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How to cite:

Hornibrook, Edward; Maxfield, Peter; Gauci, Vincent and Stott, Andrew (2013). Reassessing the stable isotope composition assigned to methane flux from natural wetlands in isotope-constrained budgets. In: European Geosciences Union General Assembly 2013, 7-12 Apr 2013, Vienna, Austria.

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Version: Version of Record

Link(s) to article on publisher's website:

<http://meetingorganizer.copernicus.org/EGU2013/EGU2013-13060.pdf>

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## Reassessing the stable isotope composition assigned to methane flux from natural wetlands in isotope-constrained budgets

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Stable isotope ratios in CH<sub>4</sub> preserve information about its origin and history, and are commonly used to constrain global CH<sub>4</sub> budgets. Wetlands are key contributors to the atmospheric burden of CH<sub>4</sub> and typically are assigned a stable carbon isotope composition of ~-60 permil in isotope-weighted stable isotope models despite the considerable range of δ<sup>13</sup>C(CH<sub>4</sub>) values (~ -100 to -40 permil) known to occur in these diverse ecosystems. Kinetic isotope effects (KIEs) associated with the metabolism of CH<sub>4</sub>-producing microorganisms generate much of the natural variation but highly negative and positive δ<sup>13</sup>C(CH<sub>4</sub>) values generally result from secondary processes (e.g., diffusive transport or oxidation by soil methanotrophs). Despite these complexities, consistent patterns exist in the isotope composition of wetland CH<sub>4</sub> that can be linked conclusively to trophic status and consequently, natural succession or human perturbations that impact nutrient levels.

Another challenge for accurate representation of wetlands in carbon cycle models is parameterisation of sporadic CH<sub>4</sub> emission events. Abrupt release of large volumes of CH<sub>4</sub>-rich bubbles in short periods of time can account for a significant proportion of the annual CH<sub>4</sub> flux from a wetland but such events are difficult to detect using conventional methods. New infrared spectroscopy techniques capable of high temporal resolution measurements of CH<sub>4</sub> concentration and stable isotope composition can readily quantify short-lived CH<sub>4</sub> pulses. Moreover, the isotope data can be used conclusively to determine shifts in the mode of CH<sub>4</sub> transport and provide the potential to link initiation of abrupt emission events to forcing by internal or external factors.