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Peatland carbon dynamics at different scales across the pan-Arctic using an improved modelling approach

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The majority of northern peatlands were initiated during the Holocene around 8–12 thousand years ago[1]. Owing to their mass imbalance, they have sequestered huge amounts of carbon in the terrestrial ecosystem[2]. Distribution of soil organic carbon is widespread and uneven across the pan-Arctic[3]. Recent syntheses have filled some existing gaps[2, 4]; however, the extent and remoteness of many locations pose challenges to develop a reliable regional carbon accumulation estimate. In this work, we combined three published peat basal age datasets[1, 5, 6] with some independent measurements[2, 4, 7] to form a most up-to-date peat basal age surface for the pan-Arctic region which we then used to constrain the model in order to reduce the current and future uncertainties related to the northern peatlands carbon cycle. We employed an individual– and patch– based dynamic global vegetation model (LPJ–GUESS)[7, 8] with dynamic peatland and permafrost functionality to quantify the long-term carbon accumulation rates and to assess the effects of historical and projected climate change on peatland carbon balance. We divided our analysis into two parts– the carbon accumulation changes detected within observed peatland boundary[9] and at pan-Arctic scale under two contrasting scenarios (RCP8.5 and RCP 2.6). Our results are largely consistent with published long-term carbon accumulation rates. We found that peatlands would continue to act as carbon sink under both scenarios but their sink capacity would substantially reduce under RCP8.5 scenario after 2050. The 286 sites within the observed boundary showed similar behaviour as pan-Arctic scale but their carbon sink capacity would be further strengthened under RCP 2.6. Additionally, areas, where peat production was initially hampered by permafrost and low productivity, would accumulate more carbon because of the initial warming, moisture-rich environment due to permafrost thaw, higher precipitation and elevated CO_2 levels. On the other hand, areas which experience reduced precipitation rates and without permafrost will lose more carbon in the near future, particularly, peatlands located in the European region and between 45-55°N latitude.

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