(57-240329-B) **Detection of CH_4 Containing Aged C Released from Thermally-degrading Permafrost using $^{14}CH_4$ Measurements**

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Arctic regions have warmed 2-4 times faster than the global average, raising concerns that large, perennially frozen carbon stocks that have been stored in permafrost may become remobilized and emitted to the atmosphere as CO_2 and CH_4 – leading to the so-called "permafrost carbon-climate feedback". Atmospheric radiomethane ($^{14}CH_4$) is a sensitive tracer of emissions from aged sources indicative of this feedback process. Currently, background levels of atmospheric $^{14}CH_4$ are maintained at high levels by emissions from nuclear power plant($\Delta^{14}CH_4$ bg ≈ +350 ‰). In contrast, CH_4 emissions associated with microbial sources accessing aged, previously frozen carbon in permafrost will be depleted in ^{14}C ($\Delta^{14}CH_4 < 0$‰) because of radioactive decay during soil carbon storage, producing detectably large ^{14}C depletion signals in atmospheric $\Delta^{14}CH_4$. We present ~10-year-long records of atmospheric $\Delta^{14}CH_4$ observations from two Arctic sites: Utqiaġvik (formerly Barrow), Alaska (BRW; 71.32°N, 156.61°W) and the CARVE (Carbon in Arctic Reservoirs Vulnerability Experiment) tower (CRV; 64.99°N, 147.60°W) near Fairbanks. Preliminary results from a one-dimensional analytical framework propagating estimated uncertainties in background CH_4 mole fraction, $\delta^{13}C$-CH_4 source signatures, and combined atmospheric and soil sink fractionations indicate flux-weighted Arctic wetland $\Delta^{14}C$-CH_4 source signatures in the range of -130 ± 124 ‰ (BRW, ±1σ Monte Carlo derived uncertainty) and -132 ± 160 ‰ (CRV). These isotopic source signatures are comparable to those obtained from bottom-up measurements and are equivalent to ~34% of summertime CH_4 emissions being sourced from recently remobilized permafrost carbon (assuming a representative end-member age of ~4000 years for old permafrost carbon). Although we note a clear and consistent warm season ^{14}C depletion signal, longer observational records are needed to determine whether the flux-weighted CH_4 source signatures we observe represent a steady-state signal or the first signs of newly mobilized old carbon sources associated with accelerated permafrost degradation.

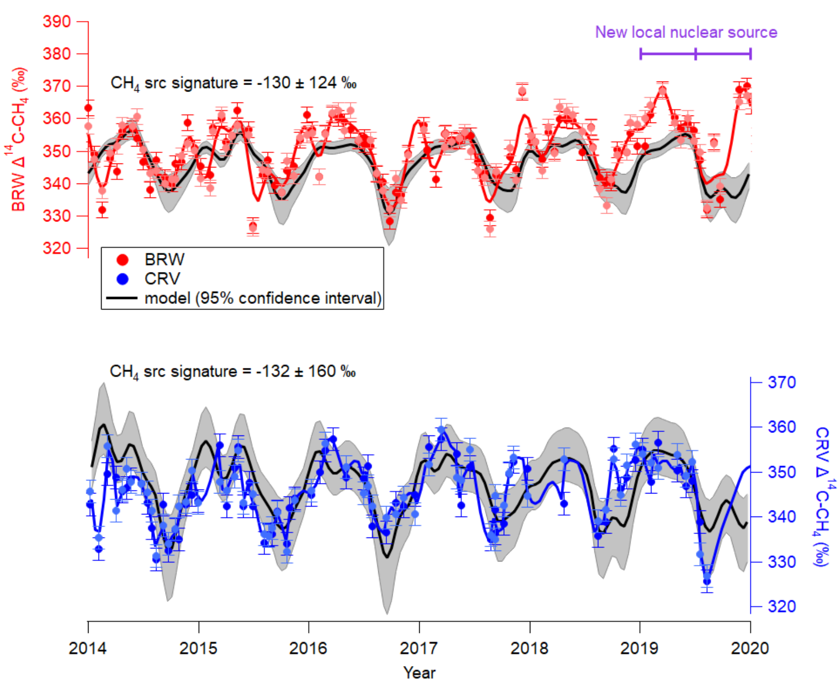

Figure 1. Measured (red and blue dots) and modeled (solid black line, with shaded grey region for 95% confidence interval) $\Delta^{14}C$-CH_4 values for two sites in Arctic Alaska, along with estimated warm-season CH_4 source ^{14}C signatures obtained from a simple one-dimensional model used to isolate the CH_4 mole fraction signal arising from wetland emissions and the range of associated best-fit source values. Source $\Delta^{14}C$ values represent the flux-weighted mean of all source components (both aged and modern).