

## Mitteilungen / Notes

# The Russian-German Research Station Samoylov, Lena Delta - A Key Site for Polar Research in the Siberian Arctic

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### INTRODUCTION

The Lena Delta – located at the Laptev Sea coast of northeast Siberia – is a key region for the understanding of the basic processes of the dynamic and development of permafrost in the Siberian Arctic. In the frame of the Russian-German scientific co-operation under the umbrella of the German Federal Ministry of Education and Research (BMBF) and the Russian Ministry of Science and Education projects *System Laptev Sea*, *System Laptev-Sea 2000* and *The Dynamics of Permafrost in the Laptev Sea* important scientific results for the understanding of carbon dynamics and involved microbial processes and communities, of the energy and water budget of Arctic tundra, of the development of the ice-rich permafrost and of Arctic coastal dynamics could be elaborated. The obtained results are the necessary data and information base for the prognosis of the impact of possible climate changes to the sensitive ecosystems of the Arctic.

For long-term investigations of the processes of permafrost formation and decay, transformation and emission of green house gases (CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O, H<sub>2</sub>O), thermal and hydrologic studies on the active layer and – not at least – as a logistic base for field investigations of the environment, formation and development of the Lena Delta and the relict late Pleistocene permafrost, the small research station Samoylov of the Lena Delta Reserve (LDR) was used and has been developed further under contribution of the Alfred Wegener Institute (AWI) into an ideal location for coastal and terrestrial polar research.

Within this context Samoylov Station has been the base and starting point for numerous international expeditions in the Siberian Arctic like the expeditions *Lena 1999* through *Lena 2005*, the expedition *COAST I* as well as many sub-projects of some marine expeditions to the Laptev Sea (e.g., RACHOLD & GRIGORIEV 1999, PFEIFFER & GRIGORIEV 2002, SCHIRRMES-TER et al. 2004).

In this paper the unique situation of Samoylov Station as a research station and a base for multi-disciplinary studies in the high Arctic of northeast Siberia will be represented. It is aimed

to give an overview of the station's facilities and research opportunities. During the last years Samoylov Station has become an important component of the Russian-German co-operation in the field of coastal and terrestrial polar research.

### SAMOYLOV ISLAND

Samoylov Island is located within the huge delta of Lena River which represents the largest delta system of the circum-arctic land masses. The Lena Delta is located at the Laptev Sea coast between the Taimyr Peninsula and the New Siberian Islands (Fig. 1). The delta occupies an area of about 32000 km<sup>2</sup> and is characterized by a network of smaller and larger rivers and channels as well as of more than 1500 islands (ARE & REIMNITZ 2000). The landscape of the delta is typically covered by the patterned ground of ice wedge polygons in different stages of development (MÜLLER 1997). The entire delta is situated in the zone of continuous permafrost with a thickness of about 500-600 m (ROMANOVSKII & HUBBERTEN 2001).

Samoylov Island (72°22'N, 126°28'E) is a representative island in the active and youngest part (8,000-9,000 yr) of the Lena Delta and covers an area of about 1200 ha (Fig. 2). The western coast of the island is characterized by modern accumulation processes of fluvial and aeolian sedimentation. Three flood plains can be distinguished, which differ in their flooding frequency and vegetation coverage. The texture of accumulated sediments is dominated by fine to medium sand. In contrast, the eastern coast of Samoylov Island is dominated by erosion processes which form an abrasional coast. This part is composed of middle Holocene deposits which cover about 70 % of the total area of the island.

