Update PCCH-WP3

WP3 – Climate change and permafrost degradation

Juditha Aga & Sebastian Westermann (UiO)

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

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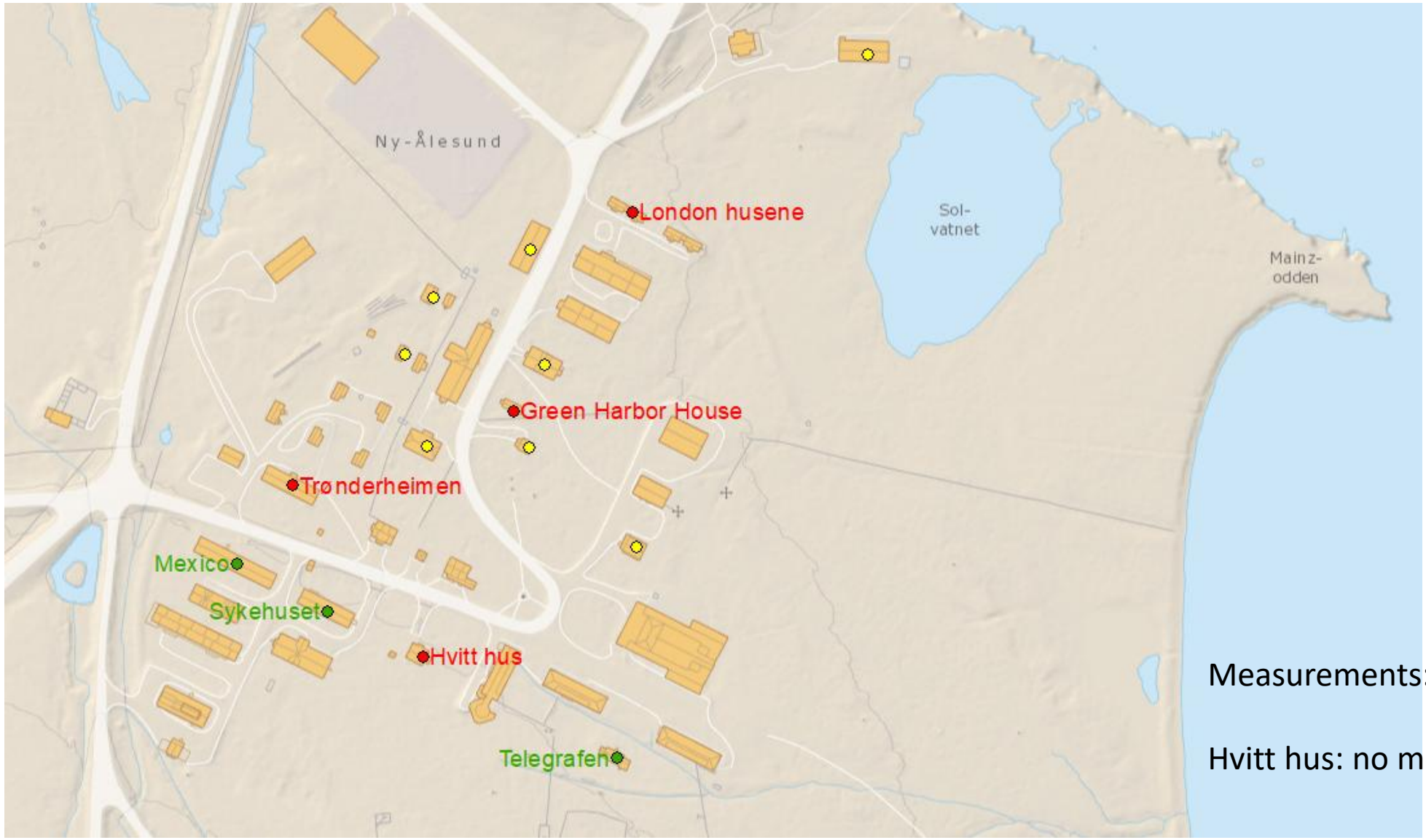
ABSTRACT

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.

