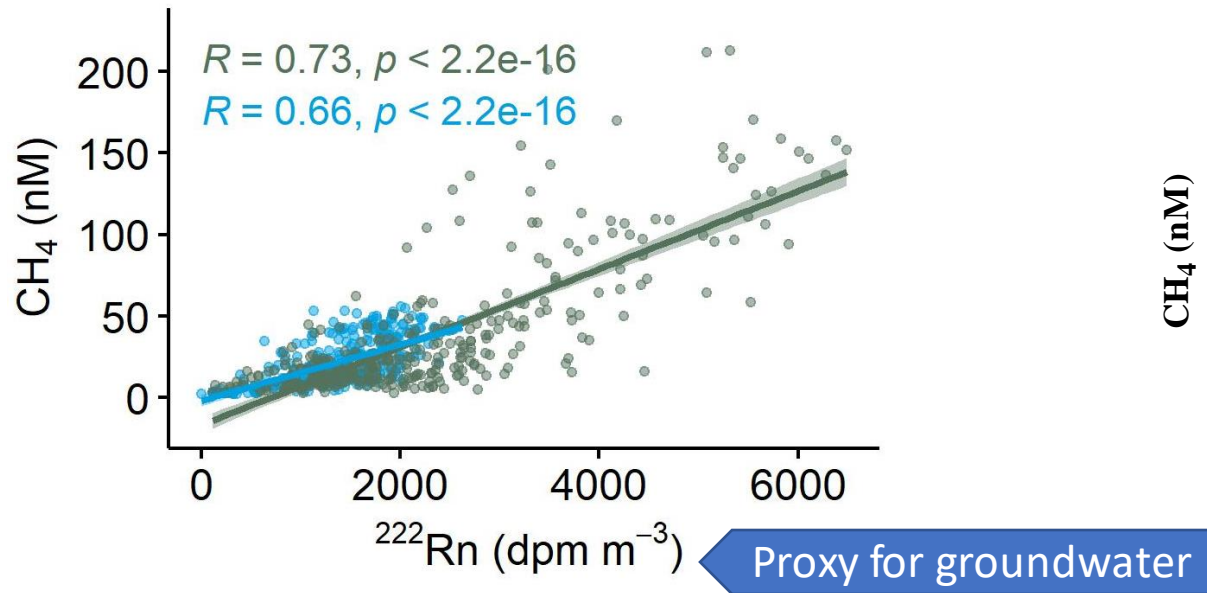
Paraty (meso-tidal)



Floripa (micro-tidal)



Tidal pumping drives CH₄



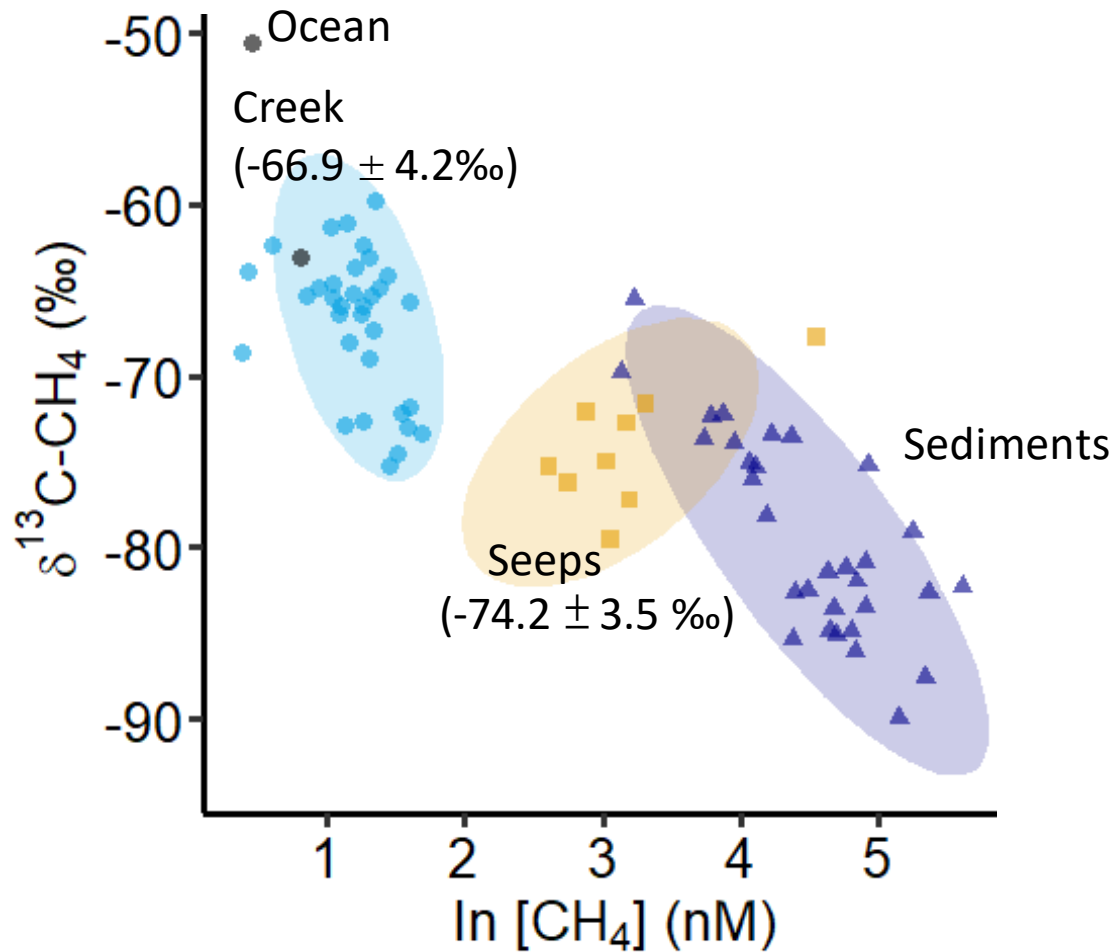
↓ Water depth
 ↑ Radon = groundwater
 ↑ CH₄