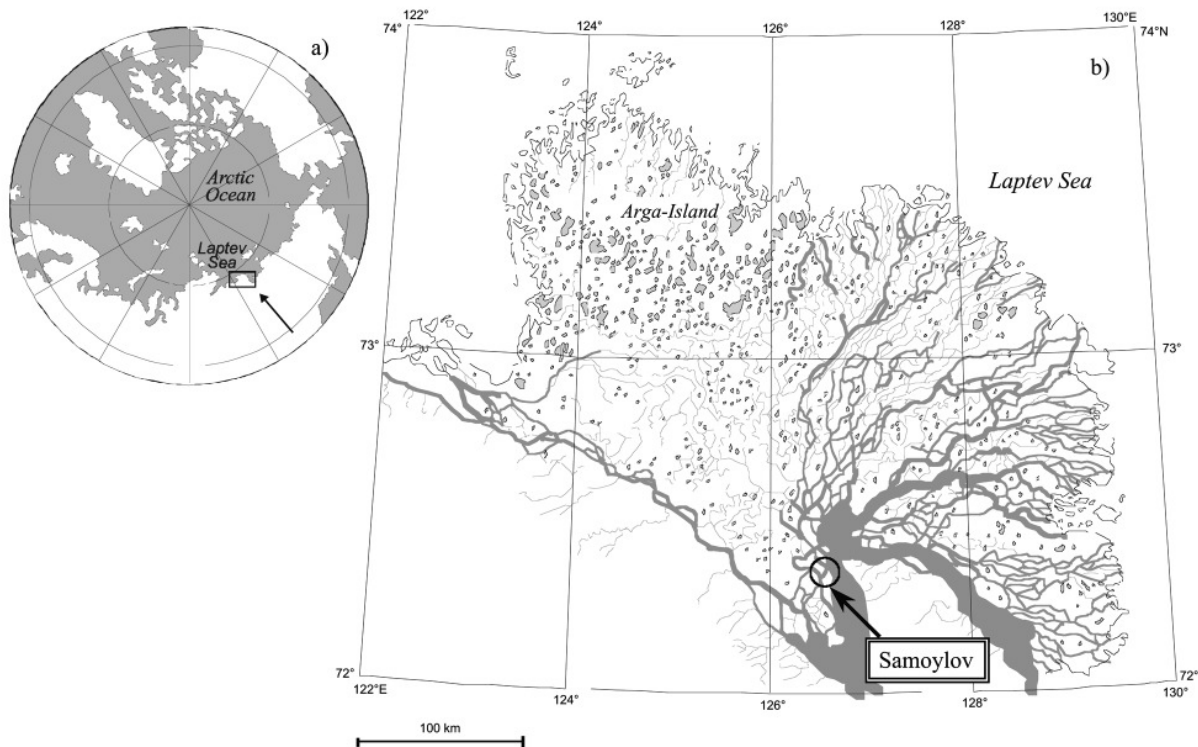
Studies of methane fluxes, microbial activity, micro-meteorology and hydrology were carried out around Samoylov Station an area which is dominated by active ice wedges with low-centred polygons. The topography is determined by this patterned ground and shows a distinct micro-relief of polygon rims and polygon depressions.

Due to the micro-relief, soil and vegetation characteristics vary in rapid succession. The soils of the investigation site are characterized by very homogeneously spread soil units: the polygon rims are dominated by *Glacic Aquiturbels* (Ajj, Bjjg, Bjjf), whereas the prevalent soil type of the polygon depressions are *Typic Historthels* (Oi, A, Bg, Bf) classified according

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**Fig. 1:** Position of the Lena Delta region on the coast of the Laptev Sea, Arctic Ocean (a) and location of Samoylov Station (72°22'N, 126°28'E) within the active and central part of the delta (b).

**Abb. 1:** Die Lenadelta-Region an der Laptevsee-Küste, Arktischer Ozean (a) und die Lage der Forschungsstation Samoylov (N 72°22, E 126°28) im aktiven und zentralen Bereich des Deltas (b).



**Fig. 2:** Satellite image of Samoylov Island and its surrounding in the central part of the Lena Delta (UNEP/GRID-Arendal and Landsat 2000).

**Abb. 2:** Satellitenbild der Samoylov-Insel und der näheren Umgebung im zentralen Teil des Lenadeltas (UNEP/GRID-Arendal and Landsat 2000).

to the U.S. Soil Taxonomy (SOIL SURVEY STAFF 1998). The peaty soils of the polygon depression are characterized by a water level near the soil surface and the predominantly anaerobic accumulation of organic matter. The drier soils of the polygon rim showed a distinctly deeper water level, lower accumulation of organic matter and pronounced cryoturbation properties. The vegetation of the polygon rim is dominated by

dwarf shrub *Dryas punctata* and the mosses *Hylocomium splendens* and *Timmia austriaca*, whereas the polygon depression is dominated by hydrophytes like various *Carex* species and different moss species (e.g. *Limprichtia revolvens*, *Meesia longiseta*). The thaw depth of the soils varies between 30 and 45 cm (rim, depression), respectively.





