3.6 Seasonal progression of active-layer thickness dependent on microrelief

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3.6.1 Introduction

Active-layer thickness is a major factor for all physical and biological processes in permafrost soils. It is closely related to the fluxes of energy, water and carbon between permafrost landscapes and the atmosphere. Active-layer thickness is mainly driven by air temperature, but also influenced by snow cover, summer rainfall, soil properties and vegetation characteristics (Nelson et al., 1998). The typical polygonal tundra of the Lena Delta is characterised by a pronounced microrelief, which causes a high small-scale heterogeneity of soil and vegetation properties. Consequently, also the active-layer thickness varies substantially across small lateral distances of decimetres to metres. In order to up-scale results of process studies to the landscape scale, a quantification of the heterogeneity of active-layer thickness is of great interest.

3.6.2 Methods

In 2002, an active-layer thickness monitoring program was started on Samoylov Island. An investigation site of 28 m x18 m was established on the area of a typical low-centre polygon in the vicinity of the permanent meteorological and soil survey station (Kutzbach et al., 2003b). 150 measurement points were mapped out in a regular grid of approximately 2 m x 2 m. The measurement points were grouped in classes according to their situation within the microrelief and their vegetation cover. A characterisation of the five distinguished classes is given in Table 3.6-1. At every measurement point, active-layer thickness was determined on a weekly basis by driving an steel rod into the unfrozen soil until the permafrost table was encountered. In 2003, measurements were conducted from June 15 to October 4 (2002: June 10 to August 30). In addition to the regular measurements, the mapping of the microrelief of the investigation site was refined for the production of a high-resolution 3-dimensional surface model. The new surface model is presented in Figure 3.6-1 and Figure 3.6-2.

