Tracing methane emissions from temperate wetlands

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In wetlands, which account for ≈ 30% of global methane emissions, methane is produced by methanogenic microorganisms in an anaerobic environment below the water table, and is transported upwards. Tracing microbial processes in present and past wetlands in order to feed precise quantitative estimates into atmospheric models has remained a challenge for biogeochemists and microbiologists. As a result, methane emissions from wetland sources are still associated with relatively high uncertainty. However, the use of biomarker lipids for methanogens (archaeol) in combination with stable isotope probing experiments can offer solutions. Here, we present data from two natural wetlands with distinct methane dynamics (low emission, $\delta^{13}C_{CH4}$ = -80 ‰, pH < 4.5, CO_2/H_2 *vs* high emission, $\delta^{13}C_{CH4}$ = -60 ‰, pH > 4.5, acetoclastic). High methane fluxes with enriched $\delta^{13}C$ in the acetoclastic setting can be linked to high relative amounts of archaeol, which was also 10‰ enriched compared to the CO_2/H_2 setting. This confirms that relative abundances and $\delta^{13}C$ values of archaeal biomarker lipids can be powerful tools to trace the past methane cycle.

Incubation experiments revealed enhanced methane production upon addition of ^{13}C-acetate at the naturally CO_2/H_2 dominated setting, confirming that substrate availability is the most significant control on wetland methane emissions if the water table remains constant. Incubations with $H^{13}CO_3^-$ resulted in significantly lower methane production in both settings. Uptake of ^{13}C into archaeol from ^{13}C-acetate occurred at both settings, further strengthening the link betweeen archaeol and acetoclastic methanogenesis. The incubation experiments strongly suggest that an increase in acetate availability due to enhanced primary production and enhanced microbial activity with increasing global temperatures will not only result in increased methane emissions from temperate and subboreal wetlands, but also in enriched $\delta^{13}C_{CH4}$ for these emissions. This might need to be taken into account when revising global methane inventories in a warming world.