Thermal regime of soil active layer at the Bolshevik Island (Archipelago Severnaya Zemlya) during 2016 – 2020 years

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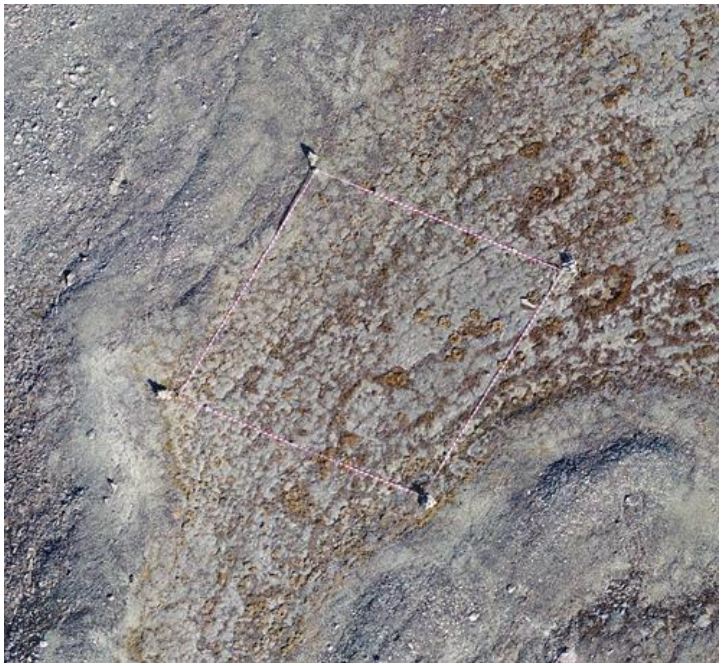
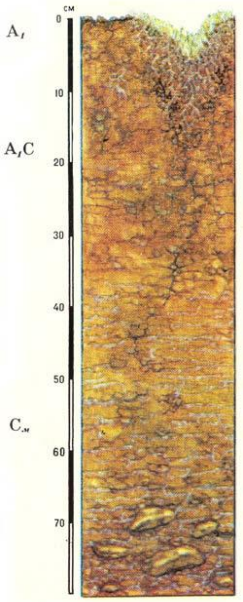
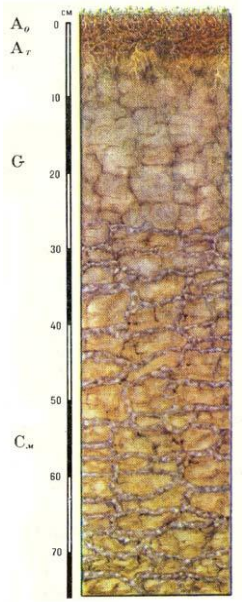
Permafrost study on CALM polygon



Morphological structure of the Arctic desert (left) and tundra (right)

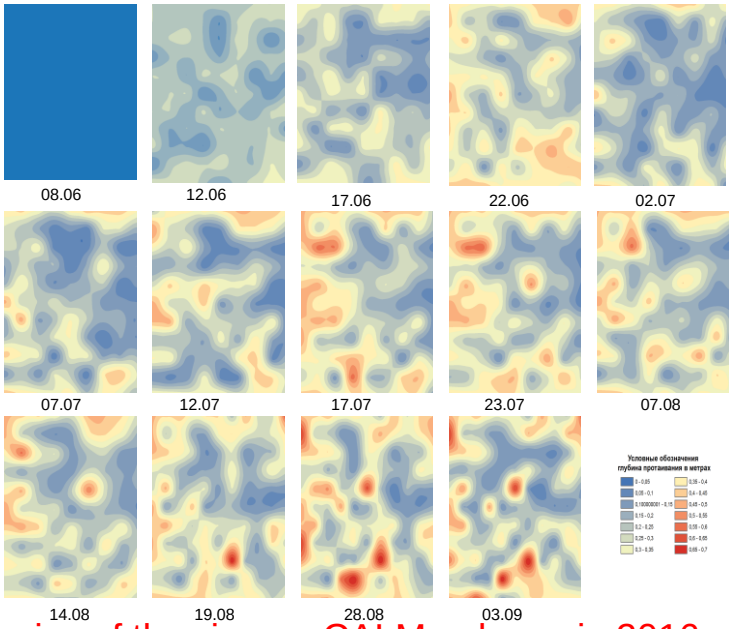


A1 — 4 cm homous layer; loamy or sandy with high quantity of plant debris and roots;
A1C —transition layer, 30-40 cm thickness, sandy;
C — freezing mother rock, sandy or crushed stone