**Fig. 3:** Aerial photograph of the southern, steep coast of Samoylov Island (view from east) with the research station ensemble (T. Sachs, AWI). The main building and storages are located at the coastline. The washing and sauna house is located close to the lake (in front of the image).

**Abb. 3:** Luftbild der südlichen Küste der Samoylov-Insel mit der Forschungsstation und ihren Nebengebäuden aus östlicher Richtung gesehen (T. Sachs, AWI). Hauptgebäude und Lager sind nahe der steilen Küste gelegen. Das Wasch- und Sauna-gebäude liegt direkt an einem kleinen See (Vordergrund rechts).



**Fig. 4:** Samoylov Station on Samoylov Island (Lena Delta) showing the main building on the left and the new extension on the right side (G. Stoof, AWI).

**Abb. 4:** Forschungsstation auf der Samoylov-Insel (Lenadelta) mit dem Hauptgebäude auf der linken Seite und dem neuen Anbau auf der rechten Seite (G. Stoof, AWI).

The climate of the southern Lena Delta with Samoylov Island is characterized by a low mean annual air temperature ( $-14.7\text{ }^{\circ}\text{C}$ ) and a mean annual precipitation of 190 mm. The winter season lasts nine months, from the end of September to the end of May ( $T_{\text{avg}} = -30\text{ }^{\circ}\text{C}$ ,  $T_{\text{min}} = -48\text{ }^{\circ}\text{C}$ ) with insufficient light (polar night) and heavy snowstorms ( $140\text{ km h}^{-1}$ , WEIN 1999). Energy for spring snow ablation is mostly provided by net radiation, Almost 50 % of available energy is lost by sublimation due to high wind speeds. The snow ablation is governed by a combination of sublimation- and radiation-driven melt (BOIKE et al. 2003). The summer period of almost 12 weeks is characterized by higher temperatures ( $T_{\text{avg}} = 7\text{ }^{\circ}\text{C}$ ,  $T_{\text{max}} = 18\text{ }^{\circ}\text{C}$ ) and by permanent light (polar day).

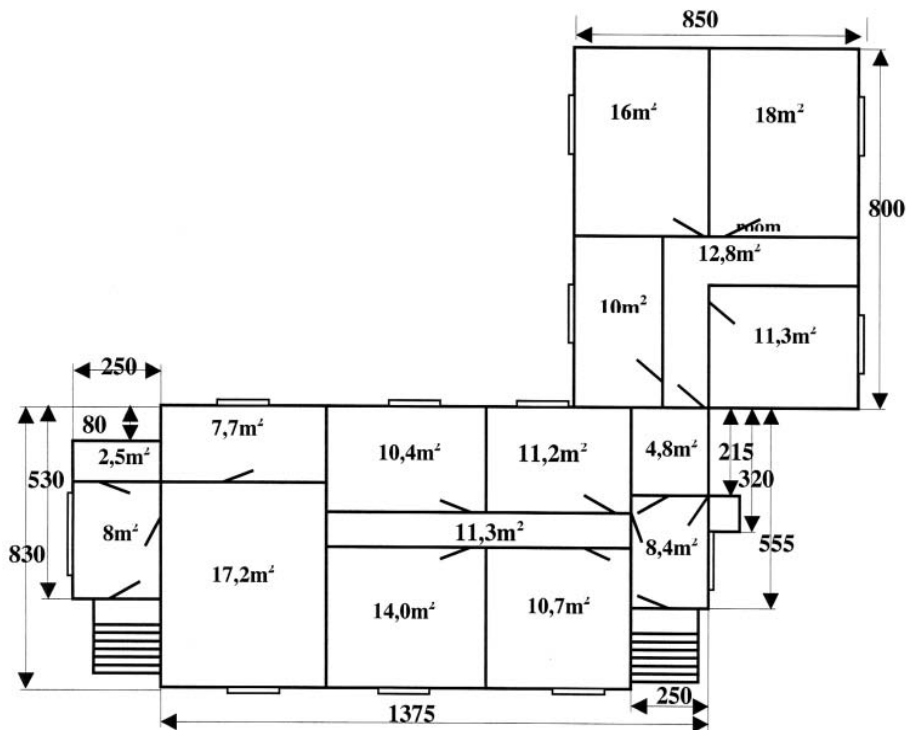
#### SAMOYLOV STATION AND ITS RESEARCH FACILITIES

Samoylov Station, which is located at the southern coast of the

island, is build up of one large wooden main building and a new building constructed in 2005 which is directly connected to the old house. Furthermore, a washing and sauna house, three small wooden stores and one big freezing store in the frozen ground (Russian = lednik) complete the ensemble (Fig. 3).

