PCCH-Arctic – Overview of deliverables

Sinitsyn, A.O. (SINTEF)

June 20 2025

PCCH-Arctic – Polar Climate and Cultural Heritage – Preservation and Restoration Management

- **Objectives:** to create a knowledge base for sustainable safeguarding and future use of cultural heritage in the Arctic in conditions of changing climate and demography
- **Project period:** 2021–2024
- **Funding:** The Research Council of Norway and User Partners, 10 MNOK (Cash) + 1.08 MNOK (InKind), i.e. ~1 MEuro.
- **Project type:** collaboration project to meet challenges in society and buisness (KSP)
- **User Partners:** Longyearbyen Lokalstyre, Store Norske Spitsbergen Kulkompani (SNSK) AS, Kings Bay AS, Svalbard Museum
- **Research Partners:** Sintef, The Norwegian Meteorological Institute, UiO, UNIS and UniVie
- **Reference group:** Governor of Svalbard, The Directorate for Cultural Heritage, Visit Svalbard
- **Web-page**: https://www.sintef.no/prosjekter/2021/pcch-arctic/
- **Research Council of Norway project number:** 320769, **SINTEF project number:** 102024999

Outline of PCCH-Arctic

PCCH-Arctic

Board – all project partners

Reference Group
Governor of Svalbard
The Directorate for Cultural Heritage
Visit Svalbard
Svalbard Museum

Workshops and Technical meeting

Cooperation with ongoing projects of The Research Council of Norway
ArcticAlpineDecay (NIBIO)
CULTCOAST (NIKU)

Cooperation with higher education – course- and MSc projects
NTNU, UNIS, TU Delft (The FlightCase)

WP1. Mapping, categorization and management of cases
*** *** *** *** *** *** ***
Input in Management plans for Case study objects in Longyearbyen and Ny-Ålesund

Establishment of monitoring program (stability of foundations under global warming)

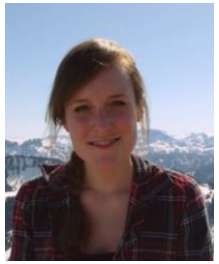
WP2 Present and future management of cultural heritage: regulation, conservation, valorization
*** *** *** *** *** *** ***
Demographic assesment, mapping of regulatory framework, mapping and assessment of practices, values, and attitudes connected to conservation, restoration, and use of CH.

WP3 Climate change and permafrost degradation
*** *** *** *** *** ***
Climate projections and permafrost degradation

WP4 Methodology and Technological management development
*** *** *** *** *** *** ***
Risk-based methodology for assessment of natural hazards and for foundation design in permafrost

Recommendations for holistic management of cultural heritage in Polar climate
*** *** *** *** *** ***
Input in management plans (see WP1)

Project participants from research and education institutes



Researcher Aga, J., UiO Geocryology

Ass. Prof. Arlov, T.B., UNIS History

Dr. Bekele, Y., SINTEF Geotechnics

Dr. Landgren, O., The Norwegian Meteorological Institute

Dr. Lutz, J., The Norwegian Meteorological Institute

PhD Meyer, A., UniVie Sociology

Dr. Sinitsyn, A., SINTEF Geotechnics, **Project lead**

Prof. Westermann, S., UiO Geocryology

Sand, G., SINTEF, Leader of Steering Committee

+ supervisors for MSc theses from UNIS, NTNU, DTU, UNIVPM, LUT, NGU

MSc '22 Enevoldsen, K., NTNU/UNIS, AT Dep.

MSc '22 Antonello, C., NTNU/DTU/UNIS AT Dep.

MSc '23 Haugen, C.G., NTNU

MSc '23 Johansen Seljelv I., NTNU

MSc '23 Pasquini, N., UNIS/ UNIVPM/UNIS AT Dep.

MSc '23 Vehola, A., LUT/UNIS, AG Dep.

Research questions

RQ1: Can new technological solutions, applied or developed by the project, lower the cost and improve the quality of the work?

RQ2: How do changing preferences, patterns and levels of tourist traffic combined with local demographic development impact on cultural heritage in Svalbard?

