Geophysical Research Abstracts
Vol. 21, EGU2019-548, 2019
EGU General Assembly 2019

Carbon Loss Vulnerability to Climate Change in Arctic Wetland Soils

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Arctic warming continues to occur at an unprecedented rate, causing increased methane (CH4) and carbon dioxide (CO_2) emissions in an environment that has been a long-term carbon sink. Warming in these regions destabilizes large soil carbon deposits, making the Arctic particularly vulnerable to positive feedback amplification. Sub-surface CO_2 and CH4 production and consumption outside of the growing season is one of the least studied and most debated positive feedbacks on Arctic warming. Recently, Arctic soils have been recognized to emit significant amounts of CH4 and CO_2 in the cold season, particularly during shoulder periods when air and surface soil temperatures are below freezing, and subsurface temperatures remain unfrozen (referred to as the “zero-curtain”). This is associated with the presence of an unfrozen anoxic soil layer, warmer than surrounding soil temperatures, where microbes are active well into the winter. Higher soil water content, which is correlated to larger CH4 emissions, further extends the duration of unfrozen soil. Given that the effects of climate change are particularly intense during the cold season (e.g. the duration of the zero-curtain is increasing over the last decade) and ecosystem hydrology is shifting, gaining an increased understanding of soil carbon cycling during non-growing seasons is of vital importance to refine predictions of Arctic carbon sensitivity in a changing climate. To this purpose, this study records year-round, continuously measurements of soil carbon (CH4 and CO_2) concentration (in-situ) at different soil layers to understand how thawing of the active layer and permafrost will ultimately affect soil carbon production, storage and release to the atmosphere. We show evidence that soil carbon is biogenically produced in the fall shoulder period, well after the surface has frozen in Arctic ecosystems. Data obtained will help to better understand carbon dynamics in the soil column throughout the year and importantly, during non-growing seasons. This dataset is crucial in understanding cold season emissions and identifying trends in soil-atmospheric interplay in the Arctic.