Arctic methane emissions under novel disturbance regimes: interactions between permafrost thaw, changing precipitation, and peat fires

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Cross-scale feedbacks between hydrology, vegetation, permafrost thaw, and wildfire will drive Arctic carbon cycle responses including methane emissions to the atmosphere. This presentation will summarize recent findings from several large-scale empirical projects examining interactions between disturbance regimes and their consequences for vegetation and carbon storage and fluxes in interior Alaska and northwestern Canada. A long-term monitoring project at the Alaska Peatland Experiment (APEX) found that early onset of abrupt thaw, driven by active layer thickening with no visible thermokarst, was predicted by changes in the moss community and stimulated CH$_4$ fluxes 5-fold, accounting for 30% of the total annual thaw-driven increase in CH$_4$. Methane emissions at several sites in interior Alaska were sensitive to rainfall and surface moisture conditions, with spring rain events stimulating soil warming and methane fluxes. Finally, new tools have allowed us to identify and examine forests and peatlands that experienced overwintering or zombie fire conditions, with early results showing interesting regional differences in how these novel fire conditions influence fuel combustion and carbon release. Results from recent and ongoing studies will be used to frame forward-looking research questions and approaches urgently needed to better understand the fate of permafrost carbon. In particular, I will discuss several efforts to incorporate abrupt thaw into circumpolar upscaling and modeling studies. Unlike active layer thickening, abrupt thaw impacts meters of soil rapidly, occurs on a fine-scale not easily detected in remote sensing products, and is further destabilized by rainfall, wildfire, and vegetation change.