RQ3: How can we take expected climate change impacts into account in risk-based management of cultural heritage in permafrost environments?

RQ4: Is the definition of permafrost temperatures based on historical data, n-factors, and field investigations suitable for geotechnical and foundation design in permafrost in rapidly changing climate?

RQ5: Can emerging numerical tools for geotechnical and foundation design in permafrost replace currently used analytical and empirical solutions?

Deliverables

Special workshops (3 pcs): Special WS on Hirthhamn 2021 (requested by SNSK), Special WS in Ny-Ålesund 2022 (requested by Kings Bay), Special Joined workshop 2022 «PCCH-Arctic, ArcticAlpineDecay, CULTCoast».

Presentations and material for thematic events (5 pcs): fagdager at Riksantikvaren 2022 and 2024, PoleSTAH 2024, presentation to KLD (Ny-Ålesund, 2023), contribution to the guide of AECO 2025.

Other presentations (10+): p Capadus H2020, ASSW2023, Frostdagen 2022 and 2023, InSAR Svalbard 2023, PMC workshop in Longyearbyen 2021, GTF 2022, Noradaprt 2023, UNIS course AT-301 and AG-352 (2023), Svalbard Conference 2023.

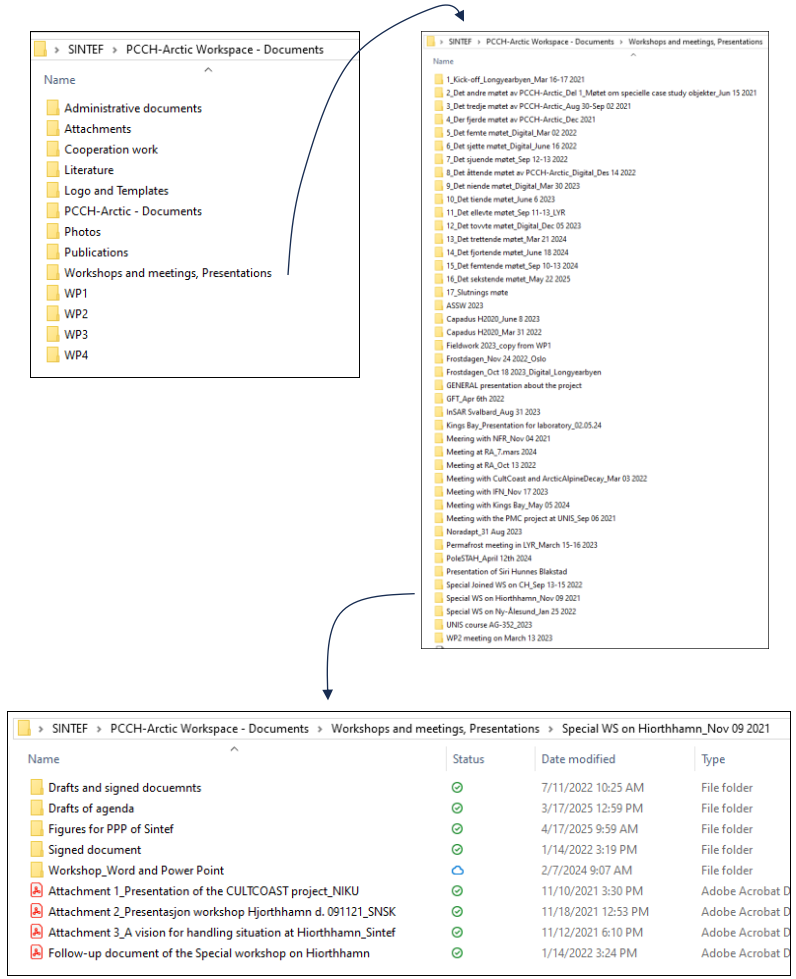
Popular science articles (ca. 10): several articles in SvalbardPosten, several other popular-science articles.

Master theses (5 pcs): Enevoldsen 2022, Antonello 2022, Seljelv, 2023, Pasquini 2023, Vehola, 2023.