In former days, Samoylov Station served as logistic base of the Lena Delta Reserve in the central Lena Delta. The station can be reached via Tiksi (connected by an airport with Moscow, St. Petersburg and Yakutsk) by Helicopter in about 45 minutes flight time or by ship in about 12 hour travelling time. The local connection to Tiksi is supported by an own radio station on the Island.

The main house is built on wooden stems installed in the permafrost, the outer walls are covered with plaster. The building fits very well into the landscape of the polygonal tundra of



**Fig. 5:** Floor map of the research station Samoylov with main building (106 m<sup>2</sup>) and the new extension (68 m<sup>2</sup>). Length are in (cm); room height 230 cm.

**Abb. 5:** Grundriss der Forschungsstation Samoylov mit dem Hauptgebäude (unten, 106 m<sup>2</sup>) und dem neuen Anbau (oben, 68 m<sup>2</sup>). Längen in (cm); Höhe der Räume 230 cm.



**Fig. 6:** Laboratory for trace gas analyses (e.g. equipped with a gas chromatograph and a hydrogen generator) and sample preparation for microbiological and pedological analyses (D. Wagner, AWI).

**Abb. 6:** Labor für Spurengasanalyse (z.B. ausgestattet mit einem Gaschromatographen und einem Wasserstoffgenerator) und Probenvorbereitung für mikrobiologische und bodenkundliche Untersuchungen (D. Wagner, AWI).

the Lena Delta. The total area is about 175 m<sup>2</sup> (Figs. 4 and 5). About 140 m<sup>2</sup> of it can be used for expedition work. The western part is used by the local station leader of the Lena Delta Reserve (LDR). The available rooms include a kitchen (10.7 m<sup>2</sup>), a sleeping room and two laboratories for scientific work.

The universal lab has a size of about 15 m<sup>2</sup> and is equipped with two working benches with a total length of 6.5 m. The second laboratory is about 12 m<sup>2</sup> and equipped with a gas chromatograph (Chrompack CP-9003; FID, WLD) and a hydrogen generator (Domnick Hunter UHP-20H) for trace gas analyses (Fig. 6). The length of the working benches is 6 m. Distilled water for extraction and sample preparation is provided by the Lena Delta Reserve in Tiksi and transported in cans to the station.

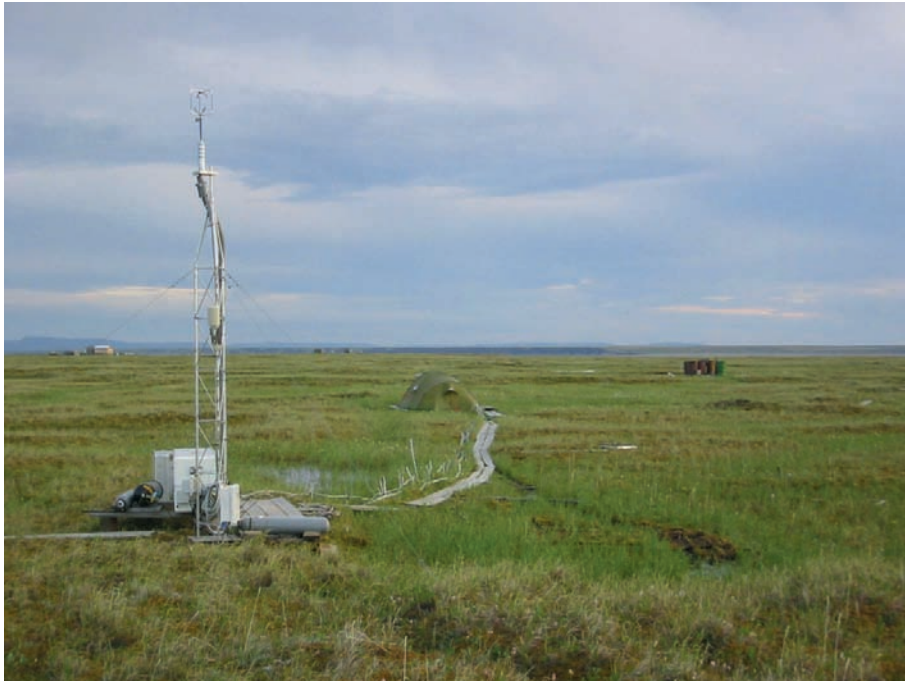
A new annex was built in a 90° angle with the existing building (Fig. 4) and is connected to the old station through the anteroom. The new building features additional room of 68 m<sup>2</sup>, which is separated into three sleeping rooms and one large living room (Fig. 5). Special attention was paid to the insulation of the annex to ensure possible future research activities in the Lena Delta also during the winter season. The extended station provides space for eight scientists during winter time and up to 16 people in the summer period using additional tents.