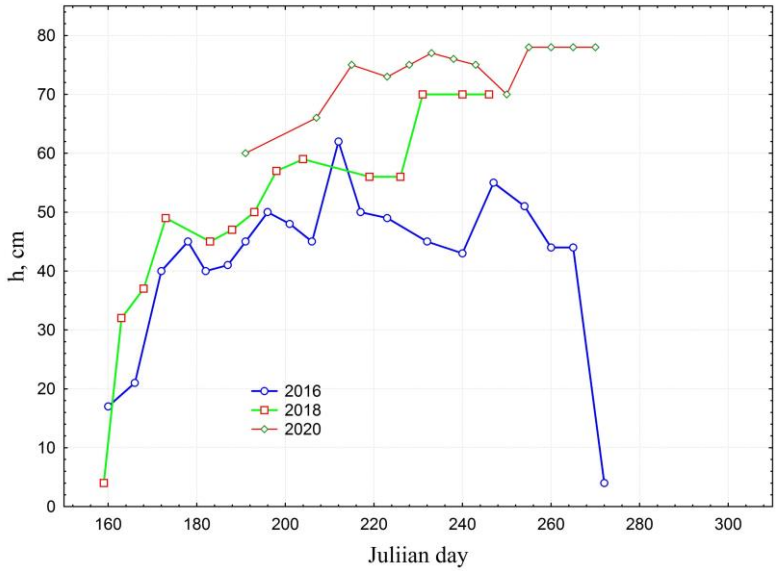


A0 —plant (moss, ground willow stems, sedge roots) layer 1-5 cm thickness;
A0A1 —humous layer with roots, loam, 3-7 cm thickness;
G —glei layer, loam, 10-20 cm thickness;
BC — transition layer, loam, 15 – 30 cm thickness;
C — mother rock, sometimes stony, frozen, ,with ice streaks