Scientific articles: Aga et al. 2025, Vickers et al. 2025

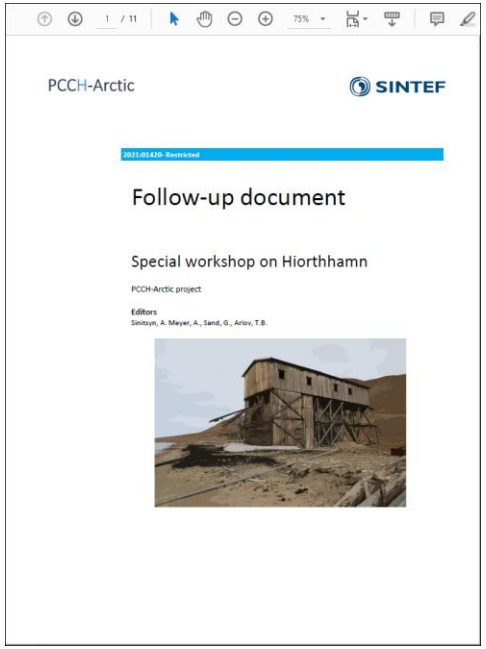
Reports (8 pcs): seven PCCH-Arctic reports.

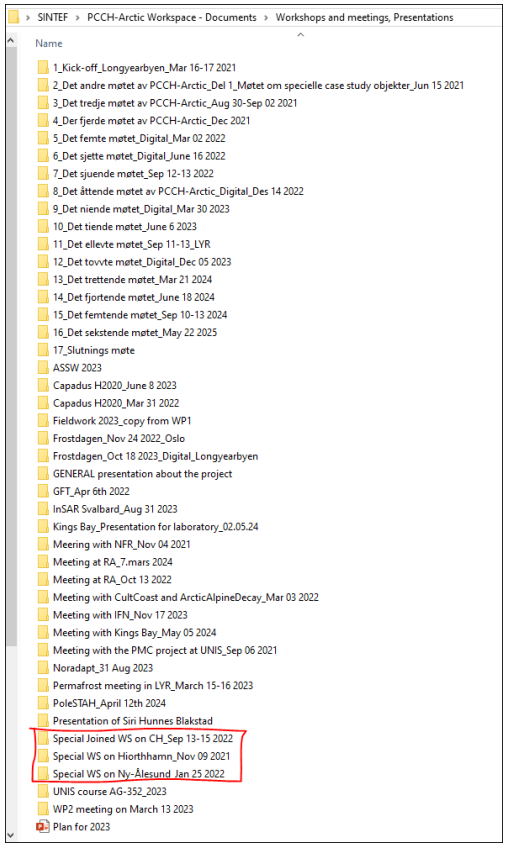
Software and digital tools (2 pcs): Excel Tool for risk analysis of natural hazards, GIS-layer for the Excel Tool.



Special workshops

- Juditha Aga, Clarissa Willmes, Anatoly O. Sinitsyn, Thor Bjørn Arlov, Julia Boike, Sebastian Westermann. Impact of snow and building management on ground surface temperatures in permafrost environments - A case study from the historical mining town Ny-Ålesund, Svalbard. Cold Regions Science and Technology, 237, 2025. https://doi.org/10.1016/j.coldregions.2025.104516
- Vickers, H., Mooney, P., and Landgren, O.: Recent and future changes in rain-on-snow event characteristics across Svalbard, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-2099, 2025.





Popular science articles

DENNE ARTIKKELEN ER PRODUSERT OG FINANSIERT AV SINTEF – LES MER.

Klimaendringer og tining av permafrosten på Svalbard truer alle konstruksjoner som er fundamentert i og på bakken. (Illustrasjonsfoto: Shutterstock/NTB)

Vår arktiske kulturarv trues av klimaendringer

Kulturarven på Svalbard viser menneskers aktivitet i et hardt og skjørt miljø. Nå jobber forskere med å bevare den for ettertida.

Kathrine Nitter
SENIOR KOMMUNIKASJONSRÅDGIVER
SINTEF

Onsdag 16. februar 2022 – 04:30

Longyearbyen og Ny-Ålesund er tidligere kullgruvesamfunn med mange verdifulle historiske kulturminner.

