Methane paradox in tropical lakes? Sedimentary fluxes rather than pelagic production in oxic conditions sustain methanotrophy and emissions to the atmosphere

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Abstract. Despite growing evidence that methane (CH_4) formation could also occur in well-oxygenated surface freshwaters, its significance at the ecosystem scale is uncertain. Empirical models based on data gathered at high latitude predict that the contribution of oxic CH_4 increases with lake size and should represent the majority of CH_4 emissions in large lakes. However, such predictive models could not directly apply to tropical lakes which differ from their temperate counterparts in some fundamental characteristics, such as year-round elevated water temperature. We conducted stable isotope tracer experiments which revealed that oxic CH_4 production is closely related to phytoplankton metabolism, and is a common feature in five contrasting African lakes. Nevertheless, methanotrophic activity in surface waters and CH_4 emissions to the atmosphere were predominantly fuelled by CH_4 generated in sediments and physically transported to the surface. Indeed, CH_4 bubble dissolution flux and diffusive benthic CH_4 flux were several orders of magnitude higher than CH_4 production in surface waters. Microbial CH_4 consumption dramatically decreased with increasing sunlight intensity, suggesting that the freshwater "CH_4 paradox" might be also partly explained by photo-inhibition of CH_4 oxidizers in the illuminated zone. Sunlight appeared as an overlooked but important factor determining the CH_4 dynamics in surface waters, directly affecting its production by photoautotrophs and consumption by methanotrophs.