Arctic Change 2014

SYNTHESIS OF PERMAFROST RESEARCH ALONG THE EURASIA ARCTIC TRANSECT

M.O. Leibman, O.V.Khitun, A.V. Khomutov, N.G.Moskalenko, P.T.Orekhov, O.E.Ponomareva, D.R.Mullanurov, A.A.Gubarkov, K.A.Ermokhina

ECI DADA COLLECTION

1. General physiographical and climatic information for the transect.
2. Summary of the existing information on vegetation, soils and permafrost for the transect locations and Yamal as a whole.
3. Summary of the own data on vegetation, soils and permafrost.
4. PhD dissertations of the participants devoted to vegetation and permafrost of Central Yamal, partly translated from Russian into English.
5. List of publications and presentations using results of LCLUC-Yamal project.
6. Maps – cartographic models of vegetation-permafrost interrelation.

Permafrost research along the Eurasia Arctic Transect (EAT) included estimation of the thermal state of permafrost and activity of cryogenic processes through ground measurements and remote-sensing data analysis. Transect covers the distance of 1880 km from Nadym (65°18'51"N, 72°51'43"E) to FJL Hayes Island (80°35'56"N, 57°54‘20"E):

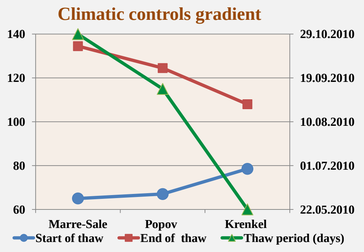
LOCATIONS	DISTANCE, km
Nadym - Laborovaya	340
Laborovaya – Vaskiny Dachi	290
Vaskiny Dachi – Kharasavey	125
Kharasavey – Bely Island	260
Bely Island – Hayes Island (Krenkel)	865

Yamal being an area of rapid natural and anthropogenic changes is an excellent object to calculate spatial distribution and temporal dynamics of ground temperature and active layer depth. Permafrost is affected by natural surface disturbances (cryogenic landslides, thermodenudation, thermoerosion, thermokarst), anthropogenic (structures, vehicle tracks, sandpits), and natural-anthropogenic (reindeer pasturing).

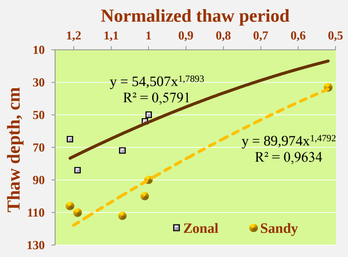
Highly variable topography, deep dissection in the central part of Yamal compared to relatively flat southern and northern parts of EAT determine the role of precipitation, both winter and summer. Main forcing factor for ground temperature is snow cover thickness. It is the highest on slopes and in the narrow valleys. Snow insulates surface not only from winter cold, but also from summer warming, because snow patches survive at least till mid-July thus reducing active layer depth. At the same time, at the hilltops snow is blown away along with vegetation cover resulting in the lowest ground temperature, but at the same time, deepest summer thaw.

Thaw depth

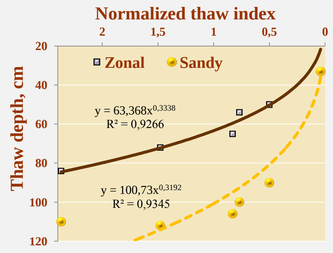
Climatic controls gradient



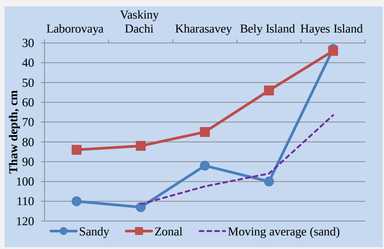
Normalized thaw period



Normalized thaw index



Thaw depth gradient

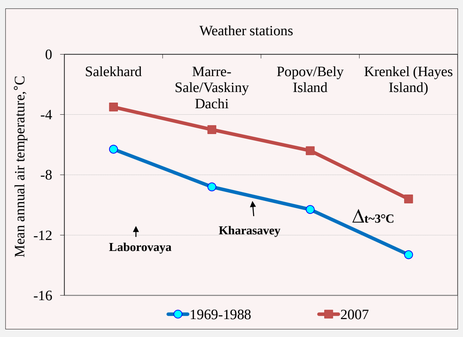


To operate with non-dimensional quantities we divided each parameter into an average value of the data array to obtain “normalized” values