Slike minner og steder gir innsikt i det sosiale, religiøse og økonomiske livet til våre forfedre. Det handler også om identitet og tilhørighet, og om attraksjoner for både lokale og besøkende.

Innstillinger for

Many reposts

Taubanebukkene – de vaklende kjempene

Taubanebukkene i Longyearbyen er legendariske. De er en viktig del av byens historie, preger bybildet og er med på å gi byen identitet som tidligere gruvedby. Noen av dem har stått siden 1 hundre år, men nå skjer det noe. Mildere klima kombinert med økt nedbør akselerer nedbrytingen. Hvis vi ønsker å ha dem med videre må vi foreta oss noe, men hva?

Ny-Ålesund har den største samlingen av vernede bygninger på Svalbard – til sammen 23 bygninger er i bruk.

Leserbrev

Hvordan tar vi best vare på Ny-Ålesund?

Taubanebukkene – de vaklende kjempene

KRONIKK

Taubanebukkene – de vaklende kjempene

Klimaforandringer – vi kan selvfølgelig velge å ignorere oppvarmingen. «Da i skjønnhet» er et uttrykk som brukes av arkeologer når forfallet får gå sin gang, helt til kulturminnene er borte for alltid. Men ønsker vi det for taubanebukkene? Hvem er forfatterne bak dette leserinnlegget. Foto: Gunnar Sand / PCCH-Arctic

10. november 2022

Hvis vi ønsker å ha dem med videre må vi foreta oss noe, men hva?

Leserinnlegg:

Kan vi redde Taubanestasjonen i Hiorthhamn?

Sjøen spiser seg stadig nærmere den gamle, ærverdige Taubanestasjonen. Forslagene til hvordan vi kan berge kulturminnet er mange, men er de aksseptable? Hvor mye kan man tukle med et kulturminne før det mister sin historiske verdi?

Anatoly Sinitsyn og Gunnar Sand, SINTEF

Thor Bjørn Arlov, UNIS

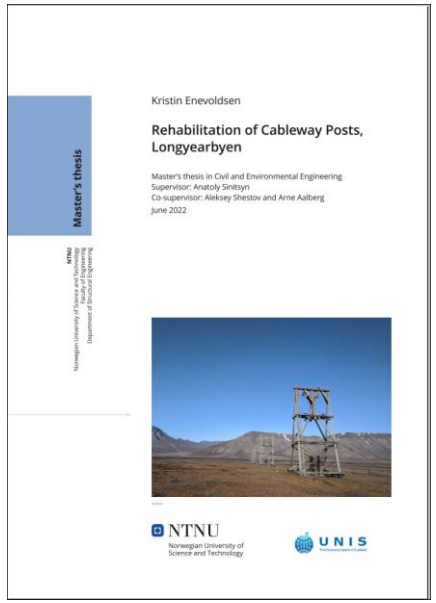
Oskar Landgren, Meteorologisk Institutt, Sebastian Westermann, Universitetet i Oslo

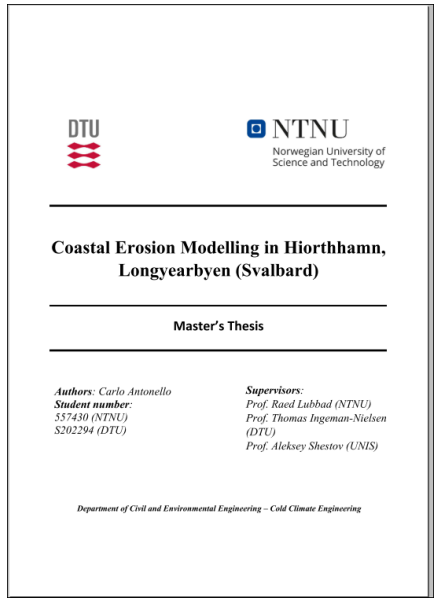
Publisert: 21.01.2022 kl 16:00

I 2021 startet et forskningsprosjekt som skal studere skader som påføres kulturminner i Longyearbyen og Ny-Ålesund på grunn av et varmere klima, og hvordan man kan sette inn tiltak som ivaretar dem. Prosjektet ledes fra SINTEF, med UNIS, Universitetet i Oslo og Meteorologisk Institutt som forskningspartnere, og Store Norske, Kings Bay og Lokalstyret som stedlige

