Mapping Permafrost Conductivity on the Arctic Coastal Plain of Alaska Using Electromagnetic Induction

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Geophysical methods are often deployed to evaluate the properties of frozen soils and permafrost conditions including permafrost thickness, state of freeze/thaw, and bulk salinity. Permafrost salinity is effectively assessed using electrical and electromagnetic instrumentation and is of high importance because high ionic concentrations in the pore fluid result in freezing point depression, and liquid-phase pore water can exist even when the ground temperature is below freezing. Subsurface salinity in currently stable permafrost landscapes has notable implications for predicting potential permafrost thaw under warming scenario. Electrical conductivity mapping of near surface permafrost using electromagnetic induction methods illuminates where zones of saline pore fluid are likely to be present. It is anticipated that saline permafrost will prematurely undergo subsidence and change to hydrologic processes due to reduced mechanical bonding of the sediments in the absence of ice bonding at temperatures below freezing. Here, we used snowmobile-towed electromagnetic mapping instrumentation in the spring of 2024 near Utqiagvik, Cape Simpson, and Point Lonely/Teshekpuk Lake, Alaska. The purpose of these measurements was to obtain data indicating where saline permafrost is likely to be present across a regional geographic scale. The campaign resulted in approximately 248 line-kilometers of measurements spaced on average 2 m apart over the course of seven field days. Electromagnetic sensor measurement tracks traversed 50 shallow (&lt;4m) borehole locations where permafrost salinity has been measured in order to determine the threshold to classify the presence of elevated permafrost salinity. The spatially-averaged bulk conductivity values are compared with co-located average conductivity observations measured along the depth of each borehole to indicate a relationship with bias towards the values measured in extracted core. Spatial analysis of the geophysical conductivity values suggests that high conductivities are proximal to coastlines and within some drained lake basins and extant lakes. However, coastline proximity alone is a poor predictor of permafrost conductivity suggesting that the distribution of saline permafrost is irregular. We expect that these results will have an impact on evaluating potential of coastline erosion, identification of hidden saline permafrost, and engineering planning.