vertical electrical sounding for identification of permafrost table and active layer depth in Arctic cryogenic environments

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Polar regions of the Earth and cryogenic ecosystems face challenges associated with climate change. Warming of the atmosphere and topsoil leads to the gradual degradation of permafrost, decreases the total volume of soil mass, and diminishes the bearing capacity of northern soils. This leads not only to serious environmental consequences but also to huge economic risks. The methods of drilling and pushing a steel probe into the soil are actively used to determine the depth of the upper permafrost horizon. These are disruptive methods, which are dangerous to the permafrost itself, and preclude reliable re-measurement at the same location for monitoring. In this context, noninvasive geophysical methods are very promising for permafrost investigation. Vertical electrical resistivity sounding (VES) of the soil and permafrost of the polar environments has been carried out within the key areas of the Spitsbergen (Svalbard) Archipelago, the North of Western Siberia (Yamal region) and Central Yakutia. It has been established that the values of apparent electric resistivity at the boundary of the active layer and the permafrost table change sharply, which allows using this noninvasive method for fieldwork in cryogenic ecosystems. We confirmed that the permafrost layer is characterized by increased electrical resistance, the values of which are 1-2 orders of magnitude greater than those in the active layer of soil sections of various textures. It was shown that the permafrost layer can be identified by vertical electrical sounding without disturbing the integrity of the soil cover. This is of particular interest for multiyear observations at permanent sites for circumpolar active layer monitoring. In general, the electrical resistivity profiling data collected at the soil-permafrost strata coincide well with the field results of determining the boundary of the active layer and permafrost sediments by excavations or drilling. The dynamics of electrical resistivity in cryogenic soils affected by wildfires were also studied. This allows us to establish the thermal stability of soils, which is extremely important due to the intensification of wildfires in the tundra and forest tundra of Northern Eurasia.