Ti meter igjen: Taubanestasjonen i Hiorthhamn pikkte å ligge hundre meter fra strandlinja. Nå er avstanden nærmere ti meter. Foto: PCCH Arctic

MSc theses


Master's thesis
Kristin Enevoldsen
Rehabilitation of Cableway Posts, Longyearbyen
Master's thesis in Civil and Environmental Engineering
Supervisor: Anatoly Sinitsyn
Co-supervisor: Aleksey Shestov and Arne Aalberg
June 2022
NTNU
Norwegian University of Science and Technology
UNIS


DTU
NTNU
Norwegian University of Science and Technology
Coastal Erosion Modelling in Hiorthhamn, Longyearbyen (Svalbard)
Master's Thesis
Authors: Carlo Antonello
Student number:
557430 (NTNU)
S202294 (DTU)
Supervisors:
Prof. Raed Lubbad (NTNU)
Prof. Thomas Ingeman-Nielsen (DTU)
Prof. Aleksey Shestov (UNIS)
Department of Civil and Environmental Engineering – Cold Climate Engineering

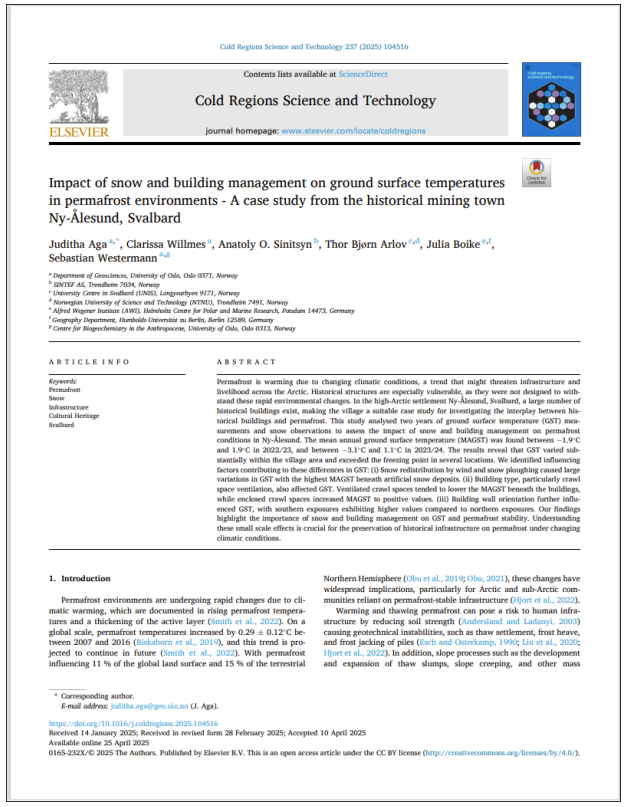

UNIVERSITÀ POLITECNICA DELLE MARCHE
FACOLTÀ DI INGEGNERIA
CORSO DI LAUREA IN INGEGNERIA EDILE-ARCHITETTURA
STUDIO DELLA STABILITÀ DEL PATRIMONIO CULTURALE DELLE SVALBARD SOTTO L'EFFETTO DEL RISCALDAMENTO GLOBALE
Stability of cultural heritage in Svalbard in a global warming
Relatore: Giuseppe Scarpelli
Tesi di laurea di: Noemi Pasquini
Correlatori: Anatoly Sinitsyn
Aleksey Shestov
A.A. 2022/2023


Masteroppgave
Ingalill Johansen Seljelv
Praktisk eller perfekt?
Kulturminner og klimaendringer på Svalbard.
Forvaltningen av taubaneanlegget i Longyearbyen og omegn 2003–2022.
Masteroppgave i Kulturminneforvaltning
Veileder: Aud Mikkelsen Tretvik
Mai 2023
NTNU
Kunnskap for en bedre verden


