Multi-scale evidence of CO_2 and CH_4 emissions during spring thaw from Northern Alaska

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Understanding Arctic carbon emissions is critical for predicting climate change feedbacks and closing the global carbon budget. The few observations of tundra greenhouse gas (GHG) fluxes before snowmelt suggest there may be large pulses of CO_2 and CH_4 during spring thaw, but little is known about underlying mechanisms, and whether they influence regional atmospheric concentrations. To address these issues, we combined ecosystem-scale observations of GHG fluxes, a mechanistic soil-core thawing experiment, and airborne observations of atmospheric GHG concentrations. We show that during the 2-week period of snow and surface-ice melt, there were pulses of GHGs that contributed 6% of the snow-free season CH_4 emissions and not only offset 29% of total growing-season CO_2 uptake, but made the snow-free season from near carbon-neutral to a net source of atmospheric CO_2. The controlled thaw released an immediate, large pulse of GHGs that had been trapped

under the surface ice, suggesting that biogenic production in autumn contributes to the spring pulse events. Regional atmospheric GHG mixing ratios, measured by aircraft, were elevated and had similar CO_2/CH_4 ratio as the in situ and core pulses. Thus, this phenomenon is widespread enough to influence the regional atmospheric budget, and although Arctic tundra is widely classified as a carbon sink, our results show that taking into account snow-season GHG pulses reveals these Arctic tundra locations to be a net source of CO_2 to the atmosphere.