High methane production in drained lake basin wetlands in northern Alaska

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Abstract

Wetlands in drained lake basins are important elements of the Arctic carbon budget. They may store large amounts of carbon while also producing substantial amounts of greenhouse gasses. After lake drainage the former lake bottom is colonized by pioneer graminoids, succeeded by moss-sedge-dwarf shrub vegetation, producing a typical peat sequence. However, post-drainage organic matter dynamics are not well studied. We hypothesize that vegetation composition reflects both succession and surface wetness, which in turn determine soil organic matter content and methane production. We propose that vegetation types detected by remote sensing-based landcover classification may be used to extrapolate methane production and organic matter composition across drained lake basin landscapes. We investigated (i) plots along a temporal drainage gradient, surveying vegetation, surface sediment, and pond water. We then used (ii) landcover classification of main eco-hydrological classes to (iii) upscale from plot to basin scale. We found that vegetation and organic matter changed markedly between recently drained basins and older age classes. Overall, vegetation composition differed more between eco-hydrological classes than between age classes. Surface sediments had very high water contents (>80 %), suggesting largely anaerobic conditions favouring methane production. Methane concentrations were indeed relatively constant throughout, and particularly high in sediments beneath few centimetres of water ("wet patches", up to 200 µmol/L) and in pond water (up to 22 µmol/L). Landcover classification yielded seven classes including five classes we also identified using statistical clustering of vegetation data plus a water class and a bare ground class. We found that 67 % of basin areas were occupied by wet patches with especially high methane production. Our study shows that remote sensing-based landcover classifications are useful for quantifying wet-vs-moist patches and high-vs-moderate methane production in Arctic drained lake basins. The study highlights the potential for future upscaling of methane emissions from these abundant wetland environments.