http://www.ecosystema.ru/08nature/soil/001t.htm

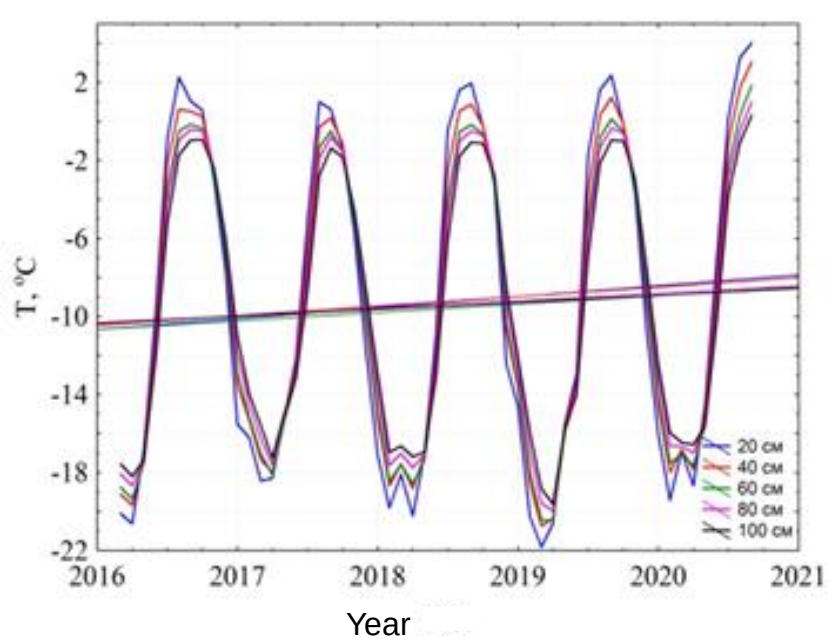


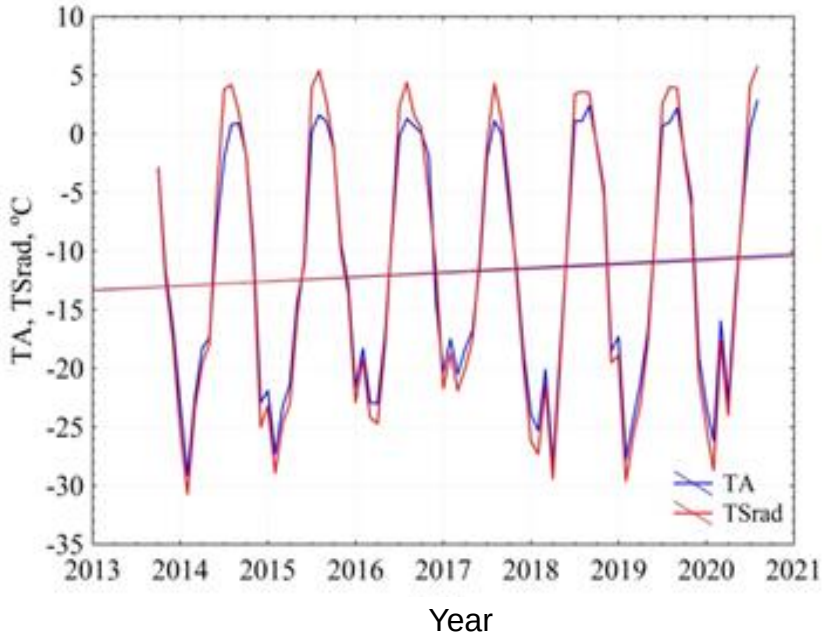
Dynamics of thawing on CALM polygon in 2016

