Permafrost is warming at a global scale
Permafrost warming has the potential to amplify global climate change, because when frozen sediments thaw it unlocks soil organic carbon. Yet to date, no globally consistent assessment of permafrost temperature change has been compiled. Here we use a global data set of permafrost temperature time series from the Global Terrestrial Network for Permafrost to evaluate temperature change across permafrost regions for the period since the International Polar Year (2007-2009). During the reference decade between 2007 and 2016, ground temperature near the depth of zero annual amplitude in the continuous permafrost zone increased by 0.39±0.15°C. Over the same period, discontinuous permafrost warmed by 0.20±0.10°C. Permafrost in mountains warmed by 0.19±0.05°C and in Antarctica by 0.37±0.10°C. Globally, permafrost temperature increased by 0.29±0.12°C. The observed trend follows the Arctic amplification of air temperature increase in the Northern Hemisphere. In the discontinuous zone, however, ground warming occurred due to increased snow thickness while air temperature remained statistically unchanged.

General information
State: Published
Organisations: Department of Civil Engineering, Geotechnics and Geology, Alfred Wegener Institute for Polar and Marine Research, Geological Survey of Canada, WSL Institute for Snow and Avalanche Research SLF, Universidade de Lisboa, George Washington University, Institut de Géographie Alpine, University of Alaska Fairbanks, University of Ottawa, RAS, Universite Laval, University Centre in Svalbard, University of Fribourg, University of Oslo, University of Insubria, Norwegian Meteorological Institute, Hokkaido University, Lund University, Arctic Portal, Free University of Berlin, University of Lausanne, Chinese Academy of Sciences, Rhodes University, University of Barcelona, University of Alcalá, Stockholm University, National Soil Survey Center
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AMAP 2017. Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region

General information
State: Published
Organisations: Department of Civil Engineering, Geotechnics and Geology
Drivers of Firn Density on the Greenland Ice Sheet Revealed by Weather Station Observations and Modelling

Recent Arctic atmospheric warming induces more frequent surface melt in the accumulation area of the Greenland ice sheet. This increased melting modifies the near-surface firn structure and density and may reduce the firn’s capacity to retain meltwater. Yet, few long-term observational records are available to determine the evolution and drivers of firn density. In this study, we compile and gap-fill Greenland Climate Network (GC-Net) automatic weather station data from Crawford Point, Dye-2, NASA-SE and Summit between 1998 and 2015. These records then force a coupled surface energy balance and firn evolution model. We find at all sites except Summit that increasing summer turbulent heat fluxes to the surface are compensated by decreasing net radiative fluxes. After evaluating the model against firn cores, we find that, starting from 2006, the density of the top 20 m of firn at Dye-2 increased by 11%, decreasing the pore volume by -18%. Crawford Point and Summit show stable near-surface firn density over 1998-2000 and 2000-2015 respectively while we calculate a -4% decrease of firn density at NASA-SE over 1998-2015. For each year, the model identifies the drivers of density change in the top 20 m firn and quantifies their contributions. The key driver, snowfall, explains alone 72 to 92% of the variance in day-to-day change in firn density while melt explains from 7 to 33 %. Our result indicates that correct estimates of the magnitude and variability of precipitation are necessary to interpret or simulate the evolution of the firn.
Ratings:

BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.19 SJR 2.272 SNIP 1.475
Web of Science (2017): Impact factor 2.752
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.36 SJR 2.369 SNIP 1.558
Web of Science (2016): Impact factor 2.733
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.39 SJR 2.754 SNIP 1.605
Web of Science (2015): Impact factor 3.318
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.27 SJR 2.853 SNIP 1.757
Web of Science (2014): Impact factor 3.426
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.38 SJR 3.086 SNIP 1.809
Web of Science (2013): Impact factor 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.93 SJR 2.917 SNIP 1.522
Web of Science (2012): Impact factor 3.174
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.03 SJR 3.018 SNIP 1.474
Web of Science (2011): Impact factor 3.021
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.056 SNIP 1.753
Web of Science (2010): Impact factor 3.303
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.85 SNIP 1.738
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.826 SNIP 1.529
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.835 SNIP 1.471
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 3.034 SNIP 1.627
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.855 SNIP 1.417
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.984 SNIP 1.643
Drivers of regional change

General information
State: Published
Organisations: Geotechnics and Geology, Department of Civil Engineering
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https://www.amap.no/documents/doc/Adaptation-Actions-for-a-Changing-Arctic-Perspectives-from-the-Baffin-BayDavis-Strait-Region/1630
Research output: Research - peer-review » Journal article – Annual report year: 2018

Summary of adaptation options for the BBDS region

General information
State: Published
Organisations: Department of Civil Engineering, Geotechnics and Geology, WWF Global Arctic Program, Nunavut Tunngavik, Government of Nunavut, Arctic Net, Aarhus University, Universite Laval
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https://www.amap.no/documents/doc/Adaptation-Actions-for-a-Changing-Arctic-Perspectives-from-the-Baffin-BayDavis-Strait-Region/1630
Research output: Research » Report chapter – Annual report year: 2018
Ice-margin and meltwater dynamics during the mid-Holocene in the Kangerlussuaq area of west Greenland

Land-terminating parts of the west Greenland ice sheet have exhibited highly dynamic meltwater regimes over the last few decades including episodes of extremely intense runoff driven by ice surface ablation, ponding of meltwater in an increasing number and size of lakes, and sudden outburst floods, or jokulhlaups’, from these lakes. However, whether this meltwater runoff regime is unusual in a Holocene context has not been questioned. This study assembled high-resolution topographical data, geological and landcover data, and produced a glacial geomorphological map covering similar to 1200km(2). Digital analysis of the landforms reveals a mid-Holocene land-terminating ice margin that was predominantly cold-based. This ice margin underwent sustained active retreat but with multiple minor advances. Over c.1000years meltwater runoff became impounded within numerous and extensive proglacial lakes and there were temporary connections between some of these lakes via spillways. The ice-dams of some of these lakes had several quasi-stable thicknesses. Meltwater was apparently predominantly from supraglacial sources although some distributary palaeochannel networks and some larger bedrock palaeochannels most likely relate to mid-Holocene subglacial hydrology. In comparison to the geomorphological record at other Northern Hemisphere ice-sheet margins the depositional landforms in this study area are few in number and variety and small in scale, most likely due to a restricted sediment supply. They include perched fans and deltas and perched braidplain terraces. Overall, meltwater sourcing, routing and the proglacial runoff regime during the mid-Holocene in this land-terminating part of the ice sheet was spatiotemporally variable, but in a manner very similar to that of the present day.

General information
State: Published
Organisations: Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions, University of Leeds, Sogn og Fjordane University College, Newcastle University
Contributors: Carrivick, J. L., Yde, J., Russell, A. J., Quincey, D. J., Ingeman-Nielsen, T., Mallalieu, J.
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Journal: Boreas
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ISSN (Print): 0300-9483
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.65 SJR 1.273 SNIP 1.016
Web of Science (2017): Impact factor 2.638
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.45 SJR 1.08 SNIP 1.078
Web of Science (2016): Impact factor 2.348
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.79 SJR 1.637 SNIP 1.27
Web of Science (2015): Impact factor 2.386
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.27 SJR 1.329 SNIP 1.259
Web of Science (2014): Impact factor 2.658
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.6 SJR 1.52 SNIP 1.087
Modeling in-situ hysteric variation of unfrozen water content in high-latitude fine-grained permafrost

General information
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Organisations: Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions
Contributors: Tomaskovicova, S., Ingeman-Nielsen, T.
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Keywords: Unfrozen water content, Freeze-thaw hysteresis, Thermal modeling, Fine-grained permafrost

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Modeling the ground resistivity from unfrozen water content in fine-grained high-latitude permafrost

General information
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Organisations: Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions
Contributors: Tomaskovicova, S., Ingeman-Nielsen, T.
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Research output: Communication > Sound/Visual production (digital) – Annual report year: 2017

The Arctic in the Twenty-First Century: Changing Biogeochemical Linkages across a Paraglacial Landscape of Greenland
The Kangersuujuaq area of southwest Greenland encompasses diverse ecological, geomorphic, and climate gradients that function over a range of spatial and temporal scales. Ecosystems range from the microbial communities on the ice sheet and moisture-stressed terrestrial vegetation (and their associated herbivores) to freshwater and oligosaline lakes. These ecosystems are linked by a dynamic glacio-fluvial-aerial geomorphic system that transports water, geological material, organic carbon and nutrients from the glacier surface to adjacent terrestrial and aquatic systems. This paraglacial system is now subject to substantial change because of rapid regional warming since 2000. Here, we describe changes in the eco- and geomorphic systems at a range of timescales and explore rapid future change in the links that integrate these systems. We highlight the importance of cross-system subsidies at the landscape scale and, importantly, how these might change in the near future as the Arctic is expected to continue to warm.

General information
State: Published
Organisations: Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions, Loughborough University, University of Maine, Pennsylvania State University, University of Nottingham, Cardiff University, Queen's University Belfast, Umeå University, University of Leeds, Aarhus University, University of Nebraska, University of Essex, Matthias Belius University, Keele University, Nansen Environmental and Remote Sensing Center, North Carolina State University, Centre de Recerca Ecològica i Aparcaments Forestals, University of California at Davis, University of Bristol, Joint Nature Conservation Committee, Peterborough, Sogn og Fjordane University College
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.96 SJR 2.754 SNIP 2.214
Web of Science (2017): Impact factor 5.876
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Automated long-term time lapse ERT monitoring of high-latitude permafrost – results of 3 years of monitoring and modeling study
Effect of electrode shape on grounding resistances - Part 1: The focus-one protocol

Electrode grounding resistance is a major factor affecting measurement quality in electric resistivity tomography (ERT) measurements for cryospheric applications. Still, little information is available on grounding resistances in the geophysical literature, mainly because it is difficult to measure. The focus-one protocol is a new method for estimating single electrode grounding resistances by measuring the resistance between a single electrode in an ERT array and all the remaining electrodes connected in parallel. For large arrays, the measured resistance is dominated by the grounding resistance of the electrode under test, the focus electrode. We have developed an equivalent circuit model formulation for the resistance measured when applying the focus-one protocol. Our model depends on the individual grounding resistances of the electrodes of the array, the mutual resistances between electrodes, and the instrument input impedance. Using analytical formulations for the potentials around prolate and oblate spheroidal electrode models (as approximations for rod and plate electrodes), we have investigated the performance and accuracy of the focus-one protocol in estimating single-electrode grounding resistances. We also found that the focus-one protocol provided accurate estimations of electrode grounding resistances to within ±7% for arrays of 30 electrodes or more when the ratio of instrument input impedance to the half-space resistivity was 1000 m⁻¹ or more. The focus-one protocol was of high practical value in field operations because it helped to optimize array installation, electrode design, and placement. The measured grounding resistances may also be included in future inversion schemes to improve data interpretation under difficult environmental conditions such as those encountered in cryospheric applications.
Effect of electrode shape on grounding resistances - Part 2: Experimental results and cryospheric monitoring

Although electric resistivity tomography (ERT) is now regarded as a standard tool in permafrost monitoring, high grounding resistances continue to limit the acquisition of time series over complete freeze-thaw cycles. In an attempt to alleviate the grounding resistance problem, we have tested three electrode designs featuring increasing sizes and surface area, in the laboratory and at three different field sites in Greenland. Grounding resistance measurements showed that changing the
electrode shape (using plates instead of rods) reduced the grounding resistances at all sites by 28%-69% during unfrozen and frozen ground conditions. Using meshes instead of plates (the same rectangular shape and a larger effective surface area) further improved the grounding resistances by 29%-37% in winter. Replacement of rod electrodes of one entire permanent permafrost monitoring array by meshes resulted in an immediate reduction of the average grounding resistance by 73% from 1.5 to 0.4 kΩ (unfrozen conditions); in addition, the length of the acquisition period during the winter season was markedly prolonged. Grounding resistance time series from the three ERT monitoring stations in Greenland showed that the electrodes were rarely perfectly grounded and that grounding resistances exceeding 1 MΩ may occur in severe cases. We concluded that the temperature, electrode shape, and lithology at the sites have a marked impact on electrode performance. Choosing an optimized electrode design may be the deciding factor for successful data acquisition, and should therefore be considered when planning a long-term monitoring project.