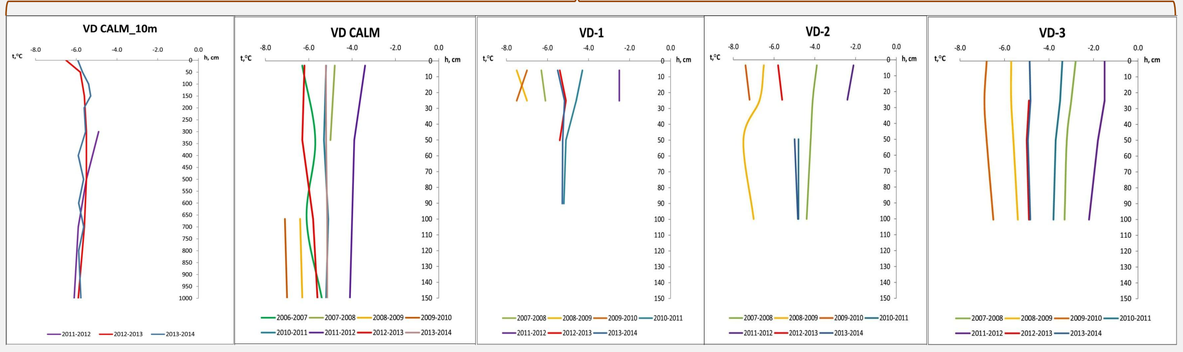
$$x_{norm} = x_i / \bar{x}$$

Ground temperature

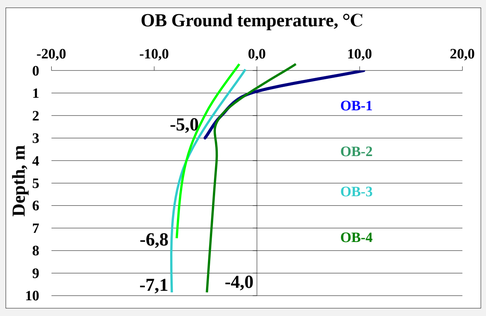
Climatic controls gradient

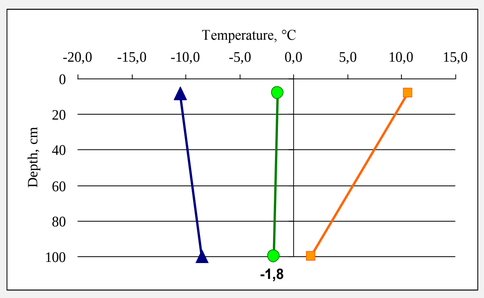


Lithology and geomorphology controls



Sandy hilltop | Silty hilltop | Loamy hilltop | Silty terrace | Sandy terrace

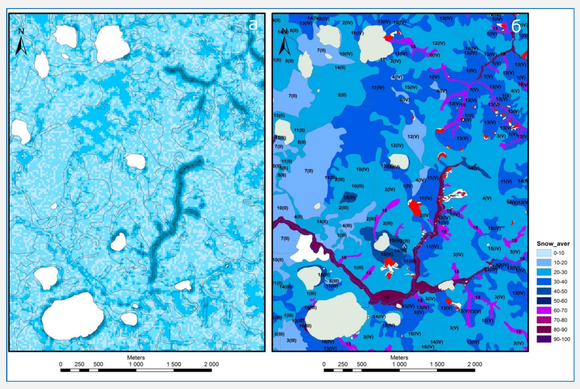




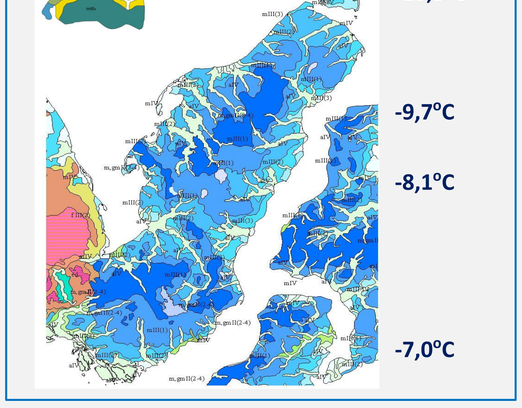
Ground temperature at Bely Ostrov the coldest in sandy windblown terrace (OB3), medium in loamy highly vegetated slope (OB2) and warmest in the stream valley with snow accumulation (OB4)