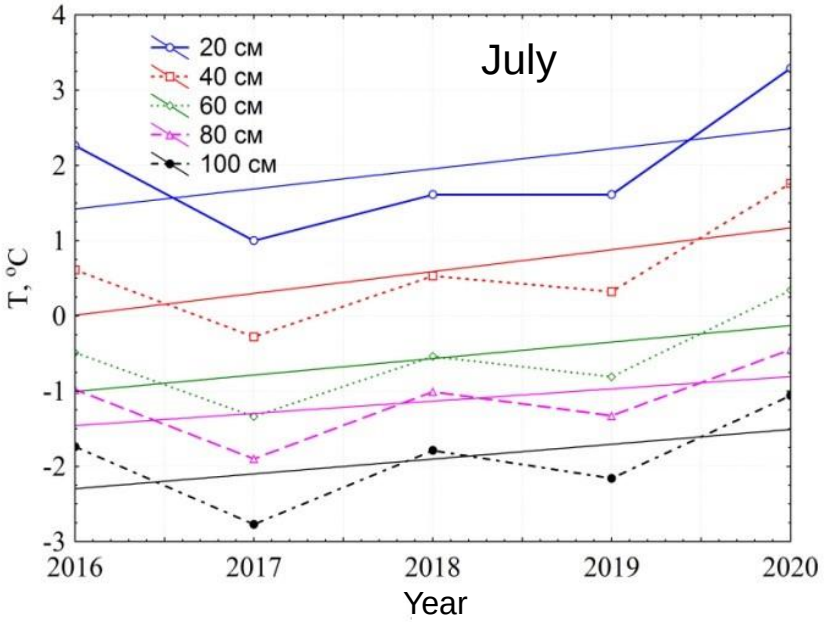


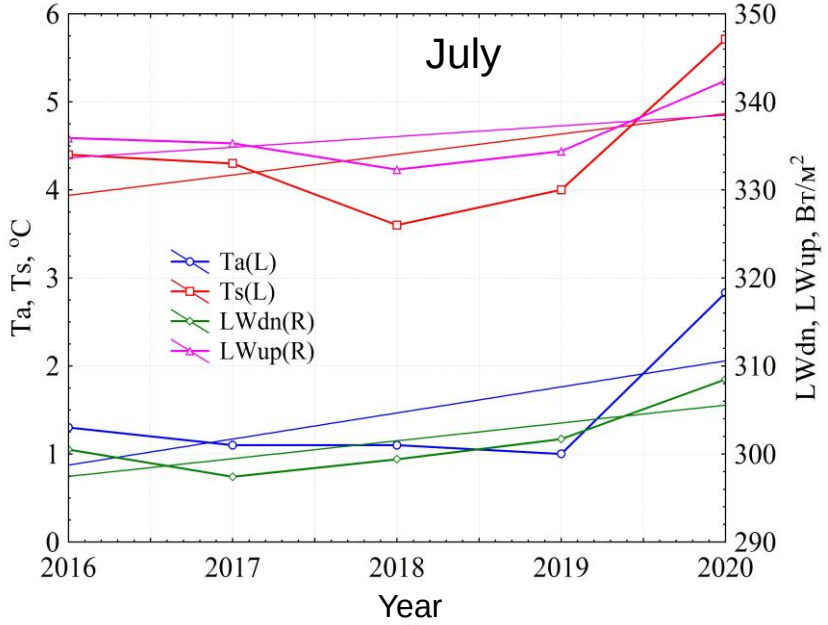
Maximal thawing from polygon's data in 2016, 2018, 2020