General information
State: Published
Organisations: Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions, Aarhus University, Orbicon Arctic A/S, Lund University, University of Copenhagen
Contributors: Tomaskovicova, S., Ingeman-Nielsen, T., Christiansen, A. V., Brandt, I., Dahlin, T., Elberling, B.
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Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Impact factor 2.368
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2017): CiteScore 2.35 SJR 1.018 SNIP 1.28
Web of Science (2016): Impact factor 2.391
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.03 SJR 1.974 SNIP 2.6
Web of Science (2015): Impact factor 2.017
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.9 SJR 1.913 SNIP 2.199
Web of Science (2014): Impact factor 1.612
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.25 SJR 2.015 SNIP 2.107
Web of Science (2013): Impact factor 1.759
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.04 SJR 1.452 SNIP 1.816
Web of Science (2012): Impact factor 1.723
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.51 SJR 3.183 SNIP 1.724
Web of Science (2011): Impact factor 1.418
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.085 SNIP 1.687
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.405 SNIP 2.592
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.265 SNIP 1.155
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.427 SNIP 1.509
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.416 SNIP 2.017
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.659 SNIP 1.292
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.498 SNIP 2.435
Scopus rating (2003): SJR 1.489 SNIP 2.192
Scopus rating (2002): SJR 1.026 SNIP 1.512
Scopus rating (2001): SJR 0.87 SNIP 1.475
Scopus rating (2000): SJR 0.891 SNIP 1.373
Scopus rating (1999): SJR 0.912 SNIP 1.209
Original language: English
Electronic versions:
geo2015_0148.1.pdf
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Optimizing electrode shapes for ERT monitoring in permafrost areas

General information
State: Published
Organisations: Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions, Aarhus University, Orbicon Arctic A/S, Lund University, University of Copenhagen
Contributors: Tomaskovicova, S., Ingeman-Nielsen, T., Christiansen, A. V., Brandt, I., Dahlin, T., Elberling, B.
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Publication date: 2016

Host publication information
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Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2016

Stable oxygen isotope variability in two contrasting glacier river catchments in Greenland
Analysis of stable oxygen isotope (δ18O) characteristics is a useful tool to investigate water provenance in glacier river systems. In order to attain knowledge on the diversity of δ18O variations in Greenlandic rivers, we examined two contrasting glacierised catchments disconnected from the Greenland Ice Sheet (GrIS). At the Mittivakkat Gletscher river, a small river draining a local temperate glacier in southeast Greenland, diurnal oscillations in δ18O occurred with a 3 h time
lag to the diurnal oscillations in run-off. The mean annual $\delta^{18}O$ was $-14.68 \pm 0.18 \%$ during the peak flow period. A hydrograph separation analysis revealed that the ice melt component constituted $82 \pm 5\%$ of the total run-off and dominated the observed variations during peak flow in August 2004. The snowmelt component peaked between 10:00 and 13:00 local time, reflecting the long travel time and an inefficient distributed subglacial drainage network in the upper part of the glacier. At the Kuannersuit Glacier river on the island Qeqertarsuaq in west Greenland, the $\delta^{18}O$ characteristics were examined after the major 1995-1998 glacier surge event. The mean annual $\delta^{18}O$ was $-19.47 \pm 0.55 \%$. Despite large spatial variations in the $\delta^{18}O$ values of glacier ice on the newly formed glacier tongue, there were no diurnal oscillations in the bulk meltwater emanating from the glacier in the post-surge years. This is likely a consequence of a tortuous subglacial drainage system consisting of linked cavities, which formed during the surge event. Overall, a comparison of the $\delta^{18}O$ compositions from glacial river water in Greenland shows distinct differences between water draining local glaciers and ice caps (between $-23.0$ and $-13.7 \%$) and the GRIS (between $-29.9$ and $-23.2 \%$). This study demonstrates that water isotope analyses can be used to obtain important information on water sources and the subglacial drainage system structure that is highly desired for understanding glacier hydrology.
The construction of Kangerlussuaq Airport - A case story from West Greenland

General information
State: Published
Organisations: Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions, Section for Geotechnics and Geology
Contributors: Ingeman-Nielsen, T., Foged, N. N.
Number of pages: 3
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Article number: 1233
Electronic versions:
Ingeman_Nielsen_Foged_2016_The_construction_of_Kangerlussuaq_Airport.pdf
Research output: Research - peer-review » Article in proceedings – Annual report year: 2017

Using resistivity method to characterize water flow patterns in permafrost environment (Ilulissat, Greenland)

General information
Direct current (DC) resistivity and induced polarization (IP) monitoring of active layer dynamics at high temporal resolution

With permafrost thawing and changes in active layer dynamics induced by climate change, interactions between biogeochemical and thermal processes in the ground are of great importance. Here, active layer dynamics have been monitored using direct current (DC) resistivity and induced polarization (IP) measurements at high temporal resolution and at a relatively large scale at a heath tundra site on Disko Island on the west coast of Greenland (69°N). At the field site, the active layer is disconnected from the deeper permafrost, due to isothermal springs in the region. Borehole sediment characteristics and subsurface temperatures supplemented the DC-IP measurements. A time-lapse DC-IP monitoring system has been acquiring at least six datasets per day on a 42-electrode profile with 0.5 m electrode spacing since July 2013. Remote control of the data acquisition system enables interactive adaptation of the measurement schedule, which is critically important to acquire data in the winter months, where extremely high contact resistances increase the demands on the resistivity meter. Data acquired during the freezing period of October 2013 to February 2014 clearly image the soil freezing as a strong increase in resistivity. While the freezing horizon generally moves deeper with time, some variations in the freezing depth are observed along the profile. Comparison with depth-specific soil temperature indicates an exponential relationship between resistivity and below-freezing temperature. Time-lapse inversions of the full-decay IP data indicate a decrease of normalized chargeability with freezing of the ground, which is the result of a decrease in the total unfrozen water and of the higher ion concentration in the pore-water. We conclude that DC-IP time-lapse measurements can non-intrusively and reliably image freezing patterns and their lateral variation on a 10-100 m scale that is difficult to sample by point measurements. In combination with laboratory experiments, the different patterns in resistivity and chargeability changes will enable the disentanglement of processes (e.g., fluid migration and freezing, advective and diffusive heat transport) occurring during freezing of the ground. The technology can be expanded to three dimensions and also to larger scale.
Direct current (DC) resistivity and Induced Polarization (IP) monitoring of active layer dynamics at high temporal resolution

With permafrost thawing and changes in active layer dynamics induced by climate change, interactions between biogeochemical and thermal processes in the ground are of great importance. Here, active layer dynamics have been monitored using direct current (DC) resistivity and induced polarization (IP) measurements at high temporal resolution at a heath tundra site on Disko Island on the west coast of Greenland (69°N). Borehole sediment characteristics and subsurface temperatures supplemented the DC-IP measurements. Data acquired during the freezing period of October 2013 – February 2014 clearly image the soil freezing as a strong increase in resistivity. While the freezing horizon generally moves deeper with time, some variations in the freezing depth are observed along the profile. Comparison with depth-specific soil temperature indicates an exponential relationship between resistivity and below-freezing temperature. Time-lapse inversions of the full-decay IP data indicate a decrease of normalized chargeability with freezing of the ground,
which can be the result of a decrease in the total unfrozen water and thus a higher ion concentration in the pore-water. We conclude that DC-IP time-lapse measurements can non-intrusively and reliably image freezing patterns and their lateral variation on a 10-100 m scale that is difficult to sample by point measurements.

**New Harbor in Kangerlussuaq, Western Greenland: Field Investigations and Utilization of Existing Materials**

The international airport of Greenland is located in Kangerlussuaq, making it an important connection point for tourists and transportation of goods. However, the existing harbor in Kangerlussuaq experiences major challenges in the form of extensive sedimentation of glaciofluvial sediments transported by rivers from the inland ice to the inner parts of the fjord. These sediment layers reduce the water depth and prevent container- and cruise ships to dock, imposing large additional maintenance costs, and inefficient operability. Through engineering geological field and lab investigations, a possible new harbor location around 10 km further out the fjord near Hancock Pynt, has been investigated. The onshore area was found to be highly suitable for a harbor support area, where a sub-base thickness of 1.8 m with gravel cover-layer was found adequate for the calculated design loads. Existing sediment deposits at the location are reusable as construction material and may reduce construction costs. Bathymetry investigations indicate however that measures must be taken to increase the water depth, and the offshore sediments were found not suitable as support for foundations.

