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Glacial influences on carbon, nutrient, and methane dynamics in ice-marginal lakes across three proglacial terrains in Greenland

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Methane, a potent greenhouse gas, is increasingly recognised to be emitted from newly deglaciated environments, particularly in the Arctic. Yet due to data scarcity, these sources remain underrepresented in global methane budgets. Deglaciation leads to the expansion of proglacial terrains, driving the formation of an increasing number of proglacial lakes worldwide, especially in Greenland. Small to medium sized glacial lakes, formed by glacial processes, typically contain organic-poor minerogenic sediments and exhibit relatively low diffusive and ebullitive methane emissions compared to other types of Arctic lakes. However, recent evidence from southwest Greenland suggests glacier-fed lakes (GFL) may produce disproportionally high methane ebullition fluxes compared to glacial lakes that are hydrologically disconnected from glacial meltwater (non-GFL). It is hypothesized that glacially derived sediments and meltwaters influence the biogeochemistry of proglacial lake environments, altering methane production dynamics. We sampled over 20 proglacial lakes in the ice-marginal terrain of southwest, southeast and northeast Greenland. The first site features GFL that are hydrologically connected to meltwaters from the Ice Sheet, while the latter two feature GFL that are linked to outflow from smaller peripheral glaciers. Our methodological approach included lake sediment coring, geo- and hydro-chemical analyses, and gas measurements. Preliminary results indicate that GFL, fed by meltwater originating from the Ice Sheet, can sustain methane concentration profiles in lake sediments and water that are similar to, or exceed, those of non-GFL. In addition, these GFL sediment profiles show minimal organic carbon content (<1% POC) to coincide with areas of peak methane concentrations and production. These findings do not apply to all studied geographical locations, as the proglacial field sites display distinct methane dynamics, underscoring the complex environmental factors influencing these lakes. Further analyses focus on identifying nutrient sources and carbon reactivity in regulating methane production. As the number of proglacial lakes is increasing, there is a growing need to understand methane emissions from these systems. This research aims to identify key drivers of methane production, reduce uncertainties in global budgets, and improve predictions of the potential significance of methane emissions from proglacial lakes as deglaciation continues.