Laborovaya location, sandy site

Surface disturbances of all kind as a rule increase snow cover thus increasing ground temperature, and at the same time increase active layer depth because vegetation cover is reduced. Landslides and thermocirques specifically for Yamal expose saline permafrost with complicated phase transition process resulting in seasonal thaw different from the depth of zero temperature. In addition, forcing factors interact with each other. Spatial pattern of vegetation cover is mainly determined by landslide and thermodenudation activity the last several millennia thus affecting distribution of the active layer depth.



Snow cover distribution, results of modelling based on field snow survey(left), and landscape-based (right)



Conclusion

In Central Yamal measured ground temperature varies from -0.3°C up to -7°C, active layer depth varies from 40 to 240 cm. Temporal variations caused by climate fluctuations range at ±2°C for ground temperature, and ±5-10 cm for active layer depth. Thus, spatial factors, such as lithology and surface covers are of much higher importance compared to climatic factors.

Spatial distribution of permafrost parameters along the EAT involves latitudinal zonality based on directional lowering of air temperature northward from Nadym site in the south to Hayes site in the north. It is established that, on the whole, consistent trend of bioclimatic subzones northward determines the consecutive change of various parameters of permafrost. However, local factors connected to relief, drainage degree, location of plots on different landforms, which determine snow accumulation and vegetation mat thickness, distort zonal pattern.

Factors specific for research polygons in Tundra zone with continuous permafrost distribution

Laborovaya: Piedmont of Urals. Deeply dissected surface, combination of well drained tops and slopes with poorly drained valleys and lake depressions. Sandy and clayey deposits with clasts and bedrock outcrops.

Vaskiny Dachi: Terraced Middle to Late Pleistocene plain. Deeply dissected surface, combination of convex drained sandy and concave poorly drained clayey tops and slopes, as well as poorly drained concave and well drained convex lake depressions and valleys. Peat on concave tops and valleys.

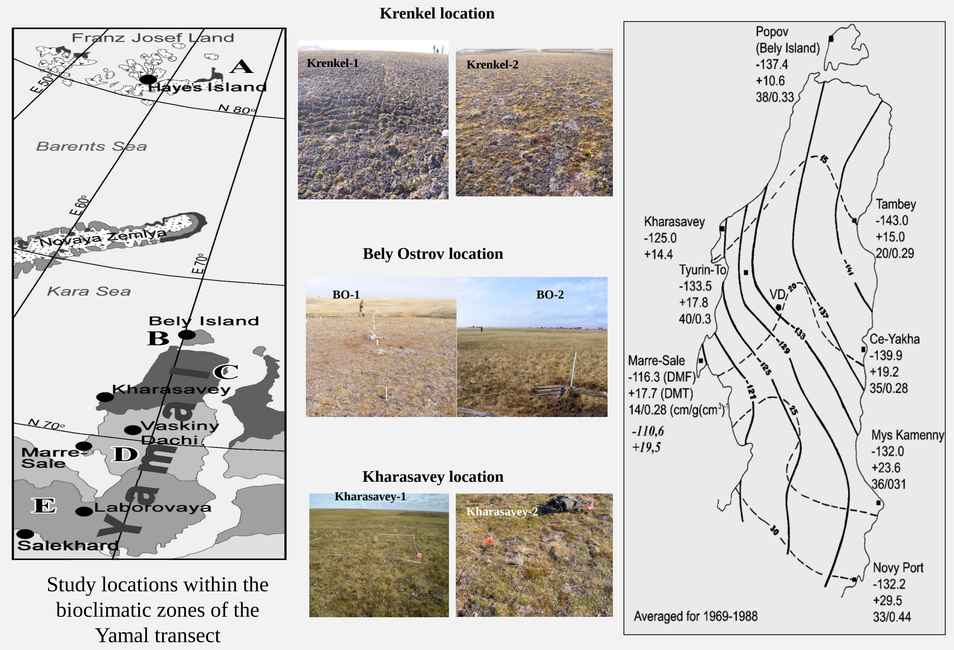
Kharasavey: Terraced Late Pleistocene plain. Moderately dissected, poorly drained both sandy and clayey deposits on tops and slopes and peat in the valleys.