Interannual variability of monthly mean temperatures of active soil layer, atmospheric surface layer and components of longwave radiation balance

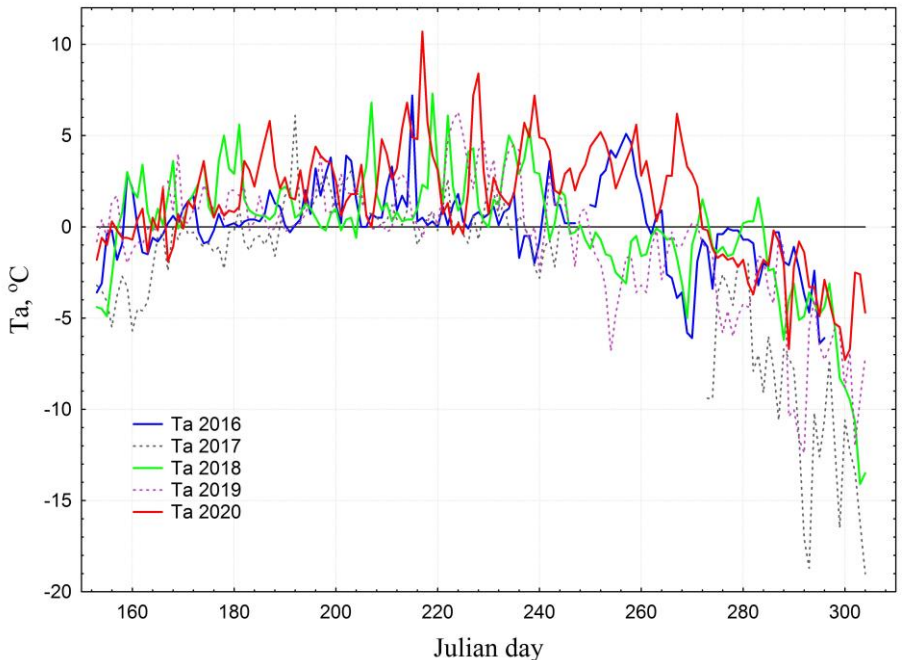