LUT University
UNIS
SINTEF
RISK OF NATURAL HAZARDS ON TECHNICAL-INDUSTRIAL CULTURAL HERITAGE IN SVALBARD
Probability analysis including considerations for climate change
Lappeenranta–Lahti University of Technology LUT
Master's Programme in Circular Economy, Master's thesis
2023
Anni Vehola
Examiners: Associate Professor, Ville Uusitalo
Post-doctoral researcher, Natasha Järviö
Supervisors: Lena Rubensdotter (UNIS)
Anatoly Sinitsyn (SINTEF)

Scientific Articles

- Juditha Aga, Clarissa Willmes, Anatoly O. Sinitsyn, Thor Bjørn Arlov, Julia Boike, Sebastian Westermann. Impact of snow and building management on ground surface temperatures in permafrost environments - A case study from the historical mining town Ny-Ålesund, Svalbard. Cold Regions Science and Technology, 237, 2025. https://doi.org/10.1016/j.coldregions.2025.104516
- Vickers, H., Mooney, P., and Landgren, O.: Recent and future changes in rain-on-snow event characteristics across Svalbard, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-2099 , 2025.
- Additional publications are expected



Cold Regions Science and Technology 237 (2025) 104516

Contents lists available at ScienceDirect

Cold Regions Science and Technology

journal homepage: www.elsevier.com/locate/coldregions

Impact of snow and building management on ground surface temperatures in permafrost environments - A case study from the historical mining town Ny-Ålesund, Svalbard

Juditha Aga [a,*], Clarissa Willmes [a], Anatoly O. Sinitsyn [b], Thor Bjørn Arlov [c,d], Julia Boike [e,f], Sebastian Westermann [a,g]

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[b] SINTEF AS, Trondheim 7034, Norway
[c] University Centre in Svalbard (UNIS), Longyearbyen 9171, Norway
[d] Norwegian University of Science and Technology (NTNU), Trondheim 7491, Norway
[e] Alfred Wegener Institute (AWI), Helmholtz Centre for Polar and Marine Research, Potsdam 14473, Germany
[f] Geography Department, Humboldt-Universität zu Berlin, Berlin 12589, Germany
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ARTICLE INFO

Keywords:
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Snow
Infrastructure
Cultural Heritage
Svalbard

ABSTRACT

Permafrost is warming due to changing climatic conditions, a trend that might threaten infrastructure and livelihood across the Arctic. Historical structures are especially vulnerable, as they were not designed to withstand these rapid environmental changes. In the high-Arctic settlement Ny-Ålesund, Svalbard, a large number of historical buildings exist, making the village a suitable case study for investigating the interplay between historical buildings and permafrost. This study analysed two years of ground surface temperature (GST) measurements and snow observations to assess the impact of snow and building management on permafrost conditions in Ny-Ålesund. The mean annual ground surface temperature (MAGST) was found between −1.9 °C and 1.9 °C in 2022/23, and between −3.1 °C and 1.1 °C in 2023/24. The results reveal that GST varied substantially within the village area and exceeded the freezing point in several locations. We identified influencing factors contributing to these differences in GST: (i) Snow redistribution by wind and snow ploughing caused large variations in GST with the highest MAGST beneath artificial snow deposits. (ii) Building type, particularly crawl space ventilation, also affected GST. Ventilated crawl spaces tended to lower the MAGST beneath the buildings, while enclosed crawl spaces increased MAGST to positive values. (iii) Building wall orientation further influenced GST, with southern exposures exhibiting higher values compared to northern exposures. Our findings highlight the importance of snow and building management on GST and permafrost stability. Understanding these small scale effects is crucial for the preservation of historical infrastructure on permafrost under changing climatic conditions.

