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Law Dome 14CH4 measurements confirm revised fossil methane emissions estimates

Content

Methane is a powerful greenhouse gas and has significant roles in the chemistry of the atmosphere. Its global concentration has risen by 240 % since 1750 AD. Atmospheric $^{14}CH_4$ is an independent and potentially unambiguous tracer of fossil CH_4 emissions from anthropogenic and natural geologic sources, however, ^{14}C from nuclear weapons tests and $^{14}CH_4$ from nuclear power plants complicate its interpretation after the late 1950s. Measurements before then rely on air extracted from polar ice and firn. Hmiel et al. (Nature, 2020) measured $^{14}CH_4$ in air extracted from firn and ice in Greenland and Antarctica and found that the natural global fossil CH_4 source is very small (<6 Tg CH_4/yr). This is inconsistent with bottom-up geological CH_4 emissions estimates (40-60 Tg CH_4/yr) and implies an upward revision of anthropogenic fossil source emissions, emphasising the need for further measurements.

We present new $^{14}CH_4$ measurements of air extracted from the high accumulation site DE08-OH on the Law Dome ice sheet in 2018/19, including firn air to 81 m depth and large ice samples combined from parallel ice cores to 240 m. Measurements of trace gases confirm that the samples were uncontaminated and only minor corrections are required for sample processing. The correction for cosmogenic in-situ production of $^{14}CH_4$ is very small at DE08-OH due to its high accumulation rate and relatively low elevation. The new $^{14}CH_4$ results compare closely with the previous measurements from the other sites. An atmospheric $^{14}CH_4$ history is reconstructed from inverse modelling of the combined ice and firn data. The pre-industrial $^{14}CH_4$ level is almost identical to that expected from contemporaneous biogenic sources, confirming very minor natural fossil CH_4 emissions. $^{14}CH_4$ decreases to a minimum in about 1940 as anthropogenic fossil methane is emitted followed by an increase during the nuclear era from 1950 to present. The record since the 1950s would allow the evolution of the anthropogenic fossil source to be quantified when improved nuclear $^{14}CH_4$ emissions estimates become available. The larger emissions from anthropogenic fossil sources implied by this result suggests opportunities for methane emissions reductions.

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