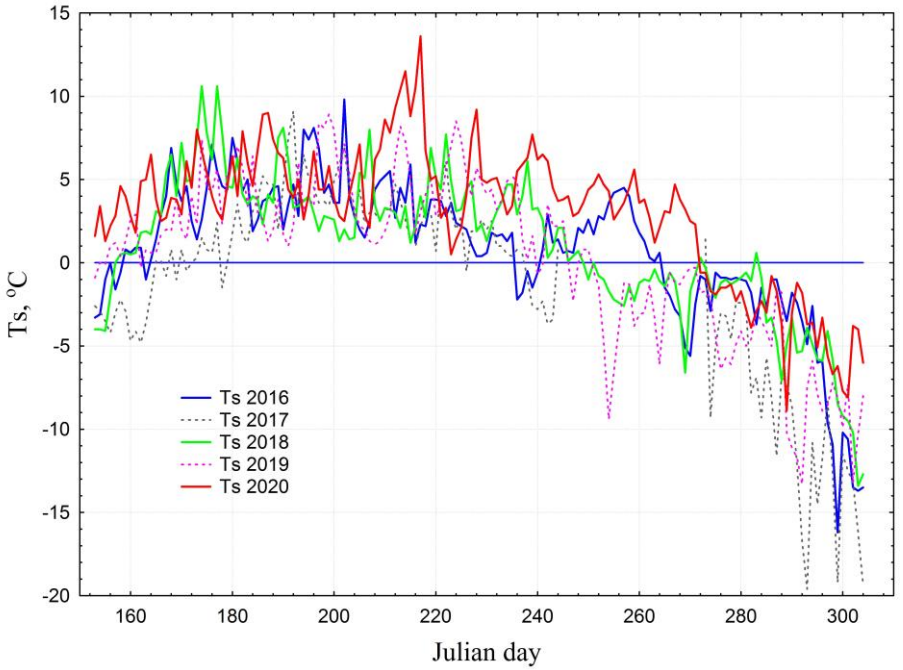


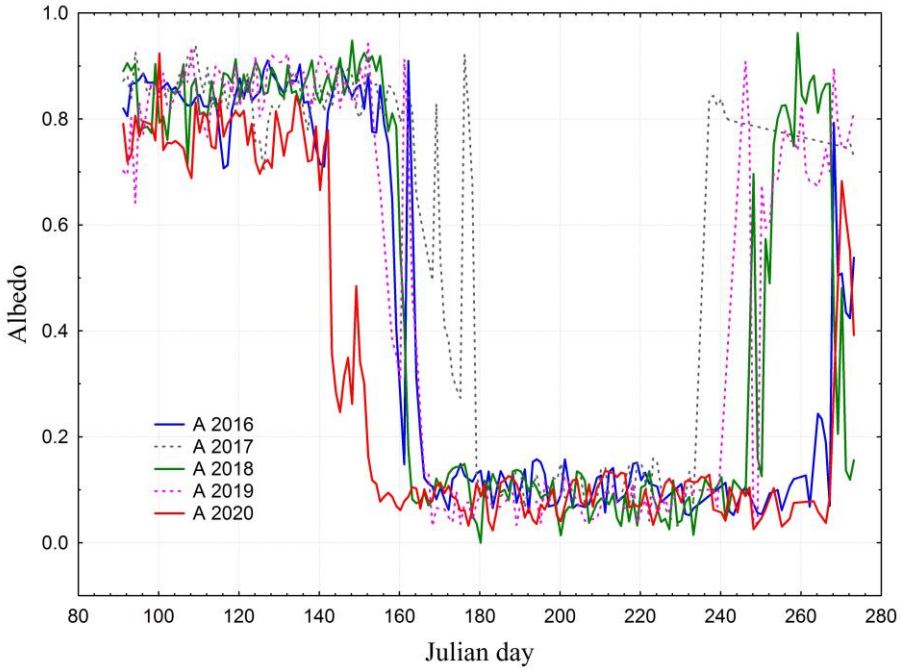


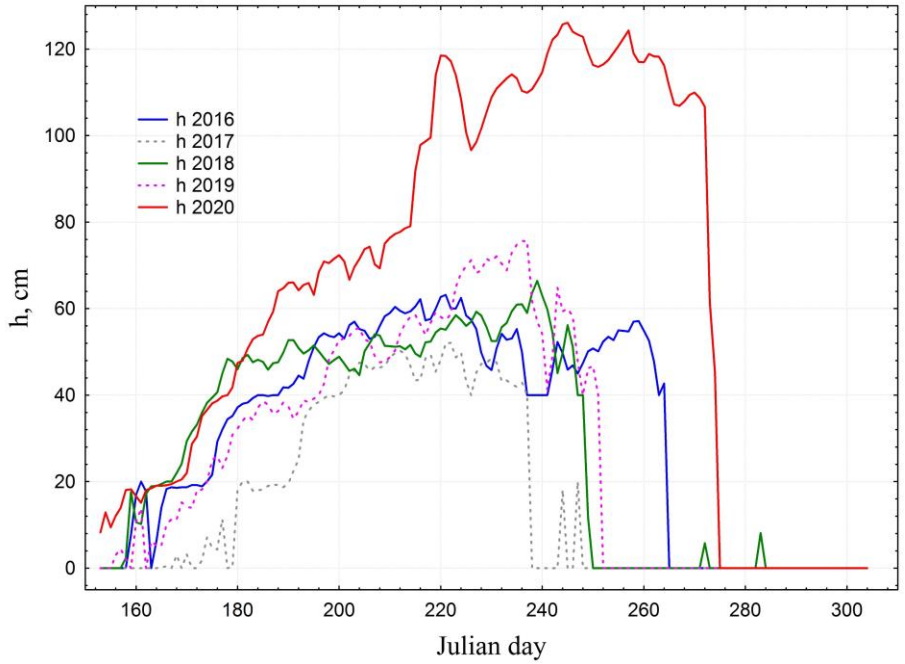


Temperatures of atmospheric surface layer and surface, albedo, and depth of soil thawing