**Spatiotemporal variability of oxygen isotope compositions in three contrasting glacier river catchments in Greenland**

Analysis of stable oxygen isotope ($\delta^{18}O$) characteristics is a useful tool to investigate water provenance in glacier river systems. In order to attain knowledge on the diversity of spatio-temporal $\delta^{18}O$ variations in glacier rivers, we have examined three glaciated catchments in Greenland with different areas, glacier hydrology and thermal regimes. At Mittivakkat Gletscher River, a small river draining a local temperate glacier in southeast Greenland, diurnal oscillations in $\delta^{18}O$ occur with a three-hour time lag to the diurnal oscillations in runoff. Throughout the peak flow season the $\delta^{18}O$ composition is controlled by the proportion between snowmelt and ice melt with episodic inputs of rainwater and occasional storage and release of a specific water component due to changes in the subglacial drainage system. At Kuannersuit Glacier River on the island Qeqertarsuaq, the $\delta^{18}O$ characteristics were examined after the major 1995–1998 glacier surge event. Despite large variations in the $\delta^{18}O$ values of glacier ice on the newly formed glacier tongue, there were no diurnal oscillations in the bulk meltwater emanating from the glacier in the post-surge years 2000–2001. In 2002 there were indications of diurnal oscillations, and in 2003 there were large diurnal fluctuations in $\delta^{18}O$. At Watson River, a large catchment at the western margin of the Greenland Ice Sheet, the spatial distribution of $\delta^{18}O$ in the river system was applied to fingerprint the relative runoff contributions from sub-catchments. Spot sampling indicates that during the early melt season most of the river water (64–73 %) derived from the Qinnguata Kuussua tributary, whereas the water flow on 23 July 2009 was dominated by bulk meltwater from the Akuliarusiarsuup Kuua tributary (where 7 and 67 % originated from the Russell Glacier and Leverett Glacier sub-catchments, respectively). A comparison of the $\delta^{18}O$ compositions from
glacial river water in Greenland shows distinct differences between water draining local glaciers (between −17.4 and −13.7 ‰), large ice caps (between −23.0 and −17.8 ‰) and the Greenland Ice Sheet (between −29.9 and −23.2 ‰).
Geotechnical variability of permafrozen glaciomarine clays in Sdr. Strømfjord in Greenland

This contribution presents the geotechnical properties of some permafrozen glaciomarine clays near to the Kangerlussuaq Airport at Sdr. Strømfjord in West Greenland. This fjord system was established by glacial erosion into the bedrock consisting of Nagssugtoqidian banded gneisses with amphibolitic and pegmatic veins. The deglaciation after 10000 y BC resulted in a number of noticeable terminal moraine systems and caused fluvial and glaciomarine sedimentation along the fjord. The interaction between isostatic depression of the bedrock and eustatic variations has resulted in changes of the relative sea level with Upper Marine Limit (UML) varying from +120 to +140 m at the West Coast to +40 at Kangerlussuaq. This retreat is well documented through C14-dating in the local area near to Kangerlussuaq Airport related to Fjord Stages F2 (+60 m/8300 y BC) and F3 (+40 m/8100 y BC) and Mt. Keglen stage (+40 m/7200 y BC) 5 km east of the Airport. Subformations found are; glaciomarine clay deposited in a coastal environment as very fine flocculated suspended matter (“rock flour”), deltaic sediments of silt and finesand and meltwater gravel and sand carried by the meltwater rivers. This sedimentation is still on-going in the area at Strømfjordshavn. The C14 datings of marine shells collected on the marine clay terraces at level 300 kPa. Clay minerals were weathered causing moderate to high activity and plasticity despite the formation age of only 7000 years. (b) The “River Bank Erosion Cut” 2 km east of the Airport Terminal. We studied a frozen marine clay deposit at +35 m with stratified ice layers under sandy gravel top layer. During laboratory analysis using fall cone testing a thawed clay sample was found to be quick (St>700) due to dilution of pore water salts. Multidisciplinary approach was necessary for this study.
Comparison of alternative electrode types for improvement of electrode-ground coupling in highly-resistive environment. Experience from the time lapse geoelectrical station for high-latitude permafrost monitoring, Ilulissat, West Greenland

General information
State: Published
Organisations: Department of Civil Engineering
Contributors: Tomaskovicova, S., Ingeman-Nielsen, T.
Number of pages: 1
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Peer-reviewed: Yes
Event: Abstract from 2nd International Workshop on Geoelectrical Monitoring, Vienna, Austria.
Electronic versions:
GELMON2013_SOTOabstract_1.pdf
Source: PublicationPreSubmission
Source-ID: 118889717
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2013

Coupled thermo-geophysical inversion for high-latitude permafrost monitoring: assessment of the method and practical considerations
The sedimentary settings of West Greenlandic towns with their fine-grained, often ice-rich marine deposits are of great concern in building and construction projects in Greenland, as they lose volume, strength and bearing capacity upon thaw. Since extensive permafrost thawing over large areas of inhabited Greenlandic coast has been predicted as a result of climate change, it is of great both technical and economical interest to assess the extent and thermal properties of such formations. Availability of methods able to determine the thermal parameters of permafrost and forecast its reaction to climate evolution is therefore crucial for sustainable infrastructure planning and development in the Arctic.
We are developing a model of heat transport for permafrost able to assess the thermal properties of the ground based on calibration by surface geoelectrical measurements and ground surface temperature measurements. The advantages of modeling approach and use of exclusively surface measurements (in comparison with direct measurements on core samples) are smaller environmental impact, cheaper logistics, assessment of permafrost conditions over larger areas and possibility of forecasting of the fate of permafrost by application of climate forcing.
In our approach, the heat model simulates temperature distribution in the ground based on ground surface temperature, specified proportions of the ground constituents and their estimated thermal parameters. The calculated temperatures in the specified model layers are governing the phase distribution between unfrozen water and ice. The changing proportion of unfrozen water content as function of temperature is the main parameter driving the evolution of electrical properties of the ground. We use a forward modeling scheme to calculate the apparent resistivity distribution of such a ground as if collected from a surface geoelectrical array. The calculated resistivity profile is compared to actual field measurements and a difference between the synthetic and the measured apparent resistivities is minimized in a least-squares inversion procedure by adjusting the thermal parameters of the heat model. A site-specific calibration is required since the relation between unfrozen water content and temperature is strongly dependent on the grain size of the soil.
We present details of an automated permanent field measurement setup that has been established to collect the calibration data in Ilulissat, West Greenland. Considering the station location in high latitude environment, this setup is unique of its kind since the installation of automated geophysical stations in the Arctic conditions is a challenging task. The main issues are related to availability of adapted equipment, high demand on robustness of the equipment and method due to the harsh environment, remoteness of the field sites and related powering issues of such systems. By showing the results from the new-established geoelectrical station over the freezing period in autumn 2012, we prove the 2D time lapse resistivity tomography to be an effective method for permafrost monitoring in high latitudes. We demonstrate the effectiveness of time lapse geoelectrical signal for petrophysical relationship calibration, which is enhanced comparing to sparse measurements.

General information
State: Published
Monitoring of active layer refreezing in Greenlandic permafrost

General information
State: Published
Organisations: Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions, Aarhus University
Contributors: Doetsch, J., Christiansen, A. V., Auken, E., Fiandaca, G., Ingeman-Nielsen, T.
Number of pages: 1
Pages: 28-28
Publication date: 2013

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Title of host publication: 2nd International Workshop on Geoelectrical Monitoring
Article number: 13
(Berichte der geologischen Bundesanstalt, Vol. 104).
Electronic versions:
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2013

Outburst flood evolution at Russell Glacier, western Greenland: effects of a bedrock channel cascade with intermediary lakes

Glacial lake outburst floods have produced a distinctive and widespread Quaternary record both onshore and offshore via widespread and intense geomorphological impacts, yet these impacts remain poorly understood due to a lack of modern analogues. This study therefore makes a systematic quantification of the evolution of a bedrock-channeled outburst flood. Channel topography was obtained from digitised aerial photographs, a 5 m grid resolution DEM and bathymetric surveys. Flood inundation was measured in the field from dGPS measurements. Flood evolution was analysed with application of a numerical model. Novel flood metrics, including 'rate-of-rise-to-peak' and 'persistence-above-a-value' of hydraulics were calculated. The key findings were that outburst floods; (i) that enter intermediary lakes are dramatically attenuated in terms of propagation whilst basin filling proceeds to the outlet level, dissipated of energy due to considerable flow recirculation during the rising stage of the flood, and after overtopping of the outlet are moderated in terms of peak discharge; (ii) can have kinematic waves that are introduced to a flood via hydraulic ponding, (iii) may develop a partitioning of flow regimes for instantaneous peak discharge, bed shear stress and Froude number due to time-transgressive changes in channel cross-section; specifically between inner channel and overbank regions. Furthermore, normalised change in cross-sectional area and normalised change in channel slope can be used to suggest the relative magnitude of instantaneous
peak discharge. Net erosion along a reach can be related to hydraulic persistence above a marker value and net deposition can be related to a 'time to peak' value. Reconstructions of Quaternary outburst floods should consider the importance of including intermediary lakes. Modern hazard mitigation studies could usefully note the potential use of reservoirs as an outburst flood alleviation resource.

**General information**

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Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, University of Leeds, Newcastle University, Sogn og Fjordane University College  
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Peer-reviewed: Yes

**Publication information**

Journal: Quaternary Science Reviews  
Volume: 67  
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Web of Science (2019): Indexed yes  
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Web of Science (2018): Indexed yes  
BFI (2017): BFI-level 2  
Scopus rating (2017): CiteScore 4.51 SJR 2.668 SNIP 1.55  
Web of Science (2017): Impact factor 4.334  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 2  
Scopus rating (2016): CiteScore 4.9 SJR 2.795 SNIP 1.8  
Web of Science (2016): Impact factor 4.797  
BFI (2015): BFI-level 2  
Scopus rating (2015): CiteScore 4.49 SJR 2.874 SNIP 1.534  
BFI (2014): BFI-level 2  
Scopus rating (2014): CiteScore 4.6 SJR 2.664 SNIP 1.657  
Web of Science (2014): Impact factor 4.572  
BFI (2013): BFI-level 2  
Scopus rating (2013): CiteScore 4.99 SJR 3.062 SNIP 1.765  
Web of Science (2013): Impact factor 4.571  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 2  
Scopus rating (2012): CiteScore 4.29 SJR 3.251 SNIP 1.661  
Web of Science (2012): Impact factor 4.076  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 2  
Scopus rating (2011): CiteScore 4.44 SJR 3.216 SNIP 1.774  
Web of Science (2011): Impact factor 3.973  
ISI indexed (2011): ISI indexed yes  
BFI (2010): BFI-level 2  
Scopus rating (2010): SJR 3.03 SNIP 2.112  
Web of Science (2010): Impact factor 4.657  
Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 2  
Scopus rating (2009): SJR 3.259 SNIP 2.039  
BFI (2008): BFI-level 2
Outburst flood evolution at Russell Glacier, western Greenland: effects of a bedrock channel cascade with intermediary lakes

Outburst floods have produced a distinctive and widespread Quaternary record both onshore and offshore via widespread and intense geomorphological impacts, yet these impacts remain poorly understood due to a lack of modern analogues. This study therefore makes the first systematic quantification of the evolution of a bedrock channelled outburst flood. Channel topography was obtained from digitised aerial photographs, a 5m grid resolution DEM and bathymetric surveys. Flood inundation was measured in the field from dGPS measurements. Flood evolution was analysed with application of a numerical model. Novel flood metrics, including 'rate-of-rise-to-peak' and 'persistence-above-a-value' of hydraulics were calculated. The key findings were that outburst floods; (i) that enter intermediary lakes are halted in terms of propagation whilst basin filling proceeds to the outlet level, dissipated of energy due to considerable flow recirculation during the rising stage of the flood, and after overtopping of the outlet are moderated in terms of peak discharge; (ii) may have a limited geomorphological impact if sediment supply due to antecedent geomorphological activity is limited; (iii) can have kinematic waves that are introduced to a flood via hydraulic ponding and these waves most likely account for distinctive 'hydropeaking'; (iv) can have a hydrograph that evolves in shape down channel and through time in a complex manner dependant on channel topography, and (v) may develop a partitioning of flow regimes for instantaneous peak discharge, bed shear stress and Froude number that is dependent on bedrock channel topography. Normalised change in cross-sectional area and normalised change in channel slope can be used to suggest the relative magnitude of instantaneous peak discharge. Reconstructions of Quaternary outburst floods should consider the importance of including intermediary lakes. Modern hazard mitigation studies could usefully note the potential use of reservoirs as an outburst flood alleviation resource.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, University of Leeds, Newcastle University, Sogn og Fjordane University College
Contributors: Carrivick, J., Russell, A., Ingeman-Nielsen, T., Yde, J.
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Geophysical Research Abstracts
Volume: 15
Article number: EGU2013-2818
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Outburst flood evolution at Russell Glacier, western Greenland: effects of a bedrock channel cascade with intermediary lakes

