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Quantifying future changes in high-latitude methane emissions and potential climate feedback under regional climate-change uncertainty

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The Arctic's eco-hydrologic system has the potential to be profoundly affected by global climate change and will likely experience greater anthropogenically-forced warming than the rest of the world. One direct consequence of warming in the Arctic would be the likelihood of widespread permafrost degradation. Subsequent subsidence of the landscape and hydrologic changes could then support the expansion of saturated areas such as (thermokarst) lakes and wetlands. These conditions combined with regions of carbon-rich, yedoma soils present a strong potential for increased in methane emissions. However, uncertainties in climate sensitivity, regional hydro-climate change, and emissions need to be considered. In this study, we quantify the future changes in the high latitude methane emission through the use of a modified version of the Community Land Model (CLM) to account for methane emissions from thermokarst lake regions. We force CLM with climate projections of the 21st century from the MIT Integrated Global System Model (IGSM) simulations, which considers the full range of climate sensitivity coupled with various policy scenarios. In order to account the regional climate-change uncertainty, we modify the pattern shifts in precipitation, temperature and radiation by imposing the distinct GCM patterns from IPCC AR4 (and AR5 where available) archive. The potential climate-methane feedback is then assessed from these future emission changes over the high latitudes. Our results indicate that while the Arctic undergoes widespread (near-surface) permafrost degradation, and the increased expanse of saturated conditions can be large (up to 50%) with subsequent strong increases in lake emissions. The radiative-forcing resulting from the increased thermokarst methane is small, particularly weighted against human emissions from the no-policy scenario. While regional climate uncertainties play an important role in the evolution of these permafrost-hydrologic-thermokarst changes, we find that the potential of any temperature feedback is small.