- Groundwater positively correlated with CH₄
- [CH₄] seep : 70 times > surface water

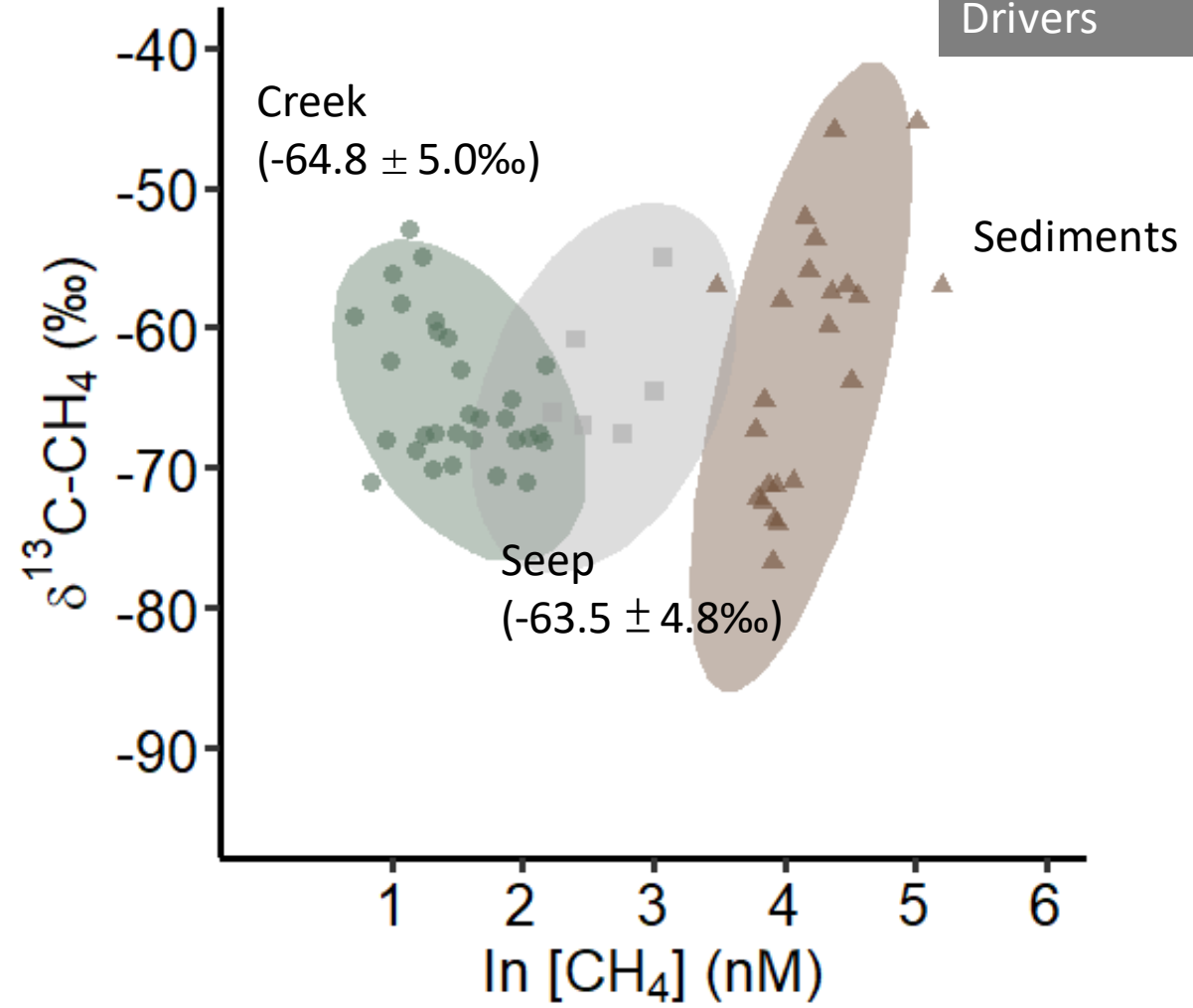
CH ₄	Paraty	Floripa
Seep (μM)	4.5 ± 10.8	0.6 ± 0.4
Sediment core (μM)	66.2 ± 86.8	28.4 ± 53.2