1. Introduction

Permafrost environments are undergoing rapid changes due to climatic warming, which are documented in rising permafrost temperatures and a thickening of the active layer (Smith et al., 2022). On a global scale, permafrost temperatures increased by 0.29 ± 0.12°C between 2007 and 2016 (Biskaborn et al., 2019), and this trend is projected to continue in future (Smith et al., 2022). With permafrost influencing 11 % of the global land surface and 15 % of the terrestrial Northern Hemisphere (Obu et al., 2019; Obu, 2021), these changes have widespread implications, particularly for Arctic and sub-Arctic communities reliant on permafrost-stable infrastructure (Hjort et al., 2022).

Warming and thawing permafrost can pose a risk to human infrastructure by reducing soil strength (Andersland and Ladanyi, 2003) causing geotechnical instabilities, such as thaw settlement, frost heave, and frost jacking of piles (Esch and Osterkamp, 1990; Liu et al., 2020; Hjort et al., 2022). In addition, slope processes such as the development and expansion of thaw slumps, slope creeping, and other mass

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E-mail address: juditha.aga@geo.uio.no (J. Aga).

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Available online 25 April 2025

Preprint

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https://doi.org/10.5194/egusphere-2025-2099

Abstract | Discussion | Metrics

27 May 2025

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- Metadata XML
- BibTeX
- EndNote

Short summary
Rain-on-snow (ROS) events are becoming a common feature in winter in Svalbard due to climate...
Read more

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Status: this preprint is open for discussion and under review for The Cryosphere (TC).

Recent and future changes in rain-on-snow event characteristics across Svalbard

Hannah Vickers, Priscilla Mooney, and Oskar Landgren

Abstract. Rain-on-snow (ROS) events in Svalbard are becoming a more frequent occurrence during the winter season due to rapid climate warming across the Arctic in recent decades. ROS events have gained increasing attention in recent decades due to their cascading impacts on the physical environment, and terrestrial and marine ecosystems that are impacted by snowmelt. While the frequency of ROS events in Svalbard has been well studied and documented, other characteristics of ROS, such as their duration, intensity and seasonal timing have received less attention. Such characteristics are equally important to quantify due to their potential consequences for the winter snowpack and snow-dependent ecosystems. This study addresses this knowledge gap using the Copernicus Arctic Regional Reanalysis (CARRA) for the present day analysis and km-scale climate projections from a regional climate model for the future period of 2030–2070 under the high emissions scenario SSP5-8.5. For the present climate, the results show significant and increasing trends in all characteristics but confined mainly to low-lying areas of Nordaustlandet and some areas in the east of the archipelago, while no statistically significant trend was found in the southern and western areas which typically exhibit the largest values in all characteristics. Analysis of the future projections showed that the largest changes relative to present day conditions in all ROS characteristics will take place over the mountainous and glaciated areas in the north and northeast of the archipelago, while some low lying western coastal areas will experience a decrease. This reduction is expected to be the result of fewer days with snow, shortening the season where rain can fall on an existing snow cover. Moreover, while ROS has increased most in November and February, the future climate simulation features a substantial increase in ROS events in April, which experiences very few, if any, ROS events in the present climate, which may lead to considerable changes in snow hydrology. Further work could include analysing an ensemble of climate projections for Svalbard to produce a range of ROS scenarios, as well as carrying out a more in-depth analysis of the hydrological impacts associated with the changes in ROS characteristics identified here.

How to cite. Vickers, H., Mooney, P., and Landgren, O.: Recent and future changes in rain-on-snow event characteristics across Svalbard, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-2099, 2025.

Received: 06 May 2025 – Discussion started: 27 May 2025

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PCCH-Arctic Reports

Report Nr. 1. Case study objects in PCCH-Arctic

Report Nr. 2. Risk Analysis of the Impact of Natural Hazards on Cultural Heritage

Report Nr. 3. Ground Thermal Simulation and Probabilistic Pile Capacity Analysis in Permafrost