Installation of temperature loggers



Measurements: Sep 2022 – Sep 2024

Hvitt hus: no measurements 2023/2024

Results of temperature loggers

Example: Sykehuset (heated) – Sep 2022 - Sep 2024

PCCH-Arctic

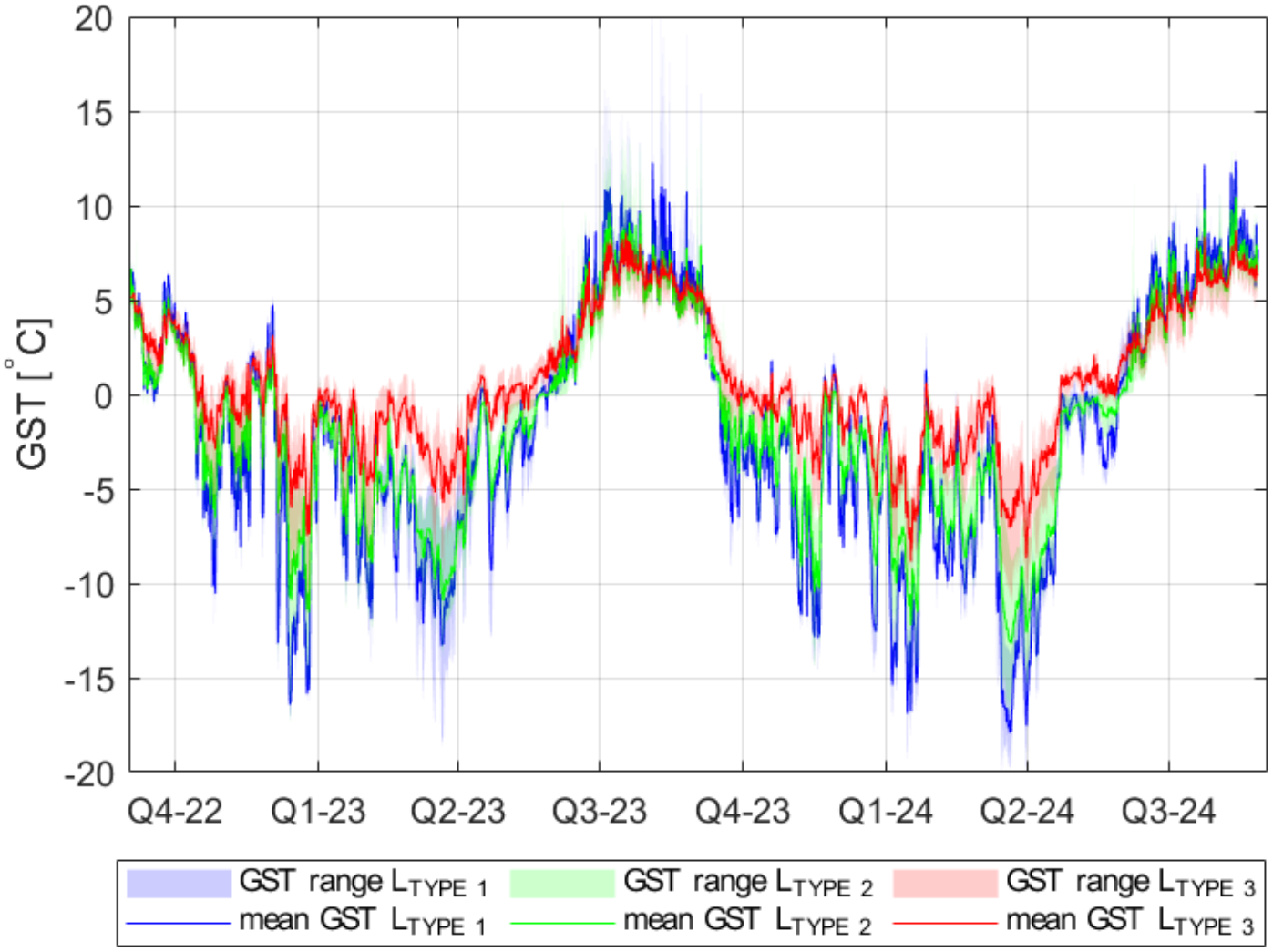
Results of temperature loggers

Effects:

- Higher temperatures beneath heated buildings with no air circulation

	2022/23	2023/24
Open:	-1.3˚C	-2.8˚C
Closed, not heated:	-0.9˚C	-2.0˚C
Closed, heated:	0.9˚C	0.2˚C