Source of CH₄ : Groundwater

Meso-tidal (Paraty)



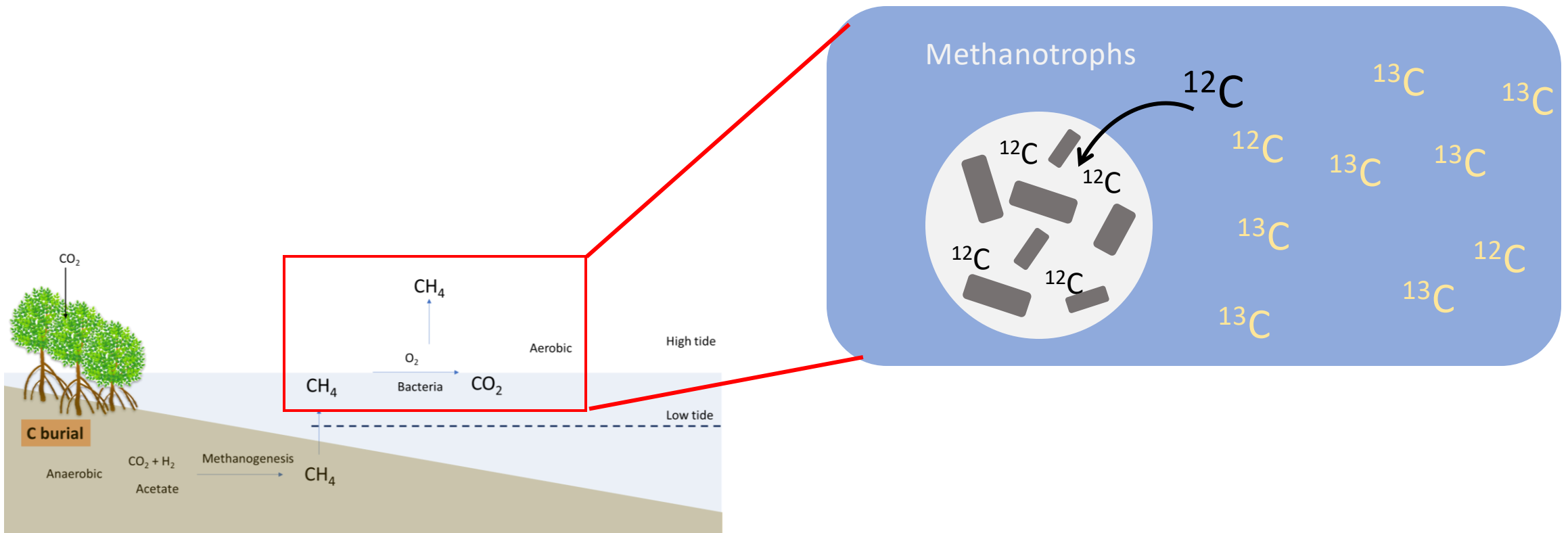
Micro-tidal (Floripa)