Bely island: Terraced Holocene plain. Not deeply dissected, flat, gentle slopes, poorly drained. Drained sandy top edges. Peat in the valleys.

Hayes island: Terraced Holocene and Late Pleistocene plain with bedrock dykes forming long narrow ridges. Deeply dissected, terraced slopes, poorly drained except dyke tops and steep sandy slopes. Limited organic matter on all surfaces.

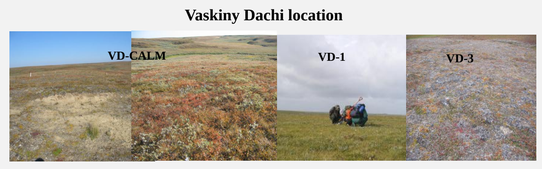
In discontinuous permafrost zone, in northern taiga forcing factors are different. Permafrost as a feature (thus Tg and ALD) appear only away from forests, at the mires and peat plateaus.

Nadym: Terraced Holocene and Late Pleistocene plain. Relatively flat, subhorizontal, poorly drained except for the frost-heave mounds. Peat on all surfaces.



Study locations within the bioclimatic zones of the Yamal transect

Freeze (degree-months, DMF) and thaw (DMT) indexes, thickness and density of snow along the Yamal transect averaged for 1969-1988, for Marre-Sale DMF and DMT averaged for 2000-s



LIST OF ECI LCLUC-RELATED AND OTHER YAMAL PUBLICATIONS

Dvornikov Yu., Khomutov A., Leibman M., Mullanurov D. 2014. DEM-based analysis of snow cover distribution in tundra zone (Yamal, Russia) // Book of Abstract of EUCOP4 - 4th European Conference on Permafrost, 18-21 June 2014 - Évora, Portugal. Eds.: G. Vieira, P. Pina, C. Mora, A. Correia. University of Lisbon and University of Évora, 2014, P. 382.

Ermokhina K. 2014. Vegetation dynamics of landslide affected slopes (Central Yamal) // Landslide Science for a Safer Geoenvironment. Proceedings of World Landslide Forum 3, 2-6 June 2014, Beijing, Eds.: K.Sassa, P.Canuti, Y.Yin, Vol.3, Targeted Landslides. Springer International Publishing Switzerland 2014. P. 443-449.

Ermokhina K. 2013. Yamal and Gydan vegetation datasets // Arctic Vegetation Archive (AVA) Workshop, Krakow, Poland, April 14-16, 2013. CAFF Proceedings Report #10. Akureyri, Iceland. ISBN: 978-9935-431-24-0, p. 40-44.

Ermokhina, K. 2012. Phytoindication of Landslide Disturbances in the Central Yamal. Third Yamal Land-Cover Land-Use Change Workshop. Rovaniemi, Finland May 19-20.

Gubarkov A., Leibman M. 2014. Cryogenic landslides in paragenetic complexes of slope and channel processes in the Central Yamal Peninsula // Landslide Science for a Safer Geoenvironment. Proceedings of World Landslide Forum 3, 2-6 June 2014, Beijing, Eds.: K.Sassa, P.Canuti, Y.Yin, Vol.3, Targeted Landslides. Springer International Publishing Switzerland 2014. P. 457-462.

Gubarkov A., Leibman M., Andreeva M. 2014. Cryogenic landslides in paragenetic complexes of slope and channel processes in the Central Yamal Peninsula // W. Shan et al. (eds.), Landslides in Cold Regions in the Context of Climate Change, Environmental Science and Engineering, DOI: 10.1007/978-3-319-00867-7_11, Springer International Publishing, Switzerland, 2014, P. 291-308.