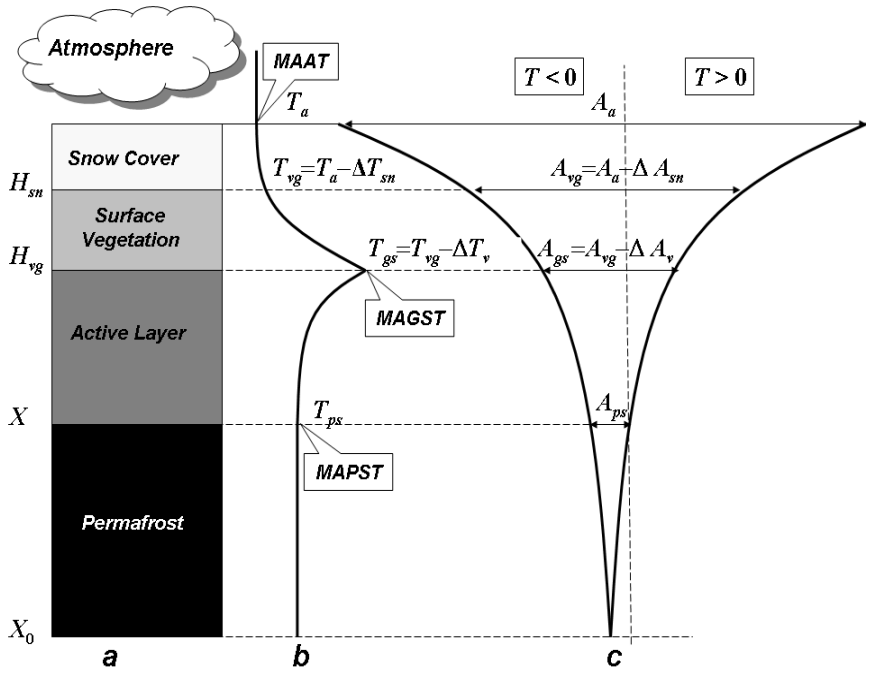






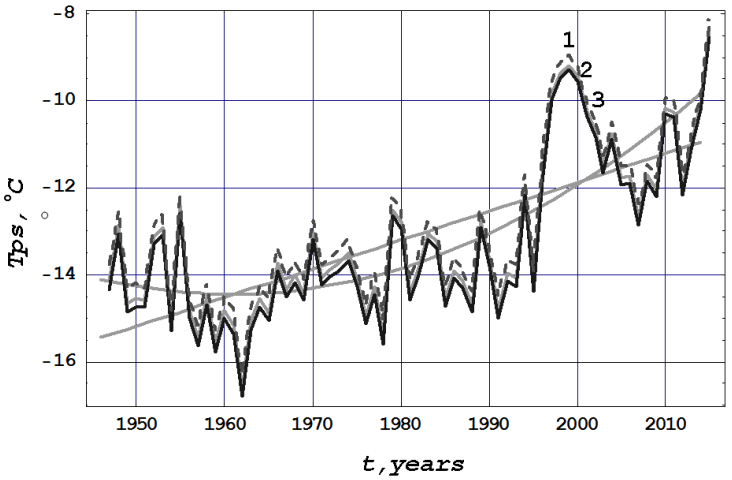


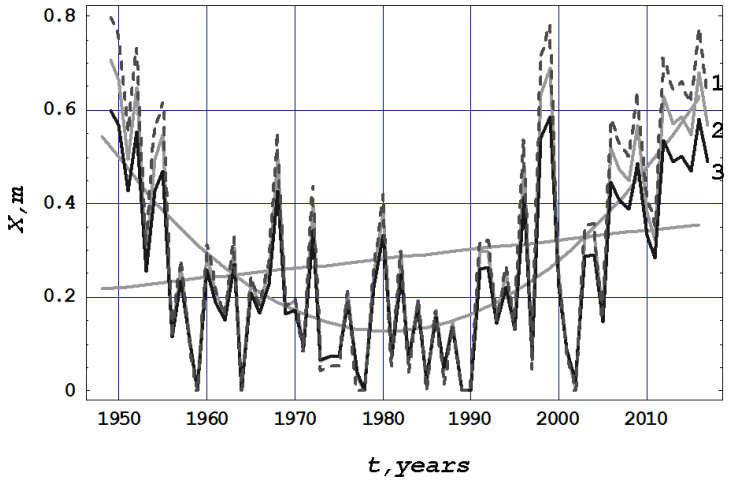
Model of seasonal thawing of the upper permafrost



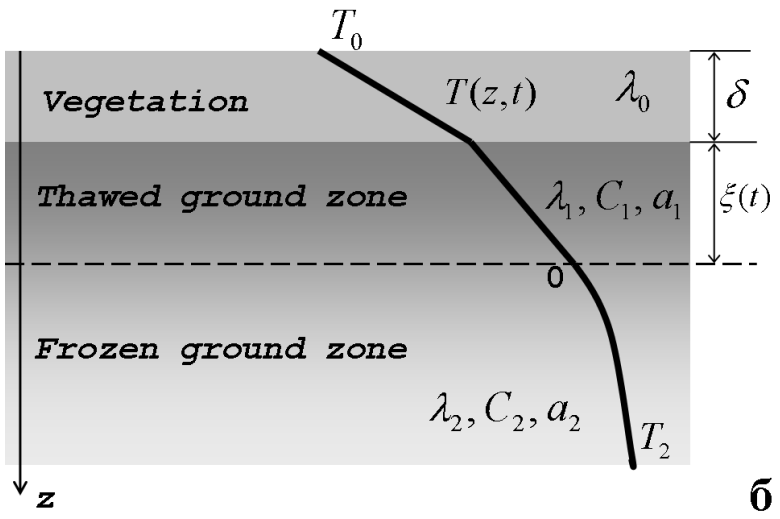
The model conceptual diagram (left), schematic profile of annual mean temperatures (center) and its seasonal range in atmospheric surface layer, soil active layer and upper permafrost (right)

Long-term variability of permafrost roof temperature and depth of seasonal thawing of sandy (1), sandy loam (2) and clay (3) soils