For power supply a 6 KVA diesel generator (Honda ECT 6D) is used. The power rating of the generator supplies sufficient energy for the general equipment of the station and the scientific instruments and still holds reserves for the future. In order to have a power supply independent from the diesel generator during periods of low power consumption, a wind generator (AIR 403;12V, 400W), a set of lead batteries (12V, 390Ah) and an AC converter (12V/220V, 400W) were installed. This system supplies sufficient energy for the laboratory lights, notebooks, chargers and other low energy devices.

Drinking water supply is realized by a pumping system transporting the water from a nearby lake to the station (see Fig.3). The nearby sauna hut is used as bathroom and as a sauna. An outhouse is about 50 m away from the station.

From the main station the long-term experimental plots – including the automatic climate and soil stations as well as the devices for trace gas flux measurements – are easily reached by a twenty minutes walk (Fig. 7). Since 1999, the measurement plots produce climatic and soil related temperature data of good quality. In future also the trace gas measurement should be run automatically.





**Fig. 7:** Micro-meteorological eddy covariance measurement system for the continuously high resolution analyses of turbulent fluxes of carbon dioxide, methane, momentum, heat and water in the atmospheric boundary layer (T. Sachs, AWI).

**Abb. 7:** Mikrometeorologisches Eddy-Kovarianz-Messsystem zur kontinuierlichen hochauflösenden Analyse der turbulenten Flüsse von Kohlendioxid, Methan, Impuls, Wärme und Wasser in der bodennahen Atmosphäre (T. Sachs, AWI).

## CURRENT RESEARCH ON SAMOYLOV ISLAND

Within the scope of the Russian-German cooperation long-term studies on carbon fluxes of the Lena Delta have been carried out since 1998. The results showed for instance that the mean flux rate of methane from the polygon depression was about 10 times higher compared to the  $\text{CH}_4$  fluxes from the elevated polygonal rim. These differences on the ecosystem-level could be attributed to the different activity of the involved microbial communities as well as of the plant-mediated  $\text{CH}_4$  transport (WAGNER et al. 2003a, KUTZBACH et al. 2004). Due to the microrelief the soil chemical and physical analysis showed element redistribution along hydraulic and redox gradients of the low-centered polygons (FIEDLER et al. 2004). The microbial community composition in the permafrost habitats was analyzed by fluorescence in situ hybridization (FISH), which indicated high cell numbers for the different investigated microbial groups in the range of  $10^7$  cells  $\text{g}^{-1}$  soil (KOBABE et al. 2004). Further studies on the microbial community in permafrost soils showed a dominance of specialists, which have adapted to the extreme conditions of their cold habitat as shown by activity analyses and the determination of phospholipids (PLFA, PLEL; WAGNER et al. 2005). It turned out that complex microbial consortia colonize the upper horizons of the permafrost soil, showing methane production activity immediately in spring with the beginning of superficial thawing without a so-called lag-phase in which the metabolic activity rises only slowly again. Further RNA-based studies indicated a high diversity of methanogenic archaea in arctic tundra soils (GANZERT 2005). Simulation experiments with permafrost microcosms show that even at temperatures near  $0^\circ\text{C}$  and below methanogenesis still takes place (WAGNER et al. 2003b).

