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Lake-change trends and permafrost thaw on the Arctic coastal plain of Alaska

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Palaeoclimatic reconstructions from ice cores show that an Arctic or boreal source was responsible for a major (>30%) increase in global atmospheric methane concentration during deglacial climate warming 14-11 ka BP. Past studies have pointed to multiple sources including the expansion of northern wetlands in response to atmospheric warming and thawing of permafrost. The significance of methane emissions from northern wetlands is underscored by recent measurements of very high methane ebullition rates in Siberian lakes situated over thawing permafrost.

To examine contemporary change of Arctic wetlands influenced by permafrost thaw we developed an automatic method to delineate lakes in wetlands using satellite imagery. The method was applied to atmospherically corrected Landsat TM/ETM+ surface reflectance data acquired over the Arctic coastal plain of Alaska. We chose this region because the permafrost has warmed by 3-4 deg. C since 1985 and because permafrost thaw may accelerate the Arctic hydrological cycle.

The delineation of lakes from satellite imagery shows major recent change. The number of lakes and their cumulative area were similar in 1980 and 1990, but lakes grew and became more frequent in 2000. In the drainage basin of the Kuparuk River, which is the most studied river in our area of interest, we found that lake area grew from 694 square km in 1990 to 819 square km in 2000, an 18% increase. We found that 1181 lakes drained completely and that 1,599 lakes drained partially, splitting into two or more smaller lakes. However, 3,574 lakes merged together, to form larger lakes. A total of 1.6 km2 of lake area was lost by complete lake drainage, whilst 39.5 square km of lake area formed by the development of new lakes. Overall, we found that 5,135 lakes lost volume, while 29,820 lakes increased in size. We report this trend together with trends for the adjacent drainage basins and we show that the growing lake-change trend changed substantially after 2000. We discuss implications of short-term (interannual) hydrometeorological variability as well as the longer-term hydrological impacts from permafrost thaw.