Results of temperature loggers



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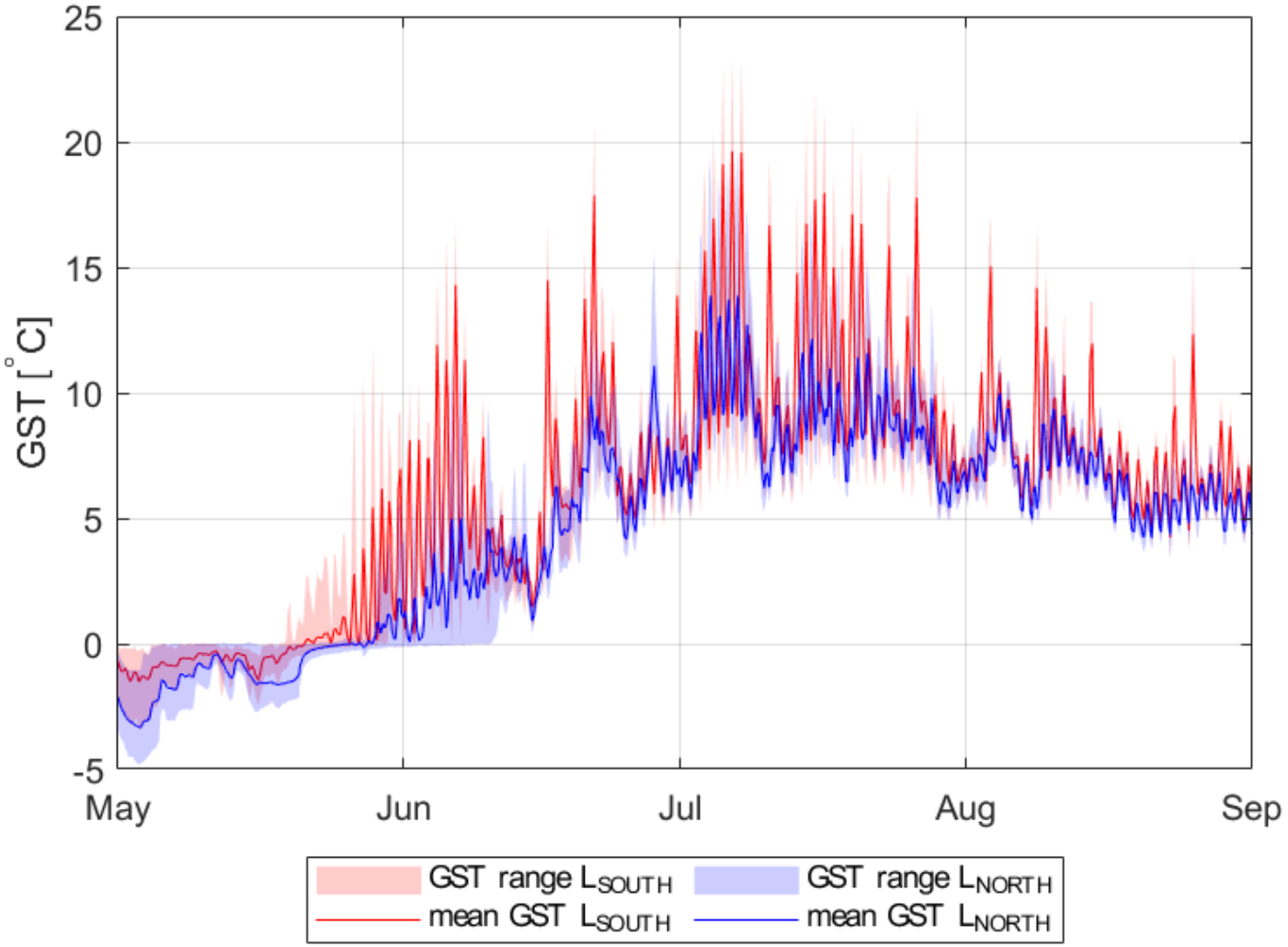
- Higher temperatures at the south side of the buildings