First studies on the energy and water budget of the active layer were undertaken by FRIEDRICH (2001) and WEIHNACHT (2000) using geophysical methods.

In 2002 the long-term studies on carbon dynamics were

supplemented by a micrometeorological eddy covariance measurement system, which was designed to continuously determine the turbulent fluxes of carbon dioxide, methane, momentum, heat and water in the atmospheric boundary layer (Fig. 7). The elaborate measurement system was applied for the first time during the expeditions *LENA 2002* in the Lena Delta, northern Siberia. The flux measurements were conducted parallel to the monitoring of standard meteorological and soil physical data during the vegetation period. The obtained data sets will allow the coupling of the energy and water budget of permafrost landscapes with the carbon exchange processes between permafrost soils, tundra vegetation, and the atmosphere (KUTZBACH 2005, SACHS et al. 2006). Such studies are necessary for the validation and improvement of process models able to assess the impact of climatic change on arctic ecosystems.

Furthermore, the following research was performed on Samoylov Island and its surroundings, which can be reached by using rubber boats or a small river boat, during the last years:

### *Hydrobiological investigations in the Lena Delta (E.N. Abramova, Lena Delta Reserve)*

Data on the seasonal-interannual variations of the zooplankton species composition and abundance in the modern high-latitude Arctic water biocoenoses are insufficient so far and information on the processes regulating population dynamics and community structure of the pelagic organisms in different seasons of the year are lacking. New data on population structure, ecology, biology, abundance and biomass fluctuations of the fresh-water pelagic organisms were obtained, which demonstrate the relationship between the unusually cold conditions of the last summer and zooplankton community dynamics.

### *Studies on recent cryogenesis (H. Meyer, AWI)*

The main aim of studying recent cryogenesis processes is to establish a stable isotope thermometer for ice wedges. The

recent ice veins are attributed to the discrete year of their formation by means of tracer experiments. A tracer (coloured lycopodium spores) is applied to a polygon with recent cryogenesis, which allows identifying all types of ground ice, which were formed in the considered year.

*Observation of the tundra's energy and water budget across multiple spatial and temporal scales (Julia Boike, AWI)* Permafrost is highly sensitive to long-term warming. Therefore, it is seen as a valuable indicator for observing and forecasting environmental changes. For this approach a long-term observation of the active layer and permafrost thermal and hydrologic state was established on Samoylov Island in 1998. These measurements will be augmented with spatially distributed measurements and a 30 m deep permafrost borehole.

*Geomorphological studies in the Lena River Delta (D. Yu. Bolshiyarov, AARI St. Petersburg)*

Geomorphologic investigation in the upper part of the Lena River Delta was connected with a hydrological program and directed to studying of modern and former sediment transport dynamics and their accumulation. The area of investigation was bordered by Bulkurskaya and Olenekskay channels and main channel of the Lena River. The general aim of the investigation was the studying of geomorphic structure of this area and river-bed forms in this part of Lena River Delta.

*Late Quaternary research (L. Schirrmeyer, AWI)*

Extensive investigations of Late Quaternary landscape dynamics were carried in the Lena Delta as well as beyond it. Numerous environmental indicators in frozen deposits and stable isotope records in ground ice were studied representing the climate and environmental changes of the Late Pleistocene and Holocene in the Siberian Arctic. Remote sensing and GIS methods should be increasingly used to classify periglacial landscape and to study landscape forming permafrost degradation. In addition, modern landscape dynamics especially the coastal retreat of ice-rich permafrost coasts were studied.

## FUTURE RESEARCH ON SAMOYLOV STATION

With the recent completion of the new annex building the Samoylov Station offers all necessary facilities to carry out research projects in the permafrost landscape of the Lena Delta and its surroundings. The station is easily reached by helicopter or boat from Tiksi and offers living space for eight scientists during winter time and up to 16 people in the summer period by using additional tents. Future plans are underway to provide better bathroom and toilette facilities. One or two new river boats (Zodiacs) with powerful motors will give the possibility to carry out excursions to other parts of the Lena Delta.

The new Samoylov Station which can be used in winter to carry out year-round measuring programs can be included in international projects as the GTN-P network for permafrost or the CALM network for active layer monitoring

In the frame of the IPY activities, the Samoylov Station could become one of the discussed „super“ sites for circum-arctic programs as ACCONET or the permafrost network GTN-P.

