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Evidence and Consequences of Warming and Thawing Permafrost in Response to a Warming Climate

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Permafrost temperatures in boreholes displayed a 2 - 4°C increase over the last 50-100 years on the North Slope of Alaska and there was a concurrent warming of discontinuous permafrost. Long-term monitoring of deep wells in a north/south transect across the North Slope of Alaska reveals variable warming with some cooling periods, over the last twenty five years; this is consistent with the broader-scale trends in air temperatures observed in northern Alaska. Discontinuous permafrost is warming and thawing and extensive areas of thermokarst terrain (marked subsidence of the surface resulting from thawing of ice-rich permafrost) are now developing as a result of climatic change. Thawing permafrost and thermokarst have been observed at several sites in Interior Alaska. Thermokarst is developing in the boreal forests of Alaska where ice-rich discontinuous permafrost is thawing. Thawing destroys the physical foundation (ice-rich soil) on which forests develop, causing dramatic changes in the ecosystem. Impacts on the forest depend primarily on the type and amount of ice present in the permafrost and on drainage conditions. In sites underlain by ice-rich permafrost, trees die when their roots are regularly flooded, causing wet sedge meadows, bogs and thermokarst ponds and lakes to replace forests. These new ecosystems favor aquatic birds and mammals, whereas the previous forest ecosystems favored land-based birds and mammals. Much of the discontinuous permafrost in Alaska is both warm and ice-rich, making it highly susceptible to thermal degradation if regional warming continues.

The active layer is an important factor in cold-regions science and engineering, because most ecological, hydrological, biogeochemical, and pedogenic activity takes place within it. The thickness of the active layer is influenced primarily by surface temperature and length of the thaw season and secondarily by several factors, including vegetative cover, thermal properties of the surface cover and substrate, soil moisture, and modes of heat transfer. To date, there has been no conclusive evidence of broad-scale increases in active layer thickness with increasing average annual air temperatures; however, it appears that the surface of the soil is experiencing broad-scale subsidence in some areas as the ice-rich soil at the base of the active layer thaws, which would mask increasing active layer thickness.