	2022/23	2023/24
North side:	-0.5˚C	-1.5˚C
South side:	0.6˚C	1.1˚C

Results of temperature loggers



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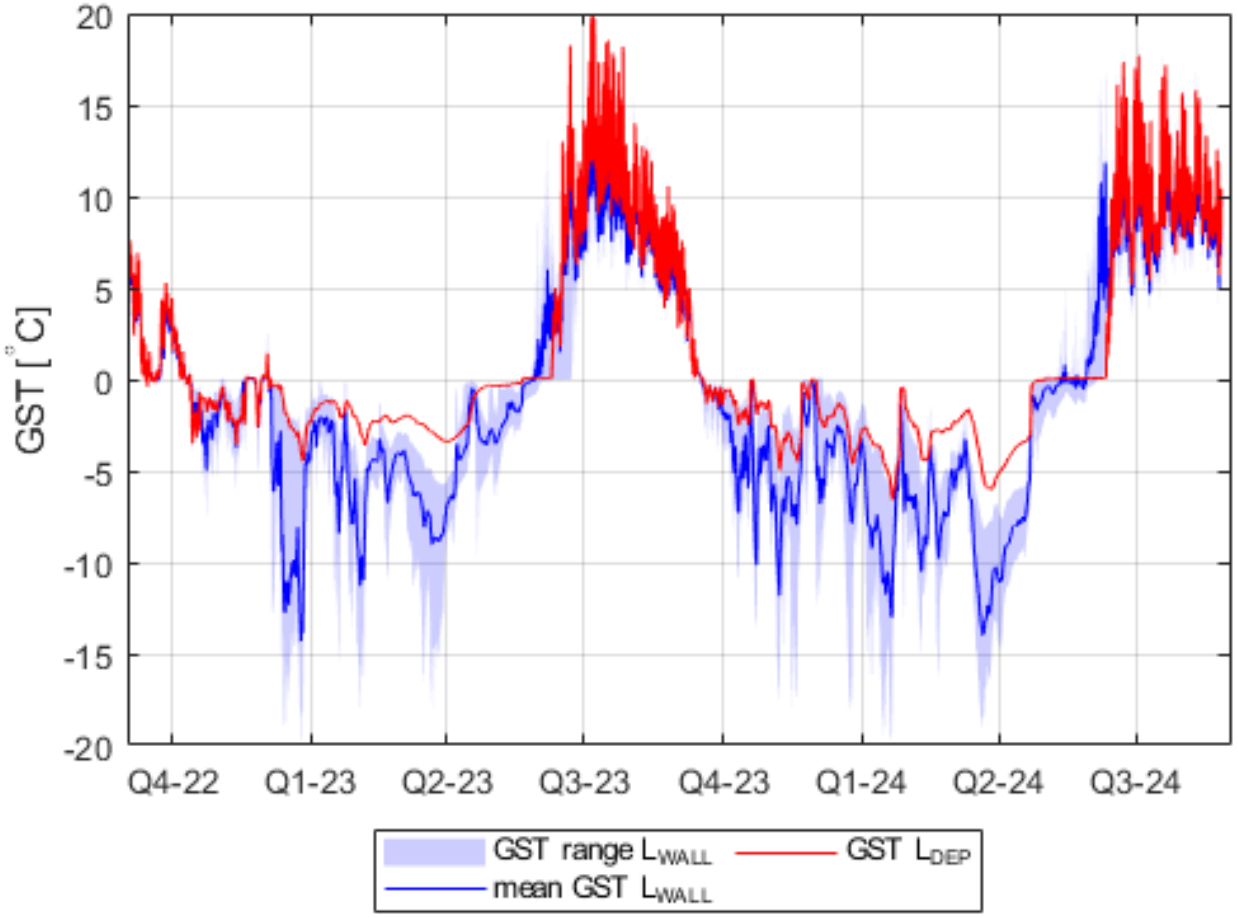
- Higher temperatures below (artificial) snow deposits

	2022/23	2023/24
“Normal” snow:	-0.5˚C	-1.6˚C
Artificial deposit:	1.4˚C	0.5˚C

Results of temperature loggers



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“Normal” snow:	-0.5˚C	-1.6˚C
Artificial deposit:	1.4˚C	0.5˚C

Results of temperature loggers

Effects:

- Higher temperatures beneath heated buildings with no air circulation
- Higher temperatur… …outh side of the buildin…
- Higher temperatures below (artificial) snow deposits

Values highly dependent on the conditions of each year!

