



Understanding permafrost carbon cycle over the Third Pole Regions in a warming climate

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The Third Pole Regions are experiencing a rapid warming during the past several decades as indicated by air temperature increase, glacier retreats, significant changes in spring phenology, vegetation greening, increase in permafrost temperatures and active layer thickness. These changes play an important role in ecosystem evolution and substantial impact on carbon exchange between the active layer and the atmosphere. The Third Pole regions have the largest areas of mountain permafrost terrain in the mid- and low- latitudes in the northern hemisphere. Mountain permafrost regions are mainly characterized with complex topography, which can greatly affect climatic conditions and pedogenesis, thus further influencing soil organic carbon (SOC) densities and leading to large uncertainties of SOC stocks estimates. SOC stored in the Third Pole regions is very sensitive to global warming due to relatively high temperatures, thin thickness and unstable thermal states of permafrost. Decomposition of SOC with temperature increasing can enhance CO₂ and CH₄ emissions, which is a potentially important feedback to climate warming. Here we highlight what we know, as well as an important knowledge gap in our understanding of differences in permafrost carbon cycling in the Arctic and Third Pole regions. We also summarize new work focused on improving our understanding of greenhouse gas dynamics in these regions. It is essential for creating a comprehensive database of soil carbon data in permafrost regions of the Third pole, which allow future studies to better synthesize existing observations. It needs to conduct a data synthesis of long-term greenhouse gas emissions, including winter emissions, which may account for a large fraction of total greenhouse gas emissions in permafrost regions. The biogeochemical dynamics of mountain permafrost carbon cycling in the Third pole regions require studies due mainly to higher temperatures and thermal instability of permafrost than the Arctic regions. It needs to improve the observation technology, such as aircraft observation, which will allow the measurements of inland water-air and thermokarst-affected gas exchange. It is still unclear to predict the effect of carbon sink and source in the Third Pole due to some uncertainties in permafrost degradation such as distributions of thermokarst landscapes. A better understanding of mountain permafrost carbon cycling and underlying environmental drivers will help scientists predict the future feedback of greenhouse gas emissions to climate change.