General information
State: Published
Organisations: Department of Civil Engineering, University of Leeds, Newcastle University, Sogn og Fjordane University College
Publication date: 2013
Peer-reviewed: Yes
Event: Poster session presented at European Geosciences Union General Assembly 2013, Vienna, Austria.
Electronic versions:
Source: PublicationPreSubmission
Source-ID: 115648487
Research output: Research - peer-review › Poster – Annual report year: 2013

An Optimization Algorithm For Interpreting Thermal Parameters For Frozen Soils With Significant Unfrozen Water Content

General information
State: Published
Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, Technical University of Denmark
Contributors: Ingeman-Nielsen, T., Gori, P., Tomaskovicova, S.
Pages: 224-225
Publication date: 2012

Host publication information
Title of host publication: Extended abstracts of the Tenth International Conference On Permafrost
Volume: 4
Source: dtu
Source-ID: u::4806
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2012

Assessment of Different Heat Drain Materials for Protection of Permafrost under Road and Airfield Embankments

General information
State: Published
Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, Technical University of Denmark, Universite Laval
Pages: 243-244
Publication date: 2012

Host publication information
Title of host publication: Extended abstracts of the Tenth international Conference on Permafrost
Volume: 4
Source: dtu
Source-ID: u::4803
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2012
Characterisation of MSWI bottom ash for potential use as subbase in Greenlandic road construction

The waste management situation in Greenland needs to be improved. Most waste in towns is incinerated with only limited separation prior to incineration and the bottom ash residue is disposed of at uncontrolled disposal sites. The bottom ash could be a valuable resource within the expansion of infrastructure due to increased oil and mineral exploitation. Thus, in this study MSWI bottom ash from a Greenlandic incinerator was tested for possible reuse as subbase in road construction. The mechanical properties (grain size distribution, wear resistance and bearing capacity) showed that the bottom ash was acceptable for reuse after some small adjustments in the grain size distribution to prevent frost sensitivity. Results obtained from heavy metal content and heavy metal leaching complied with the Danish guideline values for reuse of waste materials in construction. Leaching of Cu and Cr was high from small grain sizes and could be reduced by removing some of these smaller grain sizes to obtain the stability requirement of the bottom ash. All in all, this study showed that the Greenlandic bottom ash has potential for being reused in road construction.

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering
Contributors: Kirkelund, G. M., Jørgensen, A. S., Ingeman-Nielsen, T., Villumsen, A.
Pages: 835-840
Publication date: 2012

Host publication information
Title of host publication: The 4th International Conference on Engineering for Waste and Biomass Valorisation (WasteEng12) : Proceedings
Keywords: MSWI bottom ash, Road construction, Mechanical properties, Heavy metals, Leaching
Source: dtu
Source-ID: u::5232
Research output: Research - peer-review › Article in proceedings – Annual report year: 2012

Coupled Thermo-Geophysical Inversion for Permafrost Monitoring

General information
State: Published
Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, Department of Environmental Engineering, Water Resources Engineering, Technical University of Denmark
Contributors: Tomaskovicova, S., Paamand, E., Ingeman-Nielsen, T., Bauer-Gottwein, P.
Number of pages: 2
Publication date: 2012
Peer-reviewed: Yes
Event: Abstract from 10th International Conference on Permafrost, Salekhard, Russian Federation.

Bibliographical note
Extended abstract
Source: dtu
Source-ID: u::4805
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2012

Development of bearing capacity of fine grained permafrost deposits in western greenland urban areas subject to soil temperature changes

The bearing capacity of frozen soils is high, compared to non-frozen soils of same composition. Projected climatic warming in the Arctic will increase the soil temperature, thus affecting the bearing capacity and the deformation properties. Western Greenland temperatures are projected to increase by 2-3 °C during the 21st century. This paper presents a relation between undrained shear strength and temperature based on a series triaxial tests of fine-grained permafrost in the interval from -3 °C to -1 °C. Moderately ice-rich permafrost and excess ice free refrozen active-layer were retrieved from the Western Greenland towns of Sisimiut and Ilulissat respectively. Tests reveal undrained shear strengths ranging from 409 kPa to 940 kPa, where low temperatures and low excess ice content yield higher strengths. Normalized strengths are used for establishing a trend for the strength decrease with increasing temperature. Both excess ice free and moderately ice-rich samples show a strength decrease of 21 %/°C from -3 °C to -1 °C. Other authors’ data suggest the same trend for moderately ice-rich samples, whereas it is suggested that further studies are conducted to validate the trend for excess ice free samples. Unfrozen water contents are seen to be directly inversely proportional to the undrained shear strength when both are normalized, which may reduce costs for establishing reliable soil strength parameters. It is suggested that a relation to deformation parameters are investigated as well. The established trends could provide a valuable tool for foundation design in fine-grained permafrost areas.
Development of Construction Properties of Warming Permafrost in Western Greenland Town Areas – A Preliminary Study: Abstract of poster presentation

General information
State: Published
Organisations: Section for Arctic Technology, Department of Civil Engineering, Section for Geotechnics and Geology
Contributors: Agergaard, F. A., Ingeman-Nielsen, T.
Publication date: 2012
Peer-reviewed: No
Event: Abstract from International Polar Year 2012 Conference - From Knowledge to Action, Montreal (CA), 22-27 Apr.
Electronic versions: Development of Construction Properties.pdf
Source: orbit
Source-ID: 316559
Research output: Research - peer-review › Article in proceedings – Annual report year: 2012

Engineering Test Sections in Permafrost Environment: Performance of Permafrost Protection Measures and Mitigation Techniques to Permafrost Degradation

General information
State: Published
Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, Universite Laval, BGC Engineering Inc., State Key Laboratory of Frozen Soil Engineering, Russian Academy of Sciences, SNC-Lavalin Group
Pages: 153-154
Publication date: 2012
Host publication information
Title of host publication: Extended abstracts of the Tenth International Conference On Permafrost
Volume: 4
Source: dtu
Source-ID: u::4804
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2012

Fundering og anlæg på permafrost i Grønland

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering
Contributors: Brandt, I., Foged, N. N., Ingeman-Nielsen, T.
Pages: 296-301
Publication date: 2012
Host publication information
Optimization in the use of Air Convection Embankments for Protection of Underlying Permafrost
Since the beginning of the 1990s a significant increase in the mean annual air temperatures has been recorded all over the arctic regions. This has lead to a degrading of permafrost, which is now threatening the stability of airport and road embankments. To minimize the damages caused by thaw settlements, different mitigation techniques have been developed. This paper concerns optimization in the use of air convection embankments. In the autumn 2008 a test-site was established during the construction of a new road in Sisimiut, western Greenland. Two types of air convection embankments (ACE) were constructed on shorter sections of the road; a traditional ACE made of crushed rock and a modified ACE, where ventilation pipes were installed in the embankment shoulder. Thermistors were installed in each section to study the annual variations of the thermal regime in the embankments. The results from the first years of monitoring haven’t shown the expected effects from installing the ventilation pipes into the ACE. This is probably caused by the systems lack of potential to expel warm air. A higher amount of drainage holes in the ventilation pipes or a new approach instead of pipes will probably lead to the expected results, which has been achieved in earlier laboratory tests.

Permafrost degradation in West Greenland
Important aspects of civil engineering in West Greenland relate to the presence of permafrost and mapping of the annual and future changes in the active layer due to the ongoing climatically changes in the Arctic. The Arctic Technology Centre (ARTEK) has worked more than 10 years on this topic and the first author has been involved since 1970 in engineering geology, geotechnical engineering and permafrost related studies for foundation construction and infrastructures in towns and communities mainly in West Greenland. We have since 2006 together with the Danish Meteorological Institute, Greenland Survey (ASIAQ) and the University of Alaska Fairbanks carried out the US NSF funded project ARC-0612533: Recent and future permafrost variability, retreat and degradation in Greenland and Alaska: An integrated approach. This contribution will present data and observations from the towns Ilulissat, Kangerlussuaq, Sisimiut and Nuuk. They are situated in continuous, discontinuous and sporadic permafrost zones. We will show examples of deterioration of permafrost related to present local scale climate observations and large scale climate and permafrost simulations modeled numerically with the GIPL model driven by HIRHAM climate projections for Greenland up to 2075. The engineering modelling is based on a risk assessment methodology based on a flow diagram which classify the risk of permafrost degradation causing settlement and stability problems for buildings and infrastructures based on relatively simple parameters. It is planned as decision and planning tool for town planners and engineers in local municipality governments and to consulting engineers and contractors in Greenland, which also may be used in other arctic regions. Risk is classified in four categories: Low, Limited, Medium and High based on environmental properties as surface conditions (rock or sedimentary basins), soil grain size classification (gravel, sand, silt and clay) and ice content in the ground. The model uses ground thermal conditions quantified as the Permafrost Thaw Potential, which is defined as the potential active layer increase due to climate warming and surface alterations. Using this methodology it is expected that mapping of vulnerability in towns and construction areas together with proposed adaption and mitigation technologies will be of practical use to technical institutions and public as well as a general tool for the scientific community. The presentation will focus on the application of the Risk Evaluation diagram used in the selected towns in different permafrost zones and is illustrated with present observations of permafrost deterioration in West Greenland.
Planning a new ski lift system in Sisimiut (Greenland)

General information
State: Published
Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, National Space Institute, Geodesy
Publication date: 2012

Event information
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Location: Denmark
Electronic versions:
KD-DTU.pdf

Bibliographical note
Oral presentation
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Source-ID: u::6003
Research output: Research › Sound/Visual production (digital) – Annual report year: 2012

Strength Properties of Warming Fine-Grained Permafrost

General information
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Organisations: Department of Civil Engineering, Section for Geotechnics and Geology
Contributors: Agergaard, F. A., Ingeman-Nielsen, T.
Number of pages: 2
Publication date: 2012
Peer-reviewed: Yes
Event: Abstract from 10th International Conference on Permafrost, Salekhard, Russian Federation.
Electronic versions:
prod11341823385249.FAAgergaard_abstract.pdf
Source: dtu
Source-ID: u::4442
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2012
**Suggested best practice for geotechnical characterisation of permafrost in the Nordic countries**

Even though permafrost is a specialty within Nordic geotechnical engineering, engineers and researcher will be faced with managing the consequences of projected climatic influences to construction design in permafrost areas. This requires the determination of the frozen soil engineering properties largely influenced by the content of ice in the soil. This paper presents and discusses different methodologies for laboratory determination of the soil bulk density, ice content, unfrozen water content, strength and deformation properties as well as thermal properties from frozen soil core samples. It is proposed that a best practice for permafrost characterisation employs sample volume determination based on the Archimedes principle and that ice contents are presented as the volume fraction of excess ice to the frozen sample volume. Furthermore, direct measurements of unfrozen water content and thermal properties should be preferred, while soil residual salinity should always be determined. The procedure for determination of strength and deformation properties should be subject to projected soil temperature at end of construction service lifetime.