Oxidation in surface water using isotopes

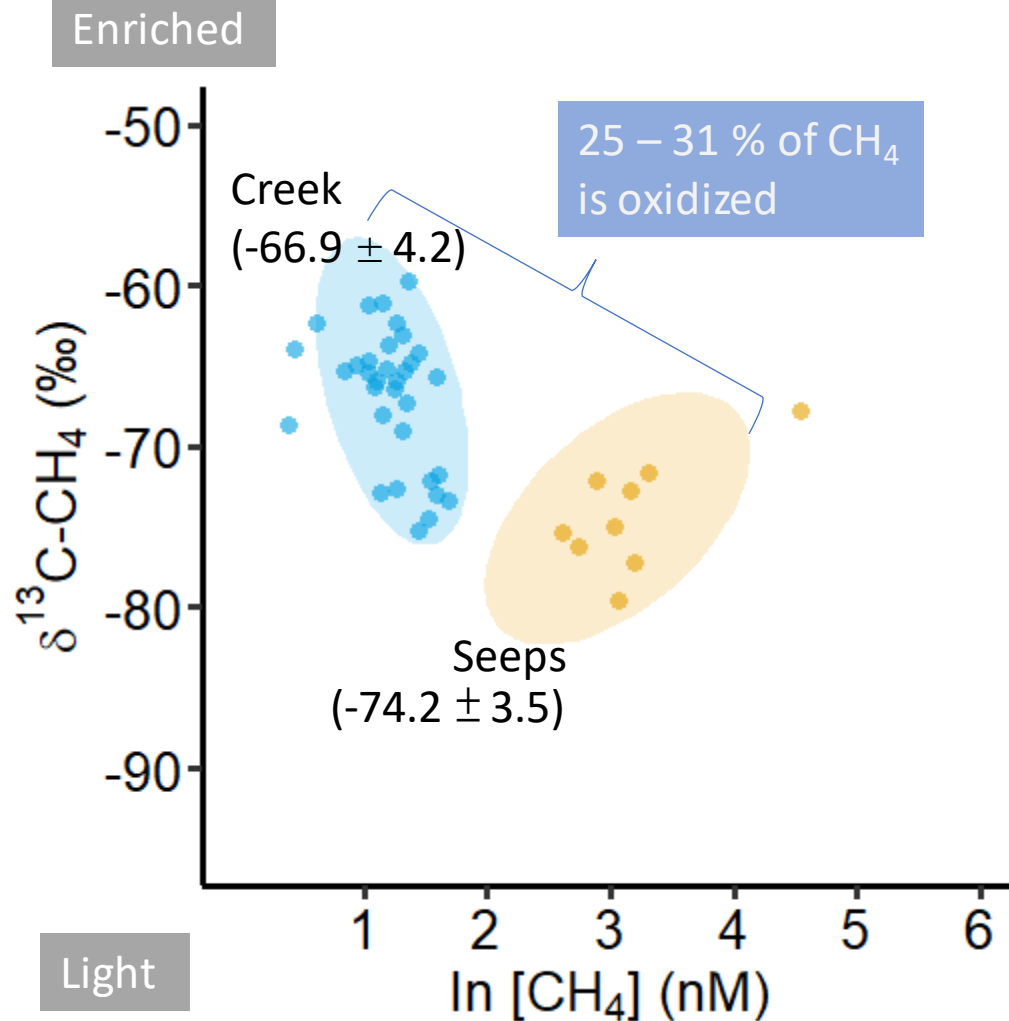
- Methanotrophs prefer lighter ^{12}C
- Oxidation \rightarrow Residual CH_4 become more enriched $\delta^{13}\text{C}-\text{CH}_4$

(Bastviken et al., 2002; Whiticar, 1999)