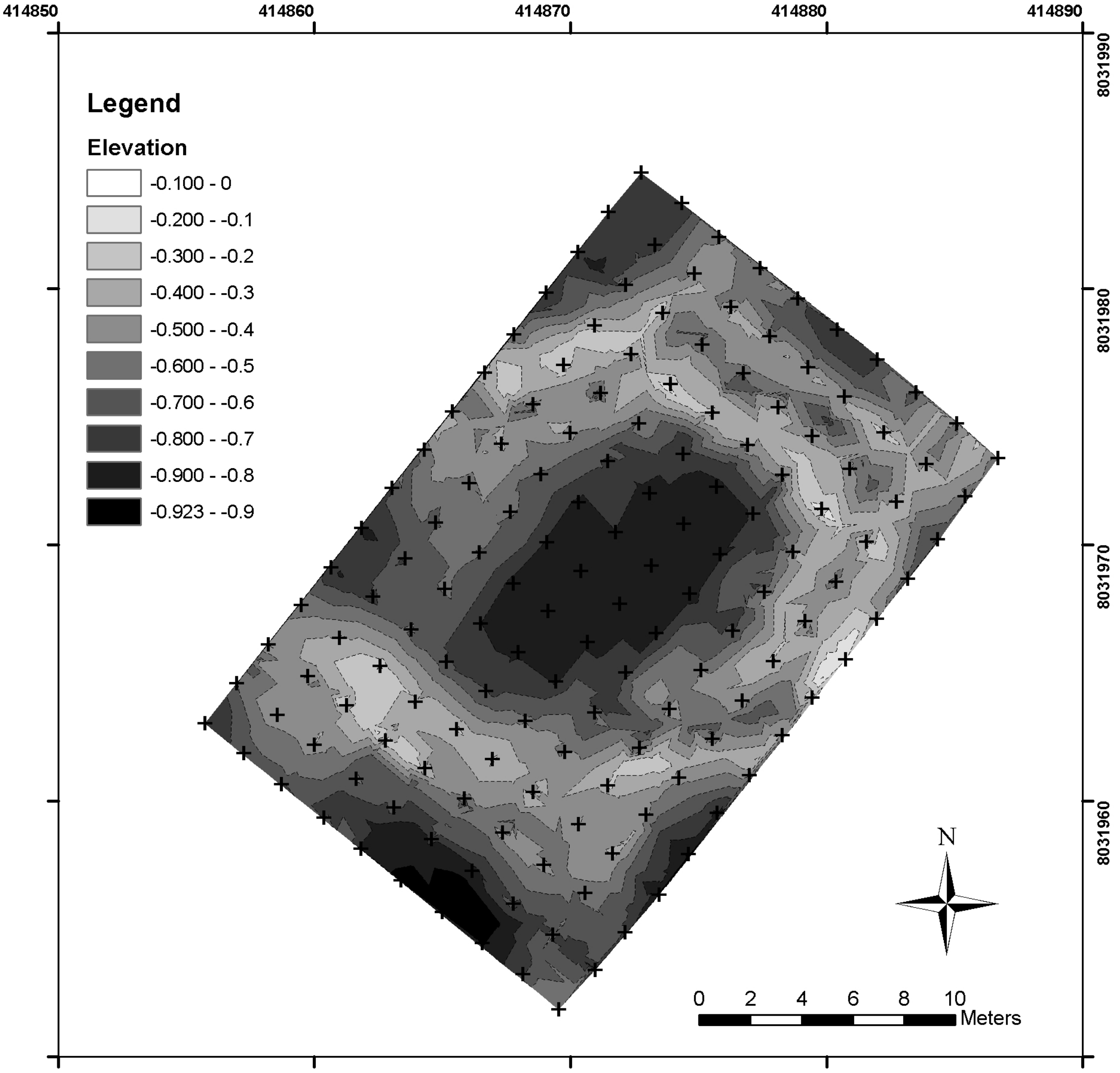

Figure 3.6-1: Map of active-layer thickness monitoring site. – Crosses: positions of measurement points. The 3D-model is based on a triangular network (TIN, 1379 points). Elevation values are relative to a reference point in metres. The coordinate system is UTM, Zone 52N, WGS84.

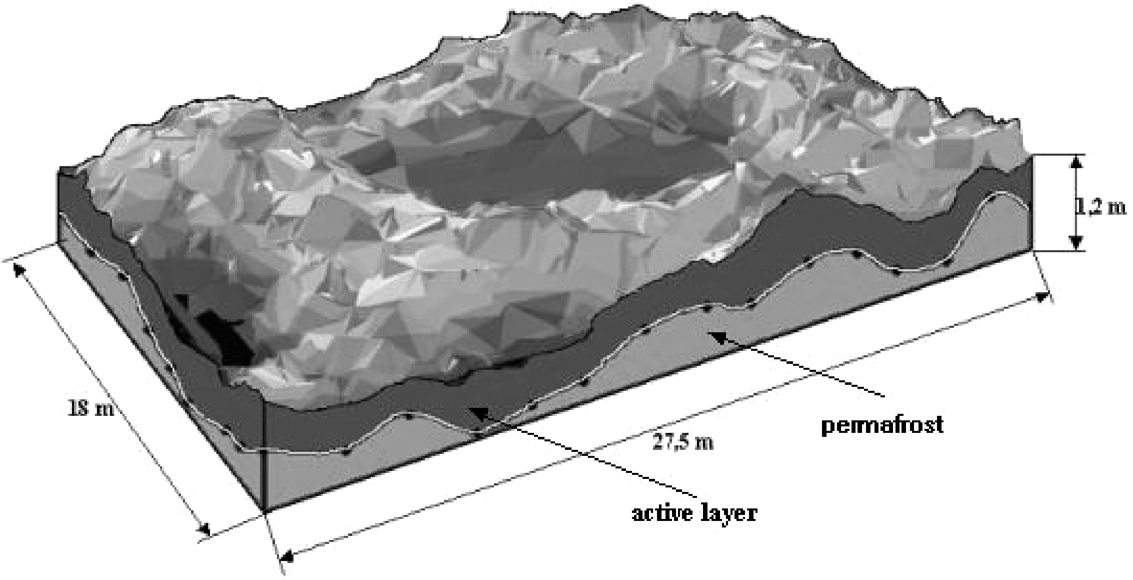

Figure 3.6-2: Three-dimensional model of the active-layer-thickness monitoring site. The white line indicates the maximum active-layer thickness in 2003 observed at the end of August. The height exaggeration factor is 4.

Table 3-6-1. Characterisation of measurement point classes at the active-layer thickness investigation site.

ID	situation within microrelief	vegetation	number of points
1	depressed polygon centre, water table at or above the soil surface	*Carex aquatilis, Limprichtia revolvens, Meesia longiseta, Calliergon giganteum, Meesia triquetra*	39
2	transition zone between centre and elevated rim	thick moss layer *Sphagnum orientale, Meesia longiseta, Aulacomnium palustre, Aulacomnium turgidum, Tomenthypnum nitens*	25
3	strongly elevated rim, strongly convex	*Carex aquatilis, Salix glauca, Salix reptans, Dryas octopetala, Astragalus frigidus, Luzula nivalis*	33
4	weakly elevated rim relatively flat	few *Carex aquatilis*, thick *Hylocomium splendens* layer	47
5	frost crack	*Limprichtia revolvens, Calliergon giganteum, Campylium stellatum, Tomenthypnum nitens*	6

3.6.3 First results

The seasonal progression of the mean active-layer thickness during the expedition periods of 2002 and 2003 is presented in Figure 3.6-3. Maximum thaw depth was observed in both years at the end of August. The mean active-layer thickness was distinctly greater in 2003 than in 2002. At the end of August, it amounted to 0.43 ± 0.08 m in 2002 and to 0.48 ± 0.07 m in 2003, respectively. It is assumed that this substantial variation between years is related to the strongly differing precipitation patterns of the years 2002 and 2003. The accumulated precipitation during June and July amounted to 46 mm in 2002, while in 2003 more than the twofold value, 110 mm, was determined for the same period (Hydrometeorological Centre of Russia, 2004). Rainfall is of high importance for the energy balance of soils, as it represents an advective heat transport from the atmosphere into the soils, increases soil moisture, and as a result alters the thermal properties of soils, as heat capacity and heat conductivity.