Gubarkov A.A., Leibman M.O. 2008 Interrelation of Cryogenic and Hydrologic Processes on Small Streams and Catchments of Central Yamal // Proc. of the 9th International Conference on Permafrost, 29 June – 3 July 2008, University of Alaska Fairbanks, USA, 2008,

Heim B., Buchhorn M., Bartsch A., Dvornikov Yu., Epstein H., Ermokhina K., Khomutov A., Leibman M., Walker D. Optical spectral remote-sensing applications: a case study in Central Yamal, Vaskiny Dachi // Int. Conf. “Earth Cryology: XXI Century (September 29 – October 3, 2013, Pushchino, Moscow region, Russia). Pushchino, 2013, P. 70–71.

Khitun O., Chernyadjeva I., Leibman M. 2014. Dynamics of vegetation on cryogenic landslides of different age in Central Yamal (West Siberian Arctic) // Landslide Science for a Safer Geoenvironment. Proceedings of World Landslide Forum 3, 2-6 June 2014, Beijing, Eds.: K.Sassa, P.Canuti, Y.Yin, Vol.3, Targeted Landslides. Springer International Publishing Switzerland 2014. P. 481-485.

Khitun, O.V., Ermokhina, K.A., Leibman, M.O., Khomutov, A.V. 2011. Plant species indicating the depth of active layer on the Bely Island. Fourth Russian Conference on Geocryology. Moscow, Russia, June 7-9.

Khomutov A., Leibman M. 2014. Assessment of landslide hazards in a typical tundra of Central Yamal // W. Shan et al. (eds.), Landslides in Cold Regions in the Context of Climate Change, Environmental Science and Engineering, DOI: 10.1007/978-3-319-00867-7_11, Springer International Publishing, Switzerland, 2014, P. 271-290.

Khomutov A., Leibman M., Bartsch A., Dvornikov Yu., Ermokhina K., Mullanurov D. 2014. Ground-based active layer monitoring as a benchmark and verifier of remote active layer depth mapping, Central Yamal, Russia // Book of Abstract of EUCOP4 - 4th European Conference on Permafrost, 18-21 June 2014 - Évora, Portugal. Eds.: G. Vieira, P. Pina, C. Mora, A. Correia. University of Lisbon and University of Évora, 2014, P. 436.

Khomutov A., Leibman M., Epstein H., Walker D. 2013. Relation between active-layer depth and vegetation indices (NDVI and LAI) along the Yamal transect, Russia // Int. Conf. “Earth Cryology: XXI Century (September 29 – October 3, 2013, Pushchino, Moscow region, Russia). Pushchino, 2013, P. 92.

Khomutov A., Leibman M.2014. Assessment of landsliding hazard in typical tundra of Central Yamal, Russia. // Landslide Science for a Safer Geoenvironment. Proceedings of World Landslide Forum 3, 2-6 June 2014, Beijing, Eds.: K.Sassa, P.Canuti, Y.Yin, Vol.3, Targeted Landslides. Springer International Publishing Switzerland 2014. P. 487-492.

Khomutov A.V. 2012. Assessment of Landslide Geohazards in Typical Tundra of Central Yamal. Tenth International Conference on Permafrost. Vol. 2: Translations of Russian Contributions. Co-edited by D.S. Drozdov and V.E. Romanovsky. The Northern Publisher, Salekhard, Russia, P. 157-162.

Khomutov A.V., Leibman M.O. 2010. Landscape pattern and cryogenic landsliding hazard analysis on Yamal peninsula, Russia // Thermal state of frozen ground in a changing climate during the IPY. Abstracts from the 3rd European Conference on Permafrost, 13 – 17 June 2010, The University Centre in Svalbard, 2010, P. 254.

Khomutov A.V., Leibman M.O., Moskalenko N.G., Epstein H.E. 2010. Correlation between active layer depth and vegetation parameters at Vaskiny Dachi, Central Yamal, Russia // Thermal state of frozen ground in a changing climate during the IPY. Abstracts from the 3rd European Conference on Permafrost, 13 – 17 June 2010, The University Centre in Svalbard, 2010, P. 227.