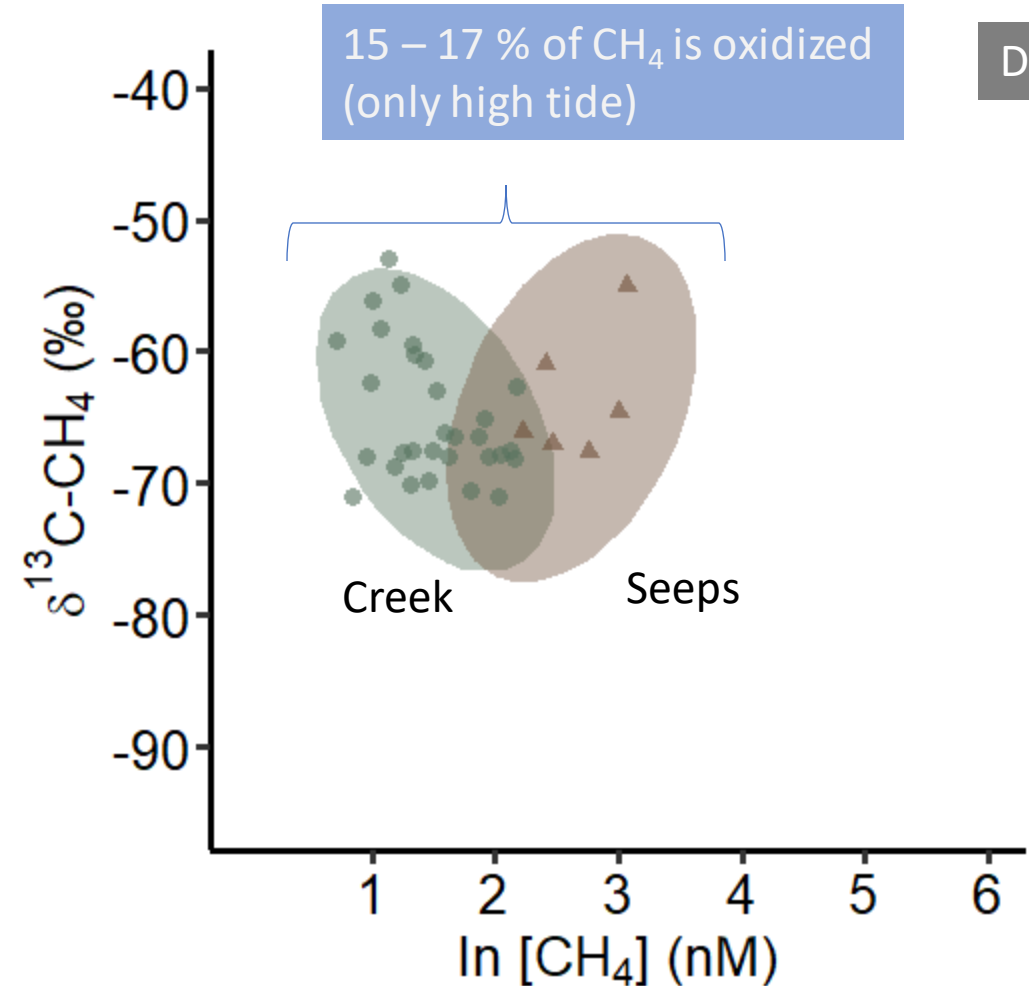


Oxidation in surface water

Paraty (meso-tidal)