**General information**

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Organisations: Section for Arctic Technology, Department of Civil Engineering, Section for Geotechnics and Geology
Contributors: Agergaard, F. A., Ingeman-Nielsen, T., Foged, N. N.
Publication date: 2012

**Host publication information**

Title of host publication: Proceedings of Nordic Geotechnical Meeting
Keywords: Laboratory tests, Codes of practice & standards, Snow ice and frost, Thermal effects, Strength and testing of materials
Source: orbit
Source-ID: 316204
Research output: Research - peer-review › Article in proceedings – Annual report year: 2012

**Surface Geophysical Measurements for Locating and Mapping Ice-Wedges**

With the presently observed trend of permafrost warming and degradation, the development and availability of effective tools to locate and map ice-rich soils and massive ground ice is of increasing importance. This paper presents a geophysical study of an area with polygonal landforms in order to test the applicability of DC electrical resistivity tomography (ERT) and Ground Penetrating Radar (GPR) to identifying and mapping ice-wedge occurrences. The site is located in Central West Greenland, and the ice-wedges are found in a permafrozen peat soil with an active layer of about 30 cm. ERT and GPR measurements give a coherent interpretation of possible ice-wedge locations, and active layer probing show a tendency for larger thaw depth in the major trench systems consistent with a significant temperature (at 10 cm depth) increase in these trenches identified by thermal profiling. Three shallow boreholes were drilled during the campaign but did not encounter ice-wedges. As the final interpretation did not predict ice-wedge occurrence at the borehole locations, results not contradictory – but more data is needed for final validation.

**General information**

State: Published
Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, Technical University of Denmark
Contributors: Ingeman-Nielsen, T., Tomaskovicova, S., Larsen, S., Aparício, S., Gori, P.
Number of pages: 10
Pages: 634-643
Publication date: 2012

**Host publication information**

Title of host publication: Cold Regions Engineering 2012 : Sustainable Infrastructure Development in a Changing Cold Environment
Publisher: American Society of Civil Engineers
ISBN (Print): 9780784412473
Keywords: Ice-wedges, Geophysical survey, ERT, GPR, Greenland
DOIs: 10.1061/9780784412473.063
Source: dtu
Source-ID: u::4792
Research output: Research - peer-review › Article in proceedings – Annual report year: 2012

**A new cycle of jökulhlaups at Russell Glacier, Kangerfussuaq, West Greenland**

Jökulhlaups in 2007 and 2008 from an ice-dammed lake at the northern margin of RussellGlacier, West Greenland, marked the onset of a renewed jökulhlaup cycle after 20 years of stability. We present a record of successive ice-dammed lake drainage events and associated ice-margin dynamicsspanning 25 years. Robust calculations of lake volumes and peak discharges are made, based onintensive field surveys and utilizing high-spatial-resolution orthophotographs of the lake basin and icemargin. These data enable identification of controls on the behaviour of the ice-dammed lake and provide the first field-based examination of controls on jökulhlaup magnitude and frequency for this system. We find that Russell Glacier jökulhlaups have a much higher peak discharge than predicted bythe Clague–Mathews relationship,
which we attribute to an unusually short englacial/subglacial routeway and the presence of a thin ice dam that permits incomplete sealing of jokulhlaup conduits between lake drainage events. Additionally, we demonstrate that the passage of jokulhlaups through an interlinked system of proglacial bedrock basins produces significant attenuation of peak discharged downstream. We highlight that improved understanding of jokulhlaup dynamics requires accurate information about ice-dammed lake volume and ice-proximal jokulhlaup discharge.

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Newcastle University, University of Leeds, Aarhus University
Contributors: Russell, A. J., Carrivick, J. L., Ingeman-Nielsen, T., Yde, J. C., Williams, M.
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Peer-reviewed: Yes

Publication information
Journal: Journal of Glaciology
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Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.25 SJR 1.929 SNIP 1.167
Web of Science (2017): Impact factor 3.2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.57 SJR 2.118 SNIP 1.257
Web of Science (2016): Impact factor 3.643
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.09 SJR 2.211 SNIP 1.074
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 3.09 SJR 2.067 SNIP 1.269
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.02 SJR 2.284 SNIP 1.141
Web of Science (2013): Impact factor 3.213
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.79 SJR 2.241 SNIP 1.192
Web of Science (2012): Impact factor 2.882
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.64 SJR 1.792 SNIP 1.216
Web of Science (2011): Impact factor 2.301
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.685 SNIP 1.041
Web of Science (2010): Impact factor 2.603
High-frequency induced polarization measurements of hydrocarbon-bearing rocks
We have investigated induced polarization (IP) effects in hydrocarbon-bearing artificial rocks at frequencies greater than 100 Hz. We have examined the instrumental and electrode phase responses of Zonge International's complex resistivity (CR) system, and optimized the performance of the Zonge system for IP measurements over the 1 mHz to 10 kHz frequency range. The reliability of the high-frequency IP measurements were confirmed by independent measurement of the same samples using the Novocontrol BDS 80 system. Our results confirm the presence of IP effects in hydrocarbon-bearing rocks, and suggest the necessity to account for IP effects in the interpretations of electromagnetic data, particularly in induction logging data.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Geotechnics and Geology, University of Utah, TechnoImaging, LLC
Contributors: Burtman, V., Endo, M., Zhdanov, M. S., Ingeman-Nielsen, T.
Number of pages: 5
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Peer-reviewed: Yes

Publication information
Journal: SEG Technical Program Expanded Abstracts (Online)
Volume: 30
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ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: English
Keywords: Conductivity, Induced polarization, Logging, Resistivity, Rock Physics
DOIs: 10.1190/1.3628168

Research output: Research - peer-review » Conference abstract in journal – Annual report year: 2012

Interdisciplinary case-based teaching of engineering geosciences and geotechnics
The complete restructuring of the 4-year Professional Bachelor programme in Arctic Technology at the Technical University of Denmark in 2007 has provided the perfect framework for implementing CDIO-based courses with focus on a
holistic and interdisciplinary approach. In this paper we present our experiences over four years teaching one such course, 11821 Site Investigations. The goal is to teach the students to conduct site investigations in connection with construction work in arctic areas. It covers technical skills and competences from several different branches of engineering in an interdisciplinary course. Course elements comprise the understanding of relevant geological processes and deposits, tools to examine and map these deposits, as well as the use of Global Navigation Satellite Systems (GNSS) and Geographical Information Systems (GIS) to collect and organize spatial information. Environmental aspects and cultural heritage screenings are also covered as well as group work and report writing. The course is constructed around a real world case, e.g. the construction of a specific road segment, and the students have to produce a realistic site investigation report based on field and laboratory investigations as well as theoretical considerations. The interdisciplinary structure of the course combined with the real-world case and just-in-time teaching applied has resulted in more motivated and hard working students, and as teachers we receive better and more interesting reports to read. However, the interdisciplinary and practically oriented nature of the course poses special demands on teachers and instructors. Among these are more complex coordination among course elements, and difficult adaption of the curriculum. Based on written and oral feedback and our own teaching experience, we conclude that the new course form is an efficient and challenging way to teach engineering with good learning outcome over a broad spectrum of the CDIO syllabus.

Lime stabilization of fine-grained sediments in western Greenland

Thick deposits of fine-grained marine sediments exist in large areas of western Greenland. Many places these sediments are located above sea-level, and now complicate construction projects in urban areas. The mineralogy of the fine-grained sediments is very different from European sediments, mainly due to the cold climate, and it is therefore of great interest to study possible methods to improve the stability and strength properties. This project includes laboratory studies of lime stabilization on fine-grained marine sediments from Kangerlussuaq, western Greenland. The results have included tests to determine the optimum lime content and the strength development in relation to both reaction time and curing temperature. Hopefully the results from this project will lead to a future use of lime stabilization and make it possible to use/reuse materials of poor quality at construction sites in Greenland.

Modelling unfrozen water content in a silty clay permafrost deposit

The mechanical properties of both unfrozen soils and permafrost soils are influenced by the amount of unfrozen water in the pore space. When dealing with foundation engineering in permafrost areas it is essential to estimate the unfrozen water content (wu). This paper deals with the establishing of a calibration equation for determining the unfrozen water content of a Greenlandic silty clay permafrost deposit. Calibration experiments have been conducted for water contents in the interval 0 – 10 % at both 5 °C and 22 °C. Calibration equations are verified against permittivity data from a permafrost core of material properties similar to the test soil. The calibration for 5°C is seen to make a good fit to the permafrost core
data. Further experiments should be performed in order to extend the range of water contents tested and hence the range of validity of the calibration equation.

**General information**
State: Published
Organisations: Section for Arctic Technology, Department of Civil Engineering, Section for Geotechnics and Geology
Contributors: Agergaard, F. A., Ingeman-Nielsen, T.
Publication date: 2011

**Host publication information**
Title of host publication: Proceedings of 2011 Pan-Am CGS Geotechnical Conference
URLs: http://panam-cgc2011.ca/
Source: orbit
Source-ID: 314053
Research output: Research - peer-review › Article in proceedings – Annual report year: 2011

**Permafrost Degradation Risk Zone Assessment using Simulation Models**
In this proof-of-concept study we focus on linking large scale climate and permafrost simulations to small scale engineering projects by bridging the gap between climate and permafrost sciences on the one hand and on the other technical recommendation for adaptation of planned infrastructures to climate change in a region generally underlain by permafrost. We present the current and future state of permafrost in Greenland as modelled numerically with the GIPL model driven by HIRHAM climate projections up to 2080. We develop a concept called Permafrost Thaw Potential (PTP), defined as the potential active layer increase due to climate warming and surface alterations. PTP is then used in a simple risk assessment procedure useful for engineering applications. The modelling shows that climate warming will result in continuing wide-spread permafrost warming and degradation in Greenland, in agreement with present observations. We provide examples of application of the risk zone assessment approach for the two towns of Sisimiut and Ilulissat, both classified with high PTP.