	2022/23	2023/24
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PCCH-Arctic – Polar Climate and Cultural Heritage
WP3 – Climate change and permafrost degradation

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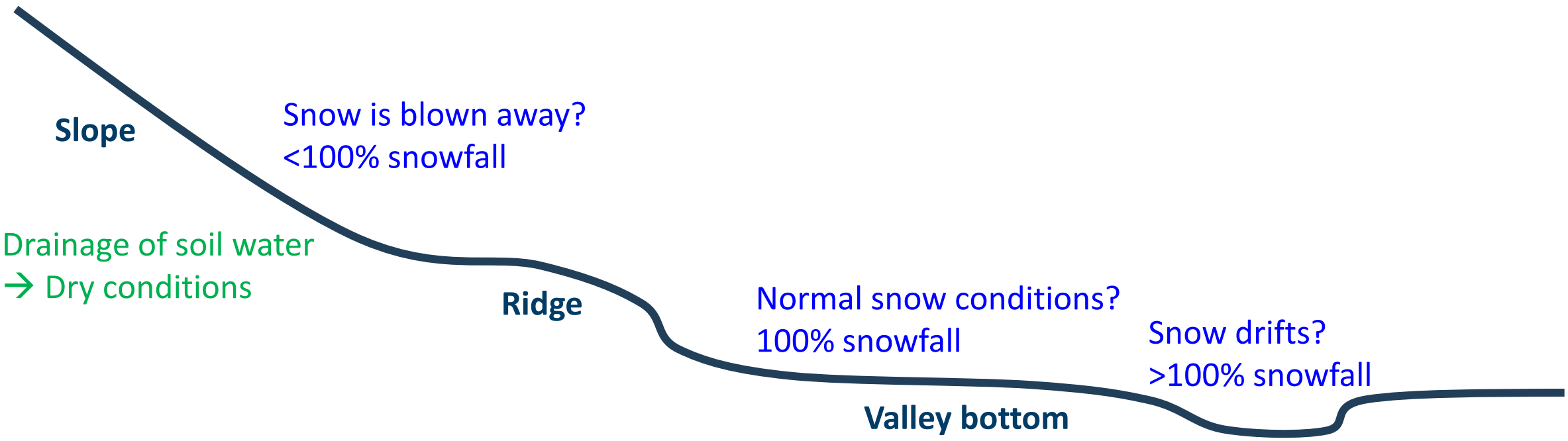
2. Permafrost simulations for Adventdalen and Ny-Ålesund

Permafrost simulations for Adventdalen

→ Different model setups necessary

Permafrost simulations for Adventdalen



Different permafrost conditions

- Different snow conditions
- Different drainage

Simulation with combination of drainage and snow conditions

→ Which run fits best for which taubanebukk?