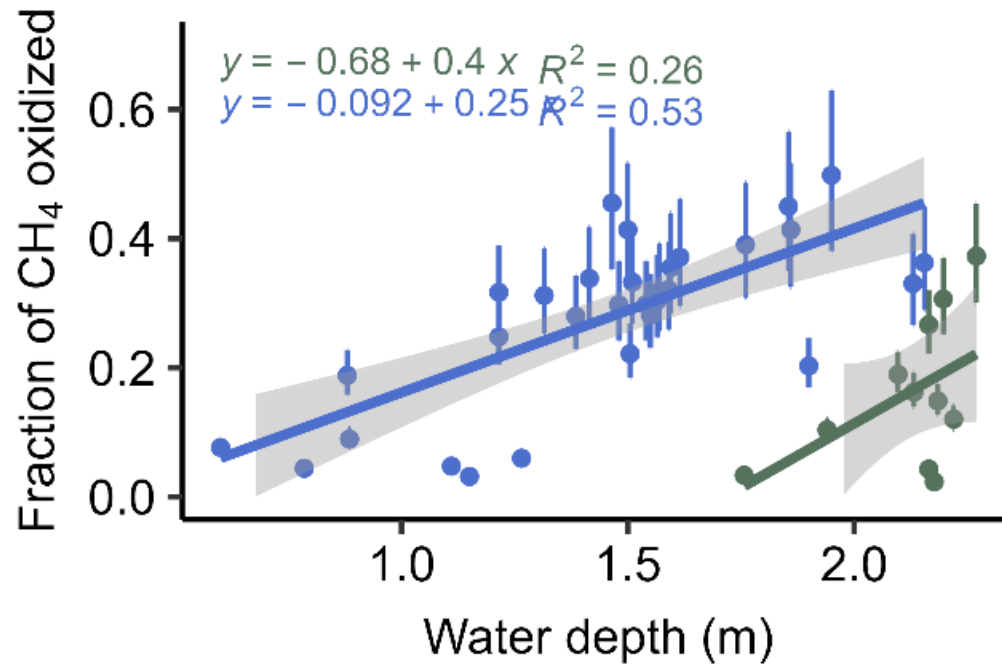


Floripa (micro-tidal)