**General information**
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, University of Alaska Fairbanks, Danish Meteorological Institute, Geological Survey of Denmark and Greenland
Contributors: Daanen, R., Ingeman-Nielsen, T., Marchenko, S., Romanovsky, V. E., Foged, N. N., Stendel, M., Christensen, J. H., Hornbech Svendsen, K.
Pages: 1043-1056
Publication date: 2011
Peer-reviewed: Yes

**Publication information**
Journal: Cryosphere
Volume: 5
Issue number: 4
ISSN (Print): 1994-0416
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.84 SJR 3.034 SNIP 1.425
Web of Science (2017): Impact factor 4.524
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.49 SJR 3.696 SNIP 1.825
Web of Science (2016): Impact factor 4.803
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 5.35 SJR 4.118 SNIP 1.663
Web of Science (2015): Impact factor 4.906
Web of Science (2015): Indexed yes
This study presents laboratory testing on quicklime (CaO) stabilization of fine-grained marine sediments in low temperature areas. The soil was sampled on the Fossil Plain in Kangerlussuaq, Greenland, and analyzed in the laboratory at Technical University of Denmark (DTU). The optimum CaO content in a soil-CaO mixture was determined using a number of laboratory methods, such as pH test, consistency limit analysis, degree of compaction, and short term California Bearing Ratio (CBR) values. The study also numerically demonstrates a long term strength development of the soil-CaO mixture at 1°C and 10°C curing temperatures, comparing stabilization effectiveness between low and normal soil temperature conditions.
Variability of active layer thickness prediction from a climate model forced permafrost model

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering
Contributors: Ingeman-Nielsen, T.
Pages: EGU2011-12980
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Geophysical Research Abstracts
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
URLs:
http://meetings.copernicus.org/egu2011/
Source: orbit
Source-ID: 278233

Determination of Ice Contents in Greenlandic Permafrost Using Geophysical Measurements

General information
State: E-pub ahead of print
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering
Contributors: Brandt, I., Ingeman-Nielsen, T., Foged, N. N.
Number of pages: 346
Publication date: 2010

Host publication information
Title of host publication: Thermal State of Frozen Ground in a Changing Climate During the IPY : Abstracts from the Third European Conference on Permafrost 13-17 June 2010
Place of publication: Longyearbyen, Svalbard, Norway
Publisher: The University Centre in Svalbard
Editors: Mertes, J. R., Christiansen, H. H., Etzelmüller, B.
URLs:
http://eucop2010.no/
Source: orbit
Source-ID: 266680

Dust Prevention and Low-Volume Road Construction in South Greenland
The dust reducing agent Dustex, which is made by lignosulphonate, has some more qualities than reducing the dust amounts. In several cases it is shown that the stability is increased. This is documented under some conditions, but some investigations could still be carried out. The use of the product in Greenland has been tried for the first time, and the preliminary test indicates good results. Laboratory test also shows an increased bearing capacity, but some investigations related to the cold climate are still to be done.

General information
State: Published
Evidence of Quick-Clay Deposit at Kangerlussuaq, West Greenland

In 2007 a large Ice dammed lake at the Russel Glacier, near Kangerlussuaq, West Greenland, drained in a catastrophic flood event – a jökulhlaup. The draining was made possible by a general retreat of the glacier due to climate amelioration. Under normal circumstances such jökulhlaups go relatively unnoticed in Greenland, but in this case the jökulhlaup propagated through a river basin which passes by the main international airport in Greenland. Due to the erosion of the riverbank during the jökulhlaup, several man-made structures were affected – roads disappeared and several storage facilities were eroded and destroyed by the river. In the wake of the catastrophic flood, a previously unknown permafrozen fingrained marine deposit was observed in the erosional bank of the river. Laboratory studies have proven this material to have extremely high sensitivity, with natural water content much higher than the liquid limit. The formation has been stabilized by the presence of permafrost in the area, but the combination of erosional energy supplied by the river and the sensitive properties of the material have resulted in quick thaw, destabilization and erosion of the formation. As an effect, the riverbank was eroded approximately 40 m inland over the course of the jökulhlaup, which lasted approximately one day. It is the first time such a quick clay formation has been observed very near surface in inhabited areas in Greenland. If such deposits are found to be more widespread, it could be very problematic for the future infrastructural development in the region. Here we present the results of recent research, including a study of mineralogy of the quick clay using SEM and XRD. We also discuss the effect of climate warming on permafrost thaw in the area.

Geotechnical Implications of a Warming Climate in West Greenland

In 2007 a large Ice dammed lake at the Russel Glacier, near Kangerlussuaq, West Greenland, drained in a catastrophic flood event – a jökulhlaup. The draining was made possible by a general retreat of the glacier due to climate amelioration. Under normal circumstances such jökulhlaups go relatively unnoticed in Greenland, but in this case the jökulhlaup propagated through a river basin which passes by the main international airport in Greenland. Due to the erosion of the riverbank during the jökulhlaup, several man-made structures were affected – roads disappeared and several storage facilities were eroded and destroyed by the river. In the wake of the catastrophic flood, a previously unknown permafrozen fingrained marine deposit was observed in the erosional bank of the river. Laboratory studies have proven this material to have extremely high sensitivity, with natural water content much higher than the liquid limit. The formation has been stabilized by the presence of permafrost in the area, but the combination of erosional energy supplied by the river and the sensitive properties of the material have resulted in quick thaw, destabilization and erosion of the formation. As an effect, the riverbank was eroded approximately 40 m inland over the course of the jökulhlaup, which lasted approximately one day. It is the first time such a quick clay formation has been observed very near surface in inhabited areas in Greenland. If such deposits are found to be more widespread, it could be very problematic for the future infrastructural development in the region. Here we present the results of recent research, including a study of mineralogy of the quick clay using SEM and XRD. We also discuss the effect of climate warming on permafrost thaw in the area.

Investigation of Newly Exposed Very Sensitive Fine-Grained Marine Deposit at Kangerlussuaq, Western Greenland

In 2007 a large Ice dammed lake at the Russel Glacier, near Kangerlussuaq, West Greenland, drained in a catastrophic flood event – a jökulhlaup. The draining was made possible by a general retreat of the glacier due to climate amelioration. Under normal circumstances such jökulhlaups go relatively unnoticed in Greenland, but in this case the jökulhlaup propagated through a river basin which passes by the main international airport in Greenland. Due to the erosion of the riverbank during the jökulhlaup, several man-made structures were affected – roads disappeared and several storage facilities were eroded and destroyed by the river. In the wake of the catastrophic flood, a previously unknown permafrozen fingrained marine deposit was observed in the erosional bank of the river. Laboratory studies have proven this material to have extremely high sensitivity, with natural water content much higher than the liquid limit. The formation has been stabilized by the presence of permafrost in the area, but the combination of erosional energy supplied by the river and the sensitive properties of the material have resulted in quick thaw, destabilization and erosion of the formation. As an effect, the riverbank was eroded approximately 40 m inland over the course of the jökulhlaup, which lasted approximately one day. It is the first time such a quick clay formation has been observed very near surface in inhabited areas in Greenland. If such deposits are found to be more widespread, it could be very problematic for the future infrastructural development in the region. Here we present the results of recent research, including a study of mineralogy of the quick clay using SEM and XRD. We also discuss the effect of climate warming on permafrost thaw in the area.

General information
State: E-pub ahead of print
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre
Contributors: Ingeman-Nielsen, T., Foged, N. N.
Publication date: 2010
Peer-reviewed: Yes
Source: orbit
Source-ID: 272512
Research output: Research - peer-review › Poster – Annual report year: 2010
Lime Stabilization of Fine-Grained Greenlandic Sediments in Relation to Construction Projects

Thick deposits of fine-grained marine sediments exist in large areas of western Greenland. Many places these sediments are located above sea-level, and now complicate construction projects in urban areas. The mineralogy of the sediments is very different from that of European sediments, mainly due to the cold climate, and it is therefore of great interest to study possible methods to improve the stability of the fine-grained sediments. This presentation will include results of laboratory studies of lime stabilization on a clay soil from Kangerlussuaq, western Greenland. The result includes tests of the optimum lime mixture in relation to both reaction time and temperature influence.

Modelling unfrozen water content in a silty clay permafrost deposit

General information
State: Published
Organisations: Arctic Technology Centre
Contributors: Agergaard, F. A., Ingeman-Nielsen, T.
Publication date: 2010
Peer-reviewed: No
Event: Abstract from PanAm-CGS Geotechnical Conference, Toronto, Ontario, Canada.
Keywords: permafrost, unfrozen water content, permittivity, silty clay
Source: orbit
Source-ID: 272040
Research output: Research › Conference abstract for conference – Annual report year: 2010

Permafrost Degradation Risk Zone Assessment using Numerical Models

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, University of Alaska Fairbanks, Danish Meteorological Institute
Contributors: Daanen, R., Ingeman-Nielsen, T., Foged, N. N., Marchenko, S., Romanovsky, V., Stendel, M., Christensen, J. H.
Publication date: 2010
The Thermal State of Permafrost in the Nordic Area during the International Polar Year 2007-2009

This paper provides a snapshot of the permafrost thermal state in the Nordic area obtained during the International Polar Year (IPY) 2007-2009. Several intensive research campaigns were undertaken within a variety of projects in the Nordic countries to obtain this snapshot. We demonstrate for Scandinavia that both lowland permafrost in palsas and peat plateaus, and large areas of permafrost in the mountains are at temperatures close to 0 degrees C, which makes them sensitive to climatic changes. In Svalbard and northeast Greenland, and also in the highest parts of the mountains in the rest of the Nordic area, the permafrost is somewhat colder, but still only a few degrees below the freezing point. The observations presented from the network of boreholes, more than half of which were established during the IPY, provide an important baseline to assess how future predicted climatic changes may affect the permafrost thermal state in the Nordic area. Time series of active-layer thickness and permafrost temperature conditions in the Nordic area, which are generally only 10 years in length, show generally increasing active-layer depths and risings permafrost temperatures.

General information
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Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre
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Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Permafrost and Periglacial Processes
Volume: 21
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BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.93 SJR 1.289 SNIP 1.429
Web of Science (2017): Impact factor 3.529
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.94 SJR 1.667 SNIP 1.478
Web of Science (2016): Impact factor 2.815
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.21 SJR 1.253 SNIP 1.101
Web of Science (2015): Impact factor 2
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.92 SJR 1.182 SNIP 1.455
Web of Science (2014): Impact factor 2.119
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.26 SJR 1.978 SNIP 1.658
Web of Science (2013): Impact factor 2.177
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.16 SJR 2.157 SNIP 2.016
Web of Science (2012): Impact factor 3.049
ISI indexed (2012): ISI indexed yes
The use of electromagnetic induction methods for establishing quantitative permafrost models in West Greenland

General information
State: E-pub ahead of print
Organisations: Arctic Technology Centre, Department of Civil Engineering, Section for Geotechnics and Geology
Contributors: Ingeman-Nielsen, T., Brandt, I.
Publication date: 2010
Peer-reviewed: Yes
Event: Abstract from European Geosciences Union General Assembly 2010, Vienna, Austria.