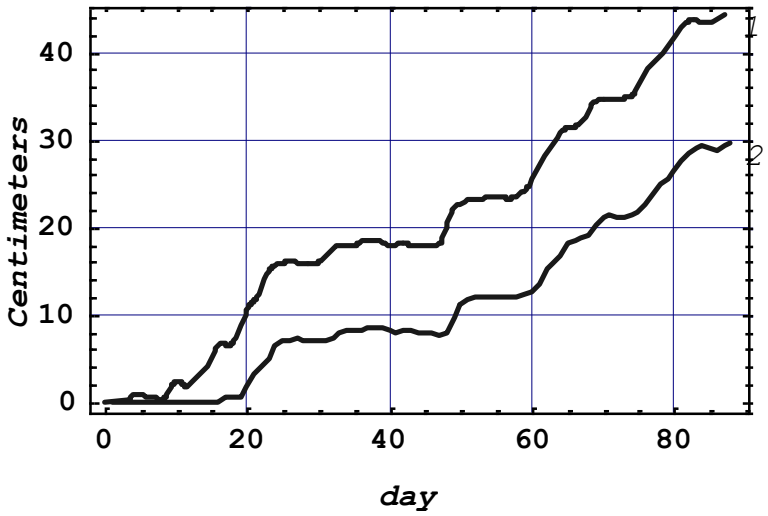




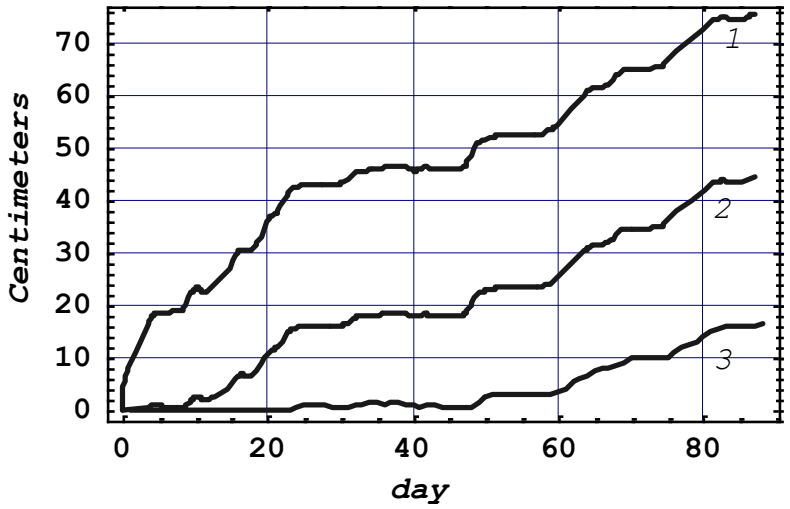
Model of soil active layer growth

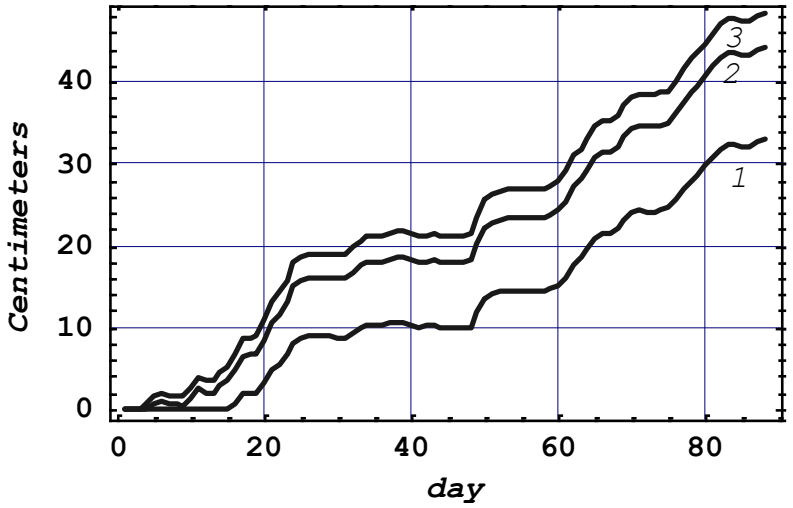


Growth of active soil layer thicknesses under 5 cm of mosses Hyloconium splendens(1) and Sanionia uncinata 7 June-2 September 2018



Growth of active soil layer thicknesses during June 7 - September 2 2018 under thickness of moss 0 (1), 2 (2) and 5 cm (3) left, and moss water content 1 (1), 2 (2) and 3 (3) for thickness of moss 2 cm (right), and temperature –5°C of underlying permafrost





CONCLUSIONS

Permafrost thawing studies using a manual contact method, carried out on the special site, organized according to CALM standards, showed significant variety of soil active layer thicknesses in the relatively small area (100 m^2), indicates significant spatial variability of microrelief, structure and thermophysical properties of soil, as well as vegetation, typical for Arctic desert.

Investigations of active soil layer with thermo-chain revealed annual cycles of soil temperature with amplitudes up to 15°C less than the amplitudes of surface air layer temperature (Ta) and especially the temperature of the soil upper surface (Tsrad), which in great degree determined by short-wave radiation heating and long-wave radiation cooling. Approximation by linear fittings shows average rates of increase Ta - 0.4°C/year, Tsrad - 0.3°C/year, and temperatures of active soil layer - 0.2°C/year during 2016 - 2020.

Comparison in temperatures of surface and characteristics of surface heat balance during period under study showed that in 2020 the temperature of soil surface at the end of May for a short time reached the temperature of snow melting. It happened 25 days earlier than in other years and led to radical decrease of surface albedo, sharp increase of heat flux to the underlying surface, and increased duration of active soil layer heating. As result the depth of thawing increased up to 1.2 m.

Calculations, executed with the model of seasonal thawing of the upper permafrost, showed the increase of soil active layer thickness beginning from 80-th years of XX Century.

Model of soil active layer growth during summer showed the high sensitivity of model results to description of thermal and physical properties of vegetation and parametrizations of soil thermal and mass-transfer characteristics.