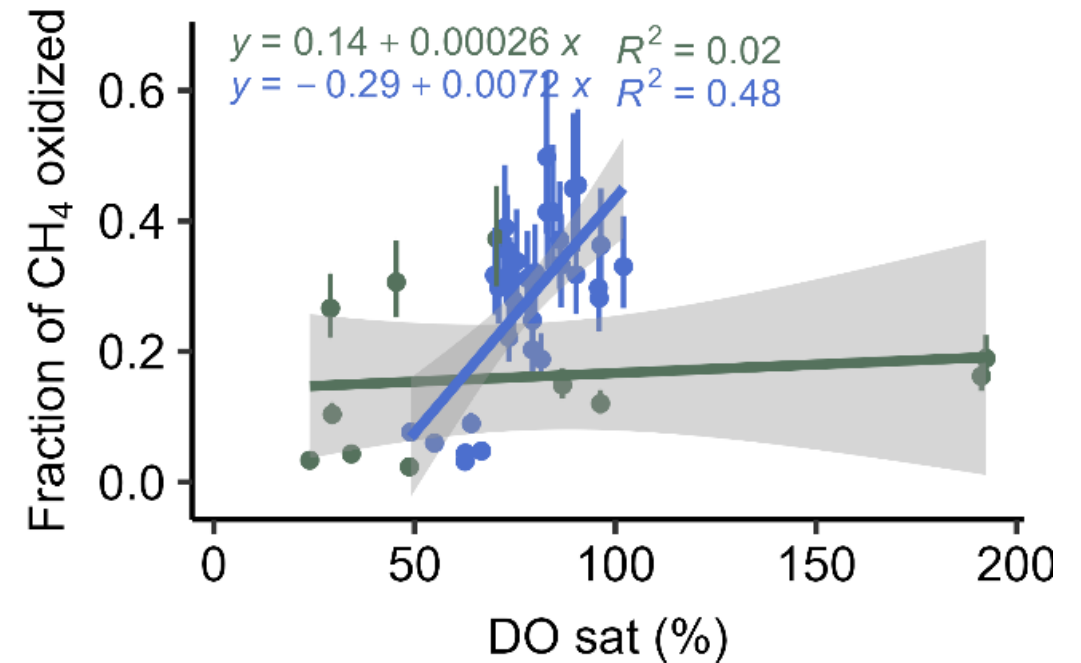


Drivers for oxidation: water depth and DO

↑ water depth ↑ CH₄ being oxidized



↑ DO ↑ CH₄ being oxidized

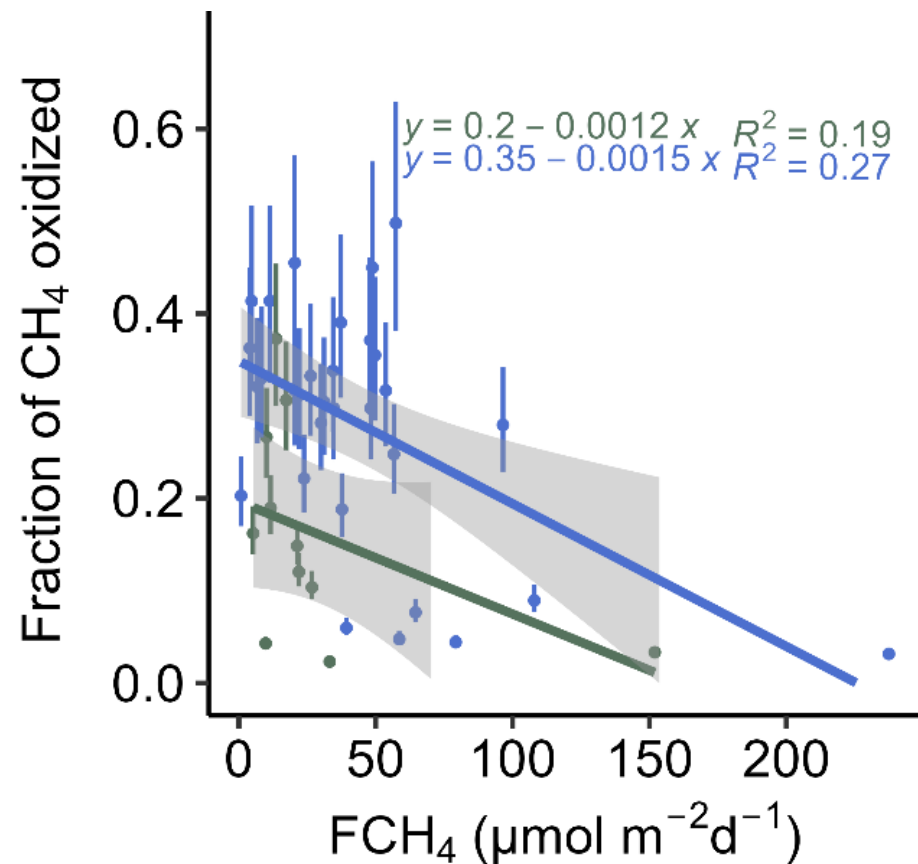


■ Paraty
(meso-tidal)

■ Floripa
(micro-tidal)

Oxidation controls CH₄ fluxes

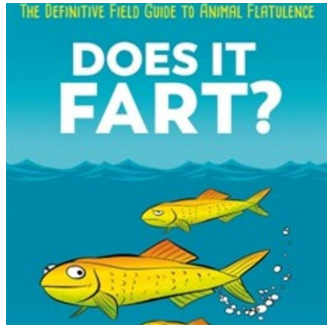
↑ CH₄ being oxidized
 ↓ CH₄ flux to the atmosphere



	Paraty	Floripa
Air-sea flux ($\mu\text{mol m}^{-2} \text{d}^{-1}$)	68	179
Oxidation ($\mu\text{mol m}^{-2} \text{d}^{-1}$)	13 - 18	3-4

↑ CH₄ Oxidation lower the CH₄ fluxes

Conclusion



- Tidal mangrove emits $68 - 179 \mu\text{mol CH}_4 \text{ m}^{-2} \text{ d}^{-1}$



I farted!

My posterior has released a small deposit of methane.

- Tidal pumping controls CH_4 dynamics in mangrove in daily and biweekly time scale



- CH_4 oxidation could reduce CH_4 emissions to atmosphere

Questions



Yvonne Yau

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Email: yvonne.yau@gu.se

Twitter: [yvonneyauu](https://twitter.com/yvonneyauu)

Shibin Zhao	In-situ radon-in-water detection benefits high resolution submarine groundwater discharge assessment (SS09)
Fenfang Wang	Warming and eutrophication promote nitrogen removal and N ₂ O emissions in coastal wetlands (SS09)
Rebecca Woodrow	Enhanced nocturnal CO ₂ , CH ₄ , and N ₂ O emissions in headwaters revealed by high temporal resolution measurements (SS20)
Tristan McKenzie	International collaborative research through the lorex program and beyond (EP005)
Stefano Bonaglia	High methane emissions from fjords (S003)
Lok Shan Cheung	The role of continental shelf denitrification for global marine nitrogen loss: the oligotrophic new zealand shelf
Aprajita Tomer	Groundwater enriches CO ₂ in diverse, global coastal waters
Wilma Ljungberg	CO ₂ fluxes, carbonate chemistry and nutrients along a tidal glacier-lagoon-ocean continuum in iceland
Tristan McKenzie	Emergence of artificial intelligence in submarine groundwater discharge research: case studies and future directions
Alex Cabral	Tidally driven porewater exchange and diel cycles control CO ₂ fluxes in mangroves
Claudia Majtenyi Hill	Inorganic carbon outwelling from a Mediterranean seagrass meadow using radium isotopes
Linnea Henriksson	CH ₄ and CO ₂ emissions from a temperate seagrass meadow over diel and seasonal time scales
Gloria Reithmaier	Coastal acidification and carbon sequestration driven by inorganic carbon export from tidal wetlands