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Ice core and firn air $^{14}CH_4$ measurements from preindustrial to present suggest that anthropogenic fossil CH_4 emissions are underestimated

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Concentrations of atmospheric methane (CH_4), a potent greenhouse gas, have more than doubled since preindustrial times yet its contemporary budget is incompletely understood, with substantial discrepancies between global emission inventories and atmospheric observations (Kirschke et al., 2013; Saunois et al., 2016). Radiomethane ($^{14}CH_4$) can distinguish between fossil emissions from geologic reservoirs (radiocarbon free) and contemporaneous biogenic sources, although poorly constrained direct $^{14}CH_4$ emissions from nuclear reactors complicate this interpretation in the modern era (Lassey et al., 2007; Zazzeri et al 2018). It has been debated how fossil emissions (172-195 Tg CH_4/yr, (Saunois et al., 2016; Schwietzke et al., 2016)) are partitioned between anthropogenic sources (such as fossil fuel extraction and consumption) and natural sources (such as geologic seeps); emission inventories suggest the latter accounts for ∼50-60 Tg CH_4/yr (Etiope, 2015; Etiope et al., 2008). Geologic emissions were recently shown to be much smaller at the end of the Pleistocene ∼11,600 years ago (Petrenko et al. 2017); However, this period is an imperfect analog for the present day due to the much larger terrestrial ice sheet cover, lowered sea level, and more extensive permafrost. We use preindustrial ice core measurements of $^{14}CH_4$ to show that natural fossil CH_4 emissions to the atmosphere are ∼1.7 Tg CH_4/yr, with a maximum of 6.1 Tg CH_4/yr (95% confidence limit), an order of magnitude smaller than estimates from global inventories. This result suggests that contemporary anthropogenic fossil emissions are likely underestimated by a corresponding amount (∼48-58 Tg CH_4/yr, or ∼25-33% of current estimates).