Evidence of Presence of Sporadic Permafrost at the Qinngorput Infrastructural Development Site in Nuuk, West Greenland

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre
Contributors: Brandt, I., Ingeman-Nielsen, T., Foged, N. N.
Number of pages: 61
Publication date: 2009

Host publication information
Title of host publication: Nuuk climate days 2009 : Changes of the Greenland Cryosphere Workshop & The Arctic Freshwater Budget International symposium
Publisher: DMI
Source: orbit
Permafrost Risk Zonation in West Greenland: Adaption to the effect of Climate Change

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, ASIAQ Greenland Survey
Contributors: Foged, N. N., Ingeman-Nielsen, T., Brandt, I., Svendsen, K. H.
Number of pages: 28
Publication date: 2009

Host publication information
Title of host publication: Nuuk climate days 2009: Changes of the Greenland Cryosphere Workshop & The Arctic Freshwater Budget International Symposium
Publisher: DMI
Source: orbit
Source-ID: 256202
Research output: Research › Conference abstract in proceedings – Annual report year: 2009

Permafrost temperature reanalysis and model predictions for Ilulissat, West Greenland

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, University of Alaska Fairbanks
Contributors: Ingeman-Nielsen, T., Romanovsky, V. E., Marchenko, S. S., Foged, N. N., Daanen, R.
Number of pages: 61
Pages: 34-35
Publication date: 2009

Host publication information
Title of host publication: Nuuk climate days 2009: Changes of the Greenland Cryosphere Workshop & The Arctic Freshwater Budget International Symposium
Publisher: DMI
Source: orbit
Source-ID: 256206
Research output: Research › Conference abstract in proceedings – Annual report year: 2009

Tourist cottages in the Arctic: Possibilities of wastewater treatment
The sanitary situation in the cottages in the area around Sisimiut and on the recommended route for wanderers between Sisimiut and Kangerlussuaq needs to be improved. Today there are toilets in 7 out of a total of 27 cottages. Open defecation is the general practice, and for the cottages with toilets problems with hygienically and environmentally safe disposal of the excreta exist. The current situation is unacceptable from a health and sanitary point of view. There are several factors that have to be taken into consideration when planning wastewater treatment in cold regions, one of them being changes in climate and thereby also changes of permafrost, which can be a serious problem. Geological and logistical aspects will also have to be taken into consideration, and they vary dependent on the location of each cottage.

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, Norwegian University of Life Sciences
Contributors: Gunnarsdottir, R., Ingeman-Nielsen, T., Jenssen, P. D., Villumsen, A.
Number of pages: 53
Pages: 44-50
Publication date: 2009

Host publication information
Title of host publication: Tourist Cottages and Climate Change
Place of publication: Copenhagen
Publisher: The Arctic Technology Centre, Department of Civil Engineering
ISBN (Print): 97887778772855
Source: orbit
Annual Report 2007

General information
State: Published
Organisations: Department of Civil Engineering, Section for Construction Materials, Section for Building Physics and Services, Section for Indoor Environment, Section for Building Design, Section for Geotechnics and Geology, Section for Structural Engineering, Arctic Technology Centre
Number of pages: 34
Publication date: 2008

Geophysical Investigations of Saline Permafrost at Ilulissat, Greenland
The technical properties and general state of permafrost in Greenland is not well documented. A new coordinated investigation has been initiated, for ground temperature measurements and permafrost mapping in Greenlandic towns in sporadic, discontinuous and continuous permafrost zones. We present investigation results from one of the sites, located at Ilulissat, in an area of discontinuous saline permafrost. We have established ground temperature measurement stations and conducted a shallow geoelectrical study. Our results show that the sediments in the studied area mainly consist of very frost susceptible silty clays. The area has permafrost with a maximum active layer thickness between 0.9 and 1 m. In spite of low permafrost temperatures a considerable part of the pore water is unfrozen, due to high residual salt concentrations. Consequently, the unfrozen water content dominates the technical properties, and the sediments have a limited heat capacity available, should the temperature conditions change.

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, ASIAQ Greenland Survey
Contributors: Ingeman-Nielsen, T., Foged, N. N., Butzbach, R., Jørgensen, A. S.
Number of pages: 1,054
Pages: 773-778
Greenland Permafrost Temperature Simulations

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, University of Alaska Fairbanks, Danish Meteorological Institute
Contributors: Daanen, R. P., Romanovsky, V. E., Marchenko, S. S., Christensen, J. H., Stendel, M., Ingeman-Nielsen, T.
Publication date: 2008
Peer-reviewed: Yes
Event: Abstract from 9th International Conference on Permafrost, Fairbanks, AK, United States.
Source: orbit
Source-ID: 231634
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2008

Permafrost in Marine Deposits at Ilulissat Airport in Greenland, Revisited
Ilulissat Airport was constructed in 1982 to 1984 after detailed geotechnical investigations as the construction site included up to 12 m thick basins of marine clay deposits. Despite soil temperatures of approx -3°C the soil appeared unfrozen from 4 to 5 m below ground surface due to a high residual salt content in the porewater. However, in the less saline top zone massive ice layers was found constituting up to 30 volume%. These formations representing a type example of saline permafrost caused the planned position of the runway to be shifted towards northwest and a removal of the layers and substitution with compacted blasted rock fill. However, a test fill of 2.5 m of rock fill and coarse gravel was constructed in the abandoned area in order to establish experiences for future constructions. Background and previous findings will be covered and present activities are topics in a companying paper.

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre
Contributors: Foged, N. N., Ingeman-Nielsen, T.
Number of pages: 1,054
Pages: 445-450
Publication date: 2008

Recent and Future Permafrost Variability, Retreat and Degradation in Greenland and Alaska: An Integrated Approach: Annual report to NSF

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, University of Alaska Fairbanks, Danish Meteorological Institute, ASIAQ Greenland Survey
Contributors: Romanovsky, V. E., Walsh, J., Christensen, J. H., Svendsen, K. H., Foged, N. N., Daanen, R., Marchenko, S., Drews, M., Ingeman-Nielsen, T., Stendel, M.
The impact of light-colored pavements on active layer dynamics revealed by Ground-Penetrating Radar monitoring

Ground-penetrating radar (GPR) has been used to study the variations in the depth of the frost table throughout a complete thaw-freeze season in Kangerlussuaq Airport, western Greenland. In autumn 2000, three test areas were painted white on the parking area of the airport in order to reduce further development of depressions in the asphalt pavement. One of these areas has been used in the GPR investigations to compare the variations of the frost table underneath a normal dark asphalt surface to that below a more reflective surface. The GPR results have shown a clear correlation between the use of the reflective surface and a reduced depth to frost table. In late summer the difference in the depths to the frost table is approximately 0.9 m. The results should promote the interest in the development and use of light colored pavement materials in order to reduce the effect of a warming climate on arctic infrastructures.

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre
Contributors: Jørgensen, A. S., Ingeman-Nielsen, T.
Number of pages: 1,054
Pages: 865-868
Publication date: 2008

Host publication information
Title of host publication: Proceedings of the Ninth International Conference on Permafrost
Volume: 1
Place of publication: Fairbanks
Publisher: Institute of Northern Engineering, University of Alaska Fairbanks
Source: orbit
Source-ID: 209940
Research output: Research › peer-review » Article in proceedings – Annual report year: 2008

Annual Report 2006

General information
State: Published
Organisations: Department of Civil Engineering, Section for Structural Engineering, Section for Building Physics and Services, Section for Geotechnics and Geology, Planning and Management of the Built Environment, Department of Management Engineering
Number of pages: 30
Publication date: 2007

Publication information
Place of publication: Kgs. Lyngby
Publisher: DTU Byg, Danmarks Tekniske Universitet
Original language: English
Electronic versions:
byg_annualreport2006_web.pdf
Source: orbit
Source-ID: 222836
Research output: Communication » Report – Annual report year: 2007

Annual variations of frost table in Kangerlussuaq Airport, western Greenland
Ground-penetrating radar (GPR) has been used to study the annual variations of the frost table beneath the southern parking area at Kangerlussuaq Airport, western Greenland. In autumn 2000, three test areas were painted white in order to reduce further development of depressions in the asphalt pavement initiated by permafrost degradation. One of these
white painted areas has been used in the investigations to compare the annual variations of the frost table underneath a normal black asphalt surface to with that below a more reflective surface. The investigations were carried out from July 2005 until August 2006. The GPR measurements have shown a clear correlation between the use of the reflective surface and a reduced depth in the annual variations to the frost table. In late summer (August) the difference in the depths to the frost table is almost 20 ns, which corresponds to approximately 0.9 m. This constitutes a major difference in the thermal conditions below the reflective surface and the normal black asphalt surface.

**General information**

**State:** Published  
**Organisations:** Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre  
**Contributors:** Jørgensen, A. S., Ingeman-Nielsen, T., Brock, N.  
**Number of pages:** 88  
**Publication date:** 2007

**Host publication information**

**Title of host publication:** International Conference, Arctic Roads: Operating, maintaining and building roads in a climatically challenging environment  
**Place of publication:** Kgs. Lyngby, Denmark  
**Publisher:** DTU Byg, Danmarks Tekniske Universitet  
**Editors:** Ingeman-Nielsen, T., Fritt-Rasmussen, J., Brock, N., Villumsen, A.  
**ISBN (Print):** 978-877877-230-5  
**URLs:** ftp://artekftp.byg.dtu.dk/arctic_roads_2007/index.htm  
**Source:** orbit  
**Source-ID:** 195076  
**Research output:** Research › Article in proceedings – Annual report year: 2007

**Engineering geological and geophysical investigations for road construction in the municipality of Sisimiut, West Greenland**

In connection with a road construction project between the towns of Sisimiut and Kangerlussuaq in Central West Greenland, the Arctic Technology Centre has been involved in prospecting and site investigations. This paper presents a selection of results concerning the climatic conditions and permafrost distribution, as well as engineering geological and geotechnical investigations conducted. We present data from two soil temperature stations, and show that the recent climatic warming has resulted in changes in the state of the permafrost. Furthermore, we present a geological type section based on engineering geological investigations in the Sisimiut area. Geophysical investigations show that presence of permafrost is widespread, and our results indicate that the vertical thickness of the permafrost may reach 20 m. Further climate warming in the near future will impose high demands on design and construction work in order to counter the effects of permafrost degradation and increased active layer thickness.