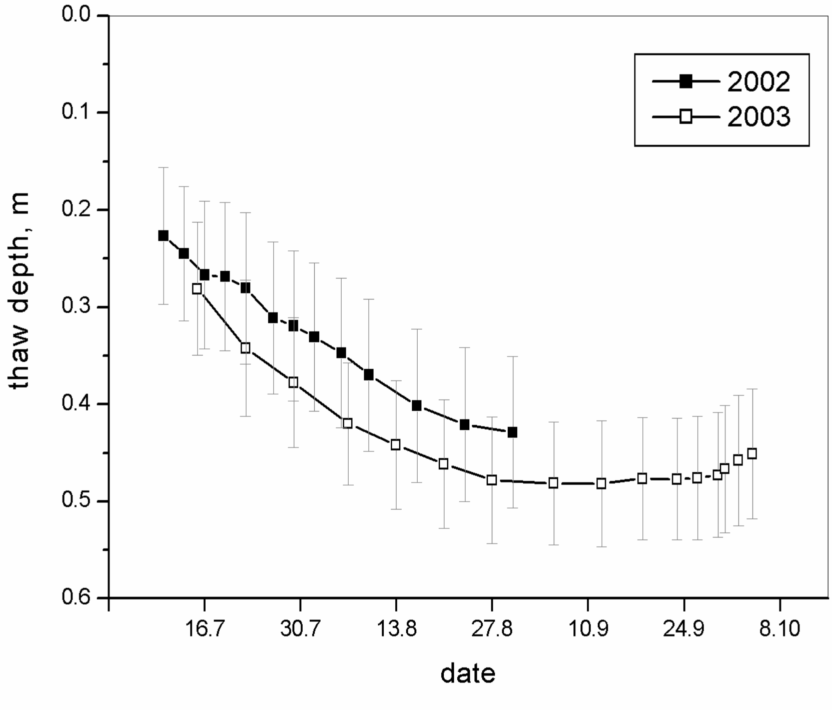

Figure 3.6-3: Seasonal progression of active-layer thickness in 2002 and 2003. Values are means of all 150 measurement points.

Figure 3.6-4 points out the strong influence of the microrelief position and vegetation cover on the active-layer thickness. In particular, the thaw depths at strongly elevated rim positions (class 3) and at weakly elevated rim positions (class 4) differ substantially. While the mean thaw depth of class 3 reached 0.53 ± 0.07 m at the end of August 2003, the mean thaw depth of class 4 reached only 0.44 ± 0.06 m. At both rim classes (3 and 4), only slow freezeback could be observed at the end of September. By contrast, the mean thaw depth at the depressed centre positions (class 1) decreased considerably faster at that time of season.

Further evaluation of the data will help to develop a better understanding of the spatial variability and the regulation of active-layer thickness of polygonal tundra landscapes.

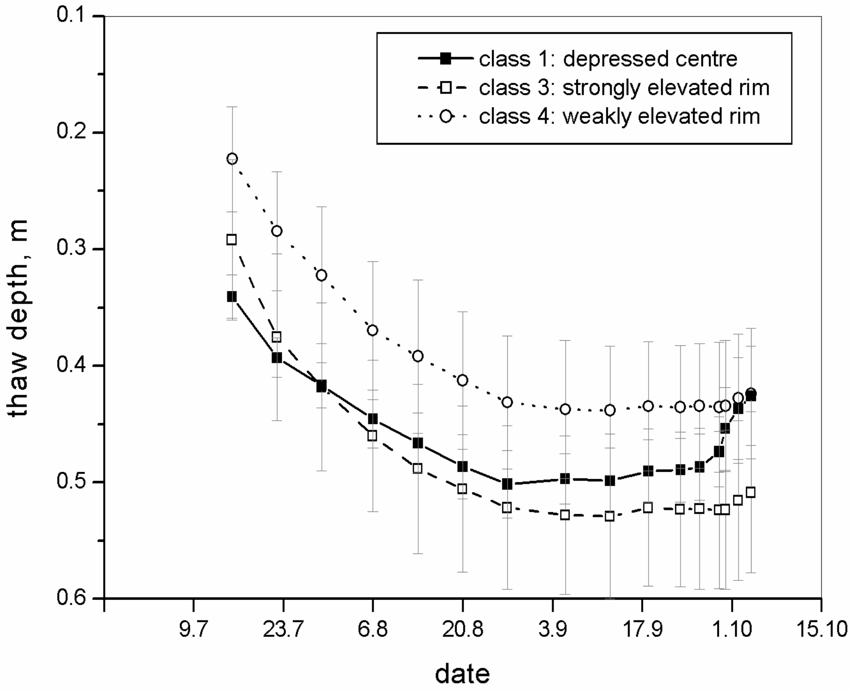

Figure 3.8-4 Seasonal progression of active-layer thickness in 2003 differentiated by situation within the microrelief (see Table 3.6-1). Values are class means (class 1: *N* = 39, class 3: *N* = 33, class 4: *N* = 47).