Khomutov, A. 2012. Mapping of Active Layer Depths Using Correlation between Active Layer Depth and Vegetation Parameters on Central Yamal, Russia. From Knowledge to Action, 2012 IPY Conference. Montreal, Quebec May 22-27.

Khomutov, A., Leibman, M.O., Moskalenko, N., Orekhov, P., Mullanurov, D. 2012. Database of EAT permafrost information. Third Yamal Land-Cover Land-Use Change Workshop. Rovaniemi, Finland May 19-20.

Leibman M., Bartsch A., Dvornikov Yu., Heim B., Ermokhina K., Khomutov A., Kumpula T., Mullanurov D., Trofaier A.M., Widhalm B. Remote-sensing data application for permafrost monitoring on Yamal, Russia // Book of Abstract of EUCOP4 - 4th European Conference on Permafrost, 18-21 June 2014 - Évora, Portugal. Eds.: G. Vieira, P. Pina, C. Mora, A. Correia. University of Lisbon and University of Évora, 2014, P. 374.

Leibman M., Khomutov A., Ermokhina K., Andreeva M., Elancev E., Gubarkov A., Gerasimov A., Dvornikov Yu. 2012. Mapping of permafrost features using land-based and remote-sensing data. In: ESA DUE Permafrost Final Workshop February 15-17, 2012, Potsdam, Alfred-Wegener-Institute for Polar and Marine Research, Germany. Abstract volume, P.11.

Leibman M., Khomutov A., Kizyakov A. 2014. Cryogenic landslides in the Arctic Plains of Russia: classification, mechanisms, and landforms. // Landslide Science for a Safer Geoenvironment. Proceedings of World Landslide Forum 3, 2-6 June 2014, Beijing, Eds.: K.Sassa, P.Canuti, Y.Yin, Vol.3, Targeted Landslides. Springer International Publishing Switzerland 2014. P. 493-497.

Leibman M., Khomutov A., Kizyakov A.2014. Cryogenic landslides in the West-Siberian plain of Russia: classification, mechanisms, and landforms // W. Shan et al. (eds.), Landslides in Cold Regions in the Context of Climate Change, Environmental Science and Engineering, DOI: 10.1007/978-3-319-00867-7_11, Springer International Publishing, Switzerland, 2014, P. 143-162.

Leibman M.O., Epstein H.E., Khomutov A.V., Moskalenko N.G., Walker D.A. 2008 Relation of active layer depth to vegetation on the Central Yamal Peninsula, Russia // Extended abstracts of the 9th International Conference on Permafrost, 29 June – 3 July 2008, University of Alaska Fairbanks, USA, 2008, P.177–178.

Leibman M.O., Khomutov A.V., Kizyakov A.I. 2012. Cryogenic Landslides in the Arctic Plains of Russia: theory and phenomena. In: Shan Wei, Guo Ying, Zhang Chengcheng, eds. Proceedings of The First Meeting of Cold Region Landslides Network and First Symposium on Landslides in Cold regions, July 23-27, 2012, Harbin, China, 2012. P.37-48.

Leibman M.O., Khomutov A.V., Mullanurov D.R., Dvornikov Yu.A. 2013. New massive ground ice exposures due to activation of earth flows on slopes in Central Yamal during extremely warm summers of 2012-2013 // Int. Conf. “Earth Cryology: XXI Century (September 29 – October 3, 2013, Pushchino, Moscow region, Russia). Pushchino, 2013, P. 94–95.

Leibman M.O., Khomutov A.V., Orekhov P.T., Gameev I.A., Gubarkov A.A., Walker D.A. 2010. Spatial distribution of the active layer depth along the Yamal transect // Thermal state of frozen ground in a changing climate during the IPY. Abstracts from the 3rd European Conference on Permafrost, 13 – 17 June 2010, The University Centre in Svalbard, 2010, P. 226.