## ACKNOWLEDGMENTS

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### References

- Are, F. & Reimnitz, E. (2000): An overview of the Lena River Delta settings: geology, tectonics, geomorphology, and hydrology.- J. Coastal Res. 16:1083-1093.
- Boike, J., Hinzman, L.D., Overduin, P.P., Romanovsky, V., Ippisch, O. & Roth, K. (2003): A comparison of snow melt at three circumpolar sites: Spitsbergen, Siberia, Alaska.- 8th Internat. Conf. Permafrost, Zürich, Switzerland, pp. 79-84.
- Fiedler, S., Wagner, D., Kutzbach, L. & Pfeiffer, E.-M. (2003): Element redistribution along hydraulic and redox gradients of low-centered polygons, Lena Delta, Northern Siberia.- J. Soil Sci. Soc. Amer. 68: 1002-1011.
- Friedrich, K. (2000): Bestimmung der Verdunstung an einem Tundrastandort, Lena Delta, Sibirien.- Diplomarbeit, Technische Univ. Dresden, pp. 74.
- Ganzert, L. (2005): Biodiversität methanogener Archaeen in arktischen Böden des Lena Deltas / Sibirien.- Diplomarbeit, Univ. Potsdam und Alfred-Wegener-Institut Potsdam, pp. 89
- Kobabe, S., Wagner, D. & Pfeiffer, E.-M. (2004): Characterization of microbial community composition of a Siberian tundra soil by fluorescence in situ hybridization.- FEMS Microbiol. Ecol. 50: 13-23.
- Kutzbach, L., Wagner, D. & Pfeiffer, E.-M. (2004): Effects of microrelief and vegetation on methane emission from wet polygonal tundra, Lena Delta, Northern Siberia.- Biogeochem. 69: 341-362.
- Kutzbach, L. (2005): The exchange of energy, water and carbon dioxide between wet Arctic tundra and the atmosphere at the Lena River Delta, northern Siberia.- Doctoral Thesis, Univ. Hamburg and Alfred Wegener Institute Potsdam, pp. 148
- Müller, K. (1997): Oberflächenstrukturen und Eigenschaften von Permafrostböden im nordsibirischen Lena-Delta.- Z. Pflanzenernährung Bodenkunde 160: 497-503.
- Pfeiffer, E.-M. & Grigoriev, M.N. (2002): Russian-German cooperation SYSTEM LAPTEV SEA: The expedition Lena-Anabar 2003.- Rep. Polar Marine Res. 426: 1-186.
- Rachold, V. & Grigoriev, M.N. (1999): Russian-German cooperation SYSTEM LAPTEV SEA: The expedition Lena 1998.- Rep. Polar Marine Res. 315: 1-268.
- Romanovskii, N.N. & Hubberten, H.-W. (2001): Results of permafrost modeling of the lowlands and shelf of the Laptev Sea region, Russia.- Permafrost Periglac. Process. 12: 191-202.
- Schirrmeyer, L., Grigoriev, M.N., Kutzbach, L., Wagner, D. & Bolshiyarov, D. Yu. (2004): Russian-German cooperation SYSTEM LAPTEV SEA: The expedition Lena-Anabar 2003.- Rep. Polar Marine Res. 489: 1-231.
- Wagner, D., Kobabe, S., Pfeiffer, E.-M. & Hubberten, H.-W. (2003a): Microbial controls on methane fluxes from a polygonal tundra of the Lena Delta, Siberia.- Permafrost Periglac. Process. 14: 173-185.
- Wagner, D., Wille, C., Kobabe, S. & Pfeiffer, E.-M. (2003b): Simulation of freezing thawing cycles in a permafrost microcosm for assessing microbial methane production under extreme conditions.- Permafrost Periglac. Process. 14:367-374.
- Wagner, D., Lipski, A., Embacher, A. & Gatterer, A. (2005): Methane fluxes in extreme permafrost habitats of the Lena Delta: effects of microbial community structure and organic matter quality.- Environm. Microbiol. 7: 1582-1592.
- Weihnacht, B. (2000): Georadaranwendung im Permafrost zur Charakterisierung der Auftauschicht.- Diplomarbeit, Univ. Freiberg, pp 81