**General information**

**State:** Published  
**Organisations:** Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, Aarhus University  
**Contributors:** Ingeman-Nielsen, T., Clausen, H., Foged, N. N.  
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**International Conference, Arctic Roads: Operating, maintaining and building roads in a climatically challenging environment**

**General information**
Recent and Future Permafrost Variability, Retreat and Degradation in Greenland and Alaska: An Integrated Approach: Annual Report to NSF

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, University of Alaska Fairbanks, Danish Meteorological Institute, ASIAQ Greenland Survey
Contributors: Romanovsky, V. E., Walsh, J., Christensen, J. H., Svendsen, K. H., Foged, N. N., Daanen, R., Marchenko, S., Ingeman-Nielsen, T., Stendel, M., Simonsen, K.
Number of pages: 17
Publication date: 2007

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Publisher: University of Alaska
Original language: English
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Research output: Research › Report – Annual report year: 2007

Road construction in Greenland: The Greenlandic case

General information
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Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre, Municipality of Sisimiut
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Publication information
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Original language: English
(Roadex III - Northern Periphery).
Source: orbit
Source-ID: 208478
Research output: Research › Report – Annual report year: 2007

Geophysical Techniques applied to permafrost investigations in Greenland

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre
CR1Dmod: A Matlab program to model 1D complex resistivity effects in electrical and electromagnetic surveys

We have constructed a forward modelling code in Matlab, capable of handling several commonly used electrical and electromagnetic methods in a 1D environment. We review the implemented electromagnetic field equations for grounded wires, frequency and transient soundings and present new solutions in the case of a non-magnetic first layer. The CR1Dmod code evaluates the Hankel transforms occurring in the field equations using either the Fast Hankel Transform based on digital filter theory, or a numerical integration scheme applied between the zeros of the Bessel function. A graphical user interface allows easy construction of 1D models and control of the parameters. Modelling results are in agreement with other authors, but the time of computation is less efficient than other available codes. Nevertheless, the CR1Dmod routine handles complex resistivities and offers solutions based on the full EM-equations as well as the quasi-static approximation. Thus, modelling of effects based on changes in the magnetic permeability and the permittivity is also possible.
Mapping ice-bonded permafrost with electrical methods in Sisimiut, West Greenland

Permafrost delineation and thickness determination is of great importance in engineering related projects in arctic areas. In this paper, 2D geoelectrical measurements are applied and evaluated for permafrost mapping in an area in West Greenland. Multi-electrode resistivity profiles (MEP) have been collected and are compared with borehole information. It is shown that the permafrost thickness in this case is grossly overestimated by a factor of two to three. The difference between the inverted 2D resistivity sections and the borehole information is explained by macro-anisotropy due to the presence of horizontal ice-lenses in the frozen clay deposits. It is concluded that where the resistivity method perform well for lateral permafrost mapping, great care should be taken in evaluating permafrost thickness based on 2D resistivity profiles alone. Additional information from boreholes or other geophysical techniques is needed for correct interpretation.

General information
State: Published
Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre
Contributors: Ingeman-Nielsen, T.
Publication date: 2006
Numerical modelling of complex resistivity effects on a homogeneous half-space at low frequencies

The many different existing models describing the spectral behavior of the resistivity of geological materials at low frequency, combined with the lack of available field data, render the interpretation of complex resistivity (CR) data very difficult. With a recent interest in CR measurements for environmental applications and thanks to technological progress, the use of wide band frequency equipment seems promising, and it is expected to shed light on the different results among the published solutions to the electromagnetic (EM) coupling problem. We review the theory of EM coupling over a homogeneous half-space with CR effects and study some aspects of the complex coupling function. We advocate the use of the CR based coupling function in the interpretation process, in order to obtain a better understanding of the physical processes involved in CR effects. Application of the model to real field data show systematic good agreement in two simple cases, even over wide ranges of frequencies. Interpretation with a double Cole-Cole model is applied for comparison, and in spite of good fits to the data, large differences are observed in the interpreted low frequency dispersion. We conclude that the use of a second Cole-Cole model to describe EM coupling may corrupt the interpretation of the low frequency dispersion, even when only the normal range of frequencies (}
The effect of electrode contact resistance and capacitive coupling on Complex Resistivity measurements

The effect of electrode contact resistance and capacitive coupling on complex resistivity (CR) measurements is studied in this paper. An equivalent circuit model for the receiver is developed to describe the effects. The model shows that CR measurements are severely affected even at relatively low contact resistances. The model suggests proportionality between the error in the phase measurements and the product of the wire-to-ground capacitance, the contact resistance, the dipole size and the frequency of the measurement. The model behavior is illustrated and confirmed by field data collected with the contact resistance artificially increased by resistors. The results emphasize the importance of keeping contact resistance low in CR measurements.

General information
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Organisations: Section for Geotechnics and Geology, Department of Civil Engineering, Arctic Technology Centre
Contributors: Ingeman-Nielsen, T.
Number of pages: 3,541
Pages: 1376-1380
Publication date: 2006

Host publication information
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Volume: 25
Publisher: Society of Exploration Geophysicists
DOIs:
10.1190/1.2369776
Projects:

**Multi-disciplinary Hazard Mapping Framework for Critical Infrastructure on Terrestrial Permafrost**
Scheer, J., PhD Student, Department of Civil Engineering
Ingeman-Nielsen, T., Main Supervisor, Department of Civil Engineering
Lubbad, R., Supervisor
01/11/2018 → 31/10/2021
Project: PhD

**Measurements and modelling of Arctic coastal environments**
Monteban, D., PhD Student, National Space Institute
Pedersen, J. O. P., Main Supervisor, National Space Institute
Ingeman-Nielsen, T., Supervisor, Department of Civil Engineering
Lubbad, R., Supervisor
Institut stipendie (DTU)
15/11/2016 → 14/02/2020
Award relations: Measurements and modelling of Arctic coastal environments
Project: PhD

**Forundersøgelser i Qaanaaq**
Hendriksen, K., Project Manager, Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions
Ingeman-Nielsen, T., Project Participant, Department of Civil Engineering, ARTEK, Section for Arctic Engineering and Sustainable Solutions
Foged, N. N., Project Participant, Department of Civil Engineering, Section for Geotechnics and Geology
01/02/2016 → 31/12/2018
Project: Research

**Quantitative analysis of firm permeability and melt water refreezing of the Greenland ice sheet**
Vandecrux, B. R. M., PhD Student, Department of Civil Engineering
Ingeman-Nielsen, T., Main Supervisor, Department of Civil Engineering
Fausto, R. S., Supervisor
Sørensen, L. S., Examiner, National Space Institute
Gallée, H., Examiner
Mermild, S. H., Examiner
Forskningsrådsfinansiering
01/11/2015 → 31/12/2018
Award relations: Quantitative analysis of firm permeability and melt water refreezing of the Greenland ice sheet
Project: PhD

**Greenlandic Government basis funding of ARTEK**
Tomaskovicova, S., PhD Student, Department of Civil Engineering
Ingeman-Nielsen, T., Main Supervisor, Department of Civil Engineering
Nielsen, T. R., Examiner, Department of Civil Engineering
Hauck, C., Examiner
Krautblatter, M., Examiner
Hauck, C., Examiner
Krautblatter, M., Examiner
Institut/centerfinansieret
01/01/2012 → 07/12/2017
Award relations: Greenlandic Government basis funding of ARTEK
Project: PhD

**Strength and deformation properties of permafrost soils in Greenland**
Agergaard, F. A., PhD Student, Department of Civil Engineering
Ingeman-Nielsen, T., Main Supervisor, Department of Civil Engineering
Assessment of dynamic flow, pressure and geo-mechanical behaviour of a CO2 storage complex
Mbia, E. N., PhD Student, Department of Civil Engineering
Frykman, P., Supervisor, Department of Civil Engineering
Ingeman-Nielsen, T., Examiner, Department of Civil Engineering
Prasad, M., Examiner
Wessel-Berg, D., Examiner
Ansat eksternt
01/10/2010 → 27/05/2014
Award relations: Assessment of dynamic flow, pressure and geo-mechanical behaviour of a CO2 storage complex
Project: PhD

Theory and Application of the Electromagnetic Induction Geophysical Method in the Arctic Region West Greenland
Ingeman-Nielsen, T., PhD Student, Department of Civil Engineering
Villumsen, A., Main Supervisor, Department of Civil Engineering
Baumgartner, F., Supervisor, Department of Geology and Geotechnical Engineering
Rasmussen, T. M., Examiner
Dahlin, T., Examiner
DTU-lønnet stipendie
01/01/2002 → 02/02/2006
Award relations: Theory and Application of the Electromagnetic Induction Geophysical Method in the Arctic Region West Greenland
Project: PhD

Recent and future permafrost variability, retreat and degradation in Greenland and Alaska: An integrated approach
Foged, N. N., Project Participant, Department of Civil Engineering
Ingeman-Nielsen, T., Project Participant, Department of Civil Engineering
Romanovsky, V., Project Manager, University of Alaska Fairbanks
Marchenko, S., Project Participant, University of Alaska Fairbanks
Daanen, R., Project Participant, University of Alaska Fairbanks
Hesselbjerg Christensen, J., Project Participant, Danish Meteorological Institute
Stendel, M., Project Participant, Danish Meteorological Institute
Svendsen, K. H., Project Participant, ASIAQ Greenland Survey
Project ID: 25775
Forsk. Andre offentlige og private - Udenlandske: DKK4,800,000,00
01/08/2006 → 01/08/2009
Collaborators: University of Alaska Fairbanks, ASIAQ Greenland Survey, Danish Meteorological Institute
Award relations: Recent and future permafrost variability, retreat and degradation in Greenland and Alaska: An integrated approach
Project: Research

Activities:

Geofysiske undersøgelser af saltholdig permafrost ved Ilulissat, Grønland: Dansk Geoteknisk Forening Medlemsmøde: Geoteknologi under Arktiske forhold
Period: 13 Nov 2008
Thomas Ingeman-Nielsen (Speaker)
Department of Civil Engineering
Section for Geotechnics and Geology
Arctic Technology Centre
Geotekniske undersøgelser ved lufthavnen i Ilulissat, Grønland: Dansk Geoteknisk Forening Medlemsmøde: Geoteknologi under Arktiske forhold
Period: 13 Nov 2008
Thomas Ingeman-Nielsen (Speaker)
Department of Civil Engineering
Section for Geotechnics and Geology
Arctic Technology Centre

Permafrost
Period: 7 Nov 2008
Thomas Ingeman-Nielsen (Lecturer)
Arctic Technology Centre
Department of Civil Engineering
Section for Geotechnics and Geology

Permafrost og klimaændringer: Forsknings Døgn
Period: 26 Apr 2008
Thomas Ingeman-Nielsen (Speaker)
Department of Civil Engineering
Section for Geotechnics and Geology
Arctic Technology Centre

Engineering geological studies of Greenlandic permafrost areas
Period: 2 Apr 2008
Description
Greenland is very sparsely inhabited, with a population of only about 56,000. Nevertheless, over the past decades, the Greenlandic society has undergone rapid development. Airports have been constructed in all major towns, and presently several larger road construction projects are under planning, as mineral exploration, hydropower exploitation and growing tourism poses a demand for better infrastructure. The main concerns when constructing such structures in permafrost terrain are the presence of fine grained sediments, their ice contents and pore water chemistry, due to the impact on ground stability upon thawing. In this presentation we will discuss current knowledge about the distribution and properties of permafrost around mainly urban areas in South-Central West Greenland from Nuuk to Ilulissat. Results of engineering geological and technical investigations will be presented with a focus on applied geophysical methods, especially geoelectrical and georadar measurements, which have proven useful in mapping frozen ground and active layer thickness.

Related event
Engineering geological studies of Greenlandic permafrost areas: IARC Seminar
02/04/2008 → 02/04/2008
International Arctic Research Center, University of Alaska Fairbanks
Activity: Talks and presentations › Conference presentations