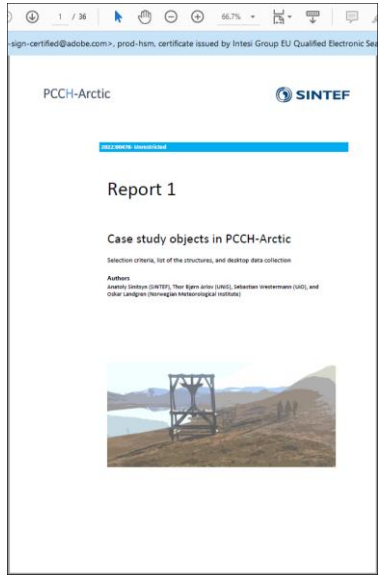
Report Nr. 4. Climate Change Impacts on Foundation Settlements of Selected Cultural Heritage Structures

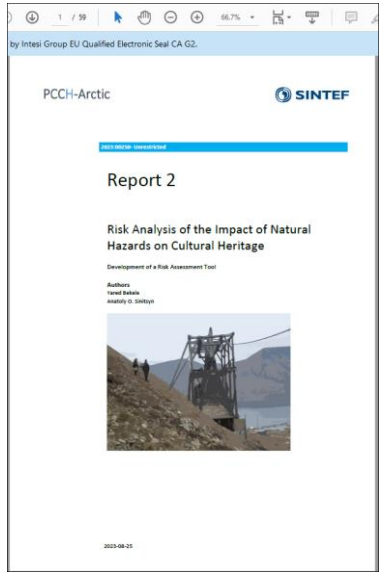
Report Nr. 5. Permafrost simulations for Adventdalen and Ny-Ålesund

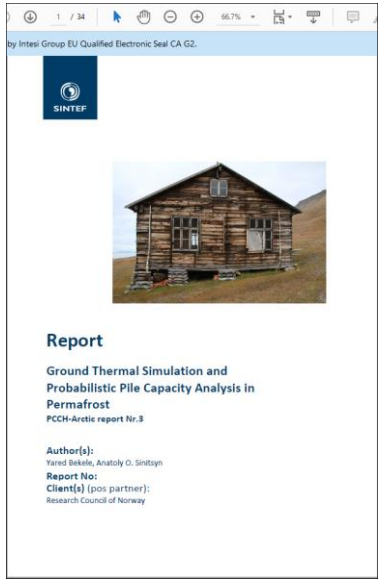
Report Nr. 6. Input in managing strategies

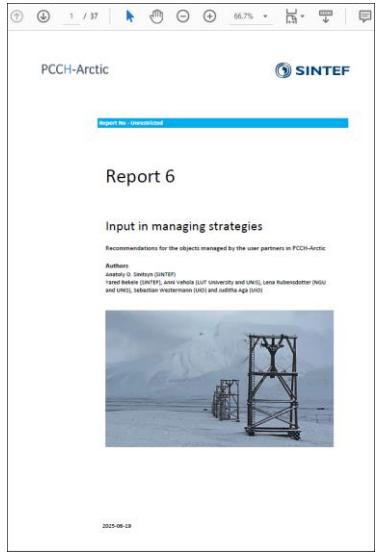
Report Nr. 7. 2.5 km future climate projections for Svalbard under the high emission scenario SSP5-8.5

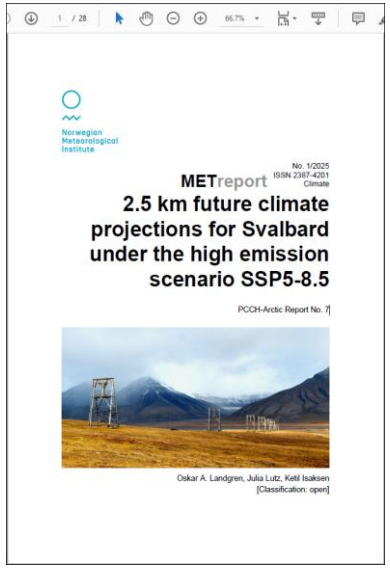
Recommendations for management of built cultural heritage in Polar climate











Software and digital tools

- Excel Tool for risk analysis of natural hazards:
  - Longyearbyen
  - Ny-Ålesund
- PCCH-Arctic ArcGIS Online map: https://unis78.maps.arcgis.com/apps/mapviewer/index.html?webmap=d66b707367874907bf5bb2c7ec9af4ff