Ground-based active layer monitoring as a benchmark and verifier of remote active layer depth mapping, Central Yamal, Russia

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Active layer depth (ALD) is an important feature characterising thermal state of permafrost. Yamal Peninsula is characterized by wide distribution of saline clay. Mechanical method of ALDs measurement by metal probe does not always provide the correct data because saline marine clays are plastic and do not have mechanical resistance to metal probe under high negative ground temperature.

In 2012 and 2013, ALD measured by metal probe on CALM grid of Research station Vaskiny Dachi averaged at 102 and 103 cm in a range 75 to 169 and 76 to 155 cm respectively. These values are 14-15% higher than perennial average (89 cm) in 1993-2011, and 5-6% higher than maximal average for the period (2005, 97 cm). Such increase of active layer depth in 2012 compared to previous years is related to extremely warm spring. The warm period started on May 25, maximal average daily temperature was +18,0°C on June 29, and thaw index calculated for the period from May 25 to September 2 (date of ALD measurement) was 853,8 degree-days with amount of precipitation 256,5 mm. To compare, the same values for the period from May 12 to September 4 of the previous warmest year of 2005 were 660,7°C and 145,5 mm respectively.

Climatic parameters (thaw index 655,5 degree-days and amount of precipitation 114,3 mm from June 8 to September 2 in 2013, and freeze index -3105 degree-days for 2012-2013 winter) are much less than in 2012, so are likely not most important factors in maintaining the abnormally high ALD this summer. We suggest that abnormally deep thaw in 2013 is due to a combination of two factors: delayed refreezing in the fall 2012, and thawing of saline marine clays overlain by sandy and loamy deposits. Saline clay retains plasticity to a temperature of -1°C and reacts to the mechanical probing as thawed.

Lateral variation of ALDs due to complicated topography and landscape. Landscape differentiation in addition to lithology and topography includes moisture content and vegetation cover, of which most important is existence/domination or absence of moss/shrub cover.

ALD monitoring data accumulated so far along with the development of remote-sensing approaches to the analysis of permafrost conditions allow us to start developing remote sensing methods of ALD monitoring. Moisture content is reflected on radar images. Digital elevation model also results from processing radar images. Componentwise interpretation of vegetative complexes is undertaken using high resolution optical images. Verification of all available remote-sensing data by ground-based monitoring allows to zone area by the rate and degree of active layer reaction to the climate change.

The study is partially supported by CALM III program; by RFBR, research project No. 13-05-91001-АНФ_а; ASF No I 1401-N29; and The Presidential Council for grants, Science School Grant No. 5582.2012.5.