

BG-2022-76 Rinne et al.

Spatial and temporal variation of ^{13}C signature of methane emitted from a temperate mire: Methanogenesis, methanotrophy, and hysteresis

General comments

The study by Rinne et al. investigates CH_4 emission rates and $\delta^{13}\text{C}\text{-CH}_4$ values, and the community structure of methanogenic and methanotrophic communities in a poor fen in southwest Sweden. It is one of the most detailed investigations to date pairing high temporal resolution upscaled $\delta^{13}\text{C}\text{-CH}_4$ values with integrated $\delta^{13}\text{C}$ values of CH_4 flux sampled from nocturnal boundary-layer accumulation. The key findings locally are that: (i) the observed spatial and temporal differences in $\delta^{13}\text{C}$ values of CH_4 emissions vary systematically in response to environmental conditions, (ii) the spatial range of values (~ 15 permil) is larger than temporal variations and appears to be governed by differences in substrate and moisture levels within the peatland that can be identified by vegetation assemblages that can be delineated via remote sensing, and (iii) metagenomic analysis indicates that methanogenic communities within the peatland are diverse and capable of adapting to changes in substrate supply and environmental conditions. I support publication of this work with minor revision.

I recommend that the authors explore further in the Discussion section the implications of their measured $\delta^{13}\text{C}$ values for isotope-weighted global CH_4 budgets. The measured $\delta^{13}\text{C}$ values (~ -81 to -79 permil) of CH_4 emissions from the site are significantly more negative than $\delta^{13}\text{C}$ values typically attributed to global and northern wetlands (e.g., -58% ; Mikaloff-Fletcher et al., 2004a,b; -58% , Bousquet et al., 2006; -59% , Monteil et al., 2011;). Similar to Fisher et al. (2017), this study presents further compelling evidence for a need to adjust $\delta^{13}\text{C}$ values attributed to CH_4 emissions from northern peatlands.

Specific comments

Manuscript title: ‘...variation of $\delta^{13}\text{C}$ values of methane...’

Line 13 – ‘...offer clues...’?

Line 76-77 and elsewhere. Replacing terms such as ‘isotopically lighter CH_4 ’ with more specific language would eliminate the need for clarifying statements in parentheses. For example (lines 75-76) could be written as ‘... hydrogenotrophic methanogenesis typically produced CH_4 that is ^{13}C -depleted relative to CH_4 generated from acetoclastic methanogenesis.’

Line 108: ‘reflect differences in CH_4 production due to differences in substrate availability for methanogenesis.’

Line 110 and elsewhere: ‘methanotrophy prefers ^{12}C , leaving more ^{13}C to the emitted CH_4 ’ = ‘Enzymatic reactions associated with methanotroph metabolism consume $^{12}\text{CH}_4$ preferentially, resulting in ^{13}C -enrichment of residual CH_4 .’

Line 113 – awkward sentence; ‘less ^{13}C depleted CH_4 ’ = ‘ ^{13}C -enriched CH_4 ’ or ‘ CH_4 having more positive $\delta^{13}\text{C}$ values’.

Line 121 – In this context ‘substrate supply’ rather than ‘trophic status’ perhaps would more accurately describe the environmental variable impacting CH₄ emission rates.

Line 163 – remove capitalization ‘polymethyl...’

Lines 203-205 – How was the CRDS calibrated in the field for concentration and stable isotope measurements?

Lines 231-233 – Data from chamber 3 are not mentioned?

Line 276 – ‘...seems to be quite similar...’ If this is an important point, perhaps employ a statistical comparison?

Line 304 – ‘there were hardly any data’

Ed Hornibrook

References

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- Fisher, R. E., France, J. L., Lowry, D., Lanoisellé, M., Brownlow, R., Pyle, J. A., et al. (2017). Measurement of the ¹³C isotopic signature of methane emissions from northern European wetlands. *Global Biogeochemical Cycles*, 31, 605–623.
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