Leibman M.O., Ukraintseva N.G. 2009. Mechanisms and geoecological consequences of cryogenic landslides in the area of marine sedimentation // Geophysical Research Abstracts, Vol. 11, EGU2009-3980, 2009, EGU General Assembly

Leibman, M.O., Gubarkov, A.A., Khomutov, A.V. 2012. Research station Vaskiny Dachi. Excursion guidebook. Tenth International Conference on Permafrost, Salekhard, Russia, June 25-29, 2012. Tyumen: Pechatnik, 50 pp.

Leibman, M.O., Khomutov A.V. 2009. Environmental controls of the thaw depth and rate of thaw under climate fluctuations 2009 AAG Annual Meeting, March 22-27, Las Vegas, NV.

Leibman, M.O., Khomutov A.V., Orekhov P.T., Khitun O.V., Epstein H.E., Frost G., Walker D.A. 2012. Gradient of Seasonal Thaw Depth along the Yamal Transect. Tenth International Conference on Permafrost. Vol. 2: Translations of Russian Contributions. Co-edited by D.S. Drozdov and V.E. Romanovsky. The Northern Publisher, Salekhard, Russia, P. 237-242.

Mullanurov D., Khomutov A., Leibman M., Dvornikov Yu. 2014. Ground temperature dynamics on the Central Yamal and digital ground temperature regime model // Book of Abstract of EUCOP4 - 4th European Conference on Permafrost, 18-21 June 2014 - Évora, Portugal. Eds.: G. Vieira, P. Pina, C. Mora, A. Correia. University of Lisbon and University of Évora, 2014, P. 440.

Mullanurov D.R., Leibman M.O., Khomutov A.V. 2013. Ground temperature controls and their relation to climate fluctuations on Central Yamal // Int. Conf. “Earth Cryology: XXI Century (September 29 – October 3, 2013, Pushchino, Moscow region, Russia). Pushchino, 2013, P. 92–93.

Orekhov P.T., Khomutov A.V., Leibman M.O., Khitun O.V. 2010. Relation of vegetative cover and active layer depth in the arctic tundra of Bely island on new CALM grids // Thermal state of frozen ground in a changing climate during the IPY. Abstracts from the 3rd European Conference on Permafrost, 13 – 17 June 2010, The University Centre in Svalbard, 2010, P. 106.

Ukraintseva N., Leibman M., Streletskaya I., Mikhaylova T. 2014. Geochemistry of plant-soil-permafrost system on landslide-affected slopes, Yamal, Russia as an indicator of landslide age // W. Shan et al. (eds.), Landslides in Cold Regions in the Context of Climate Change, Environmental Science and Engineering, DOI: 10.1007/978-3-319-00867-7_11, Springer International Publishing, Switzerland, 2014, P. 107-132.

Ukraintseva N., Leibman M., Streletskaya I., Mikhaylova T. 2014. Study of plant-soil-permafrost system on landslide-affected slopes using geochemical methods on Yamal, Russia // Proceedings of World Landslide Forum 3, 2-6 June 2014, Beijing, Eds.: K.Sassa, P.Canuti, Y.Yin, Vol.3, Targeted Landslides. Springer International Publishing Switzerland 2014. P.

Vasiliev A.A, Leibman M.O., Moskalenko N.G. 2008. Active Layer Monitoring in West Siberia under the CALM II Program // Proc. of the 9th International Conference on Permafrost, 29 June – 3 July 2008, University of Alaska Fairbanks, USA, 2008, Vol. 2. P.1815-1820.

Хомутов А.В. Оценка оползневой опасности в типичной тундре Центрального Ямала // Труды Десятой Международной конференции по мерзлотоведению, 2012, т. 3, с. 555-560.

В печати

Leibman, M.O., Gubarkov, A.A., Khomutov, A.V. Research station “Vaskiny Dachi”. Review of long-term activities // Fennia, 2014 (in press)

Khitun O.V., Ermokhina K.A., Leibman M.O., Chernyadjeva I.V., Khomutov A.V. 2014. Floristic complexes on landslides of different age in Central Yamal, West Siberian Low Arctic, Russia // Fennia, (in press)

Dvornikov Yu.A., Khomutov A.V., Mullanurov D.R., Ermokhina K.A., Gubarkov A.A., Leibman M.O. 2014. GIS- and field data based modeling of snow water equivalent in shrub tundra // Fennia, (in press)