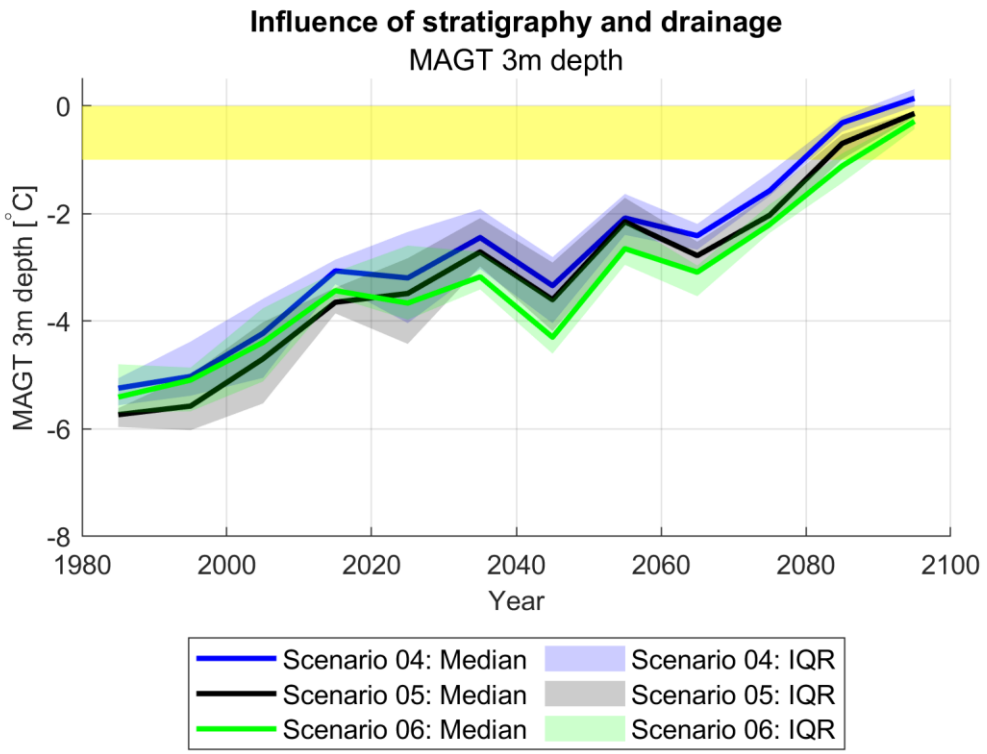
Permafrost simulations for Adventdalen

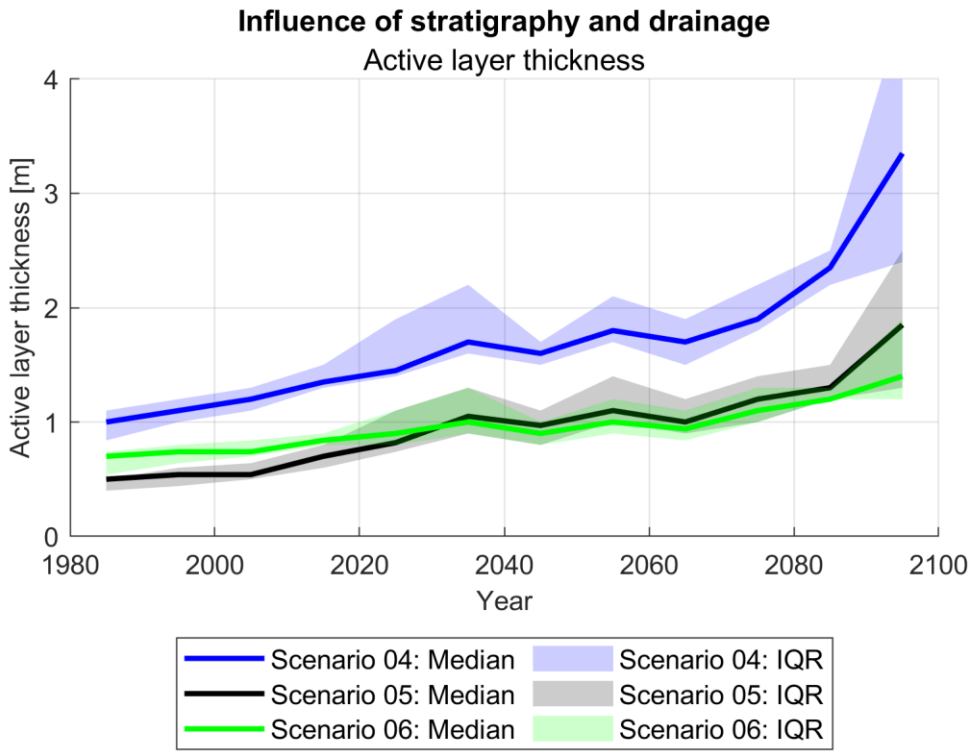
Snow / Stratigraphy	20%	50%	100%	150%
Drainage → dry	Run01	Run02	Run03	Run04
Normal	Run05	Run06	Run07	Run08
No drainage → wet	Run09	Run10	Run11	Run12

Permafrost simulations for Adventdalen

Snow / Stratigraphy	20%	50%	100%	150%
Drainage → dry	Run01	Run02	Run03	Run04
Normal	Run05	Run06	Run07	Run08
No drainage → wet	Run09	Run10	Run11	Run12

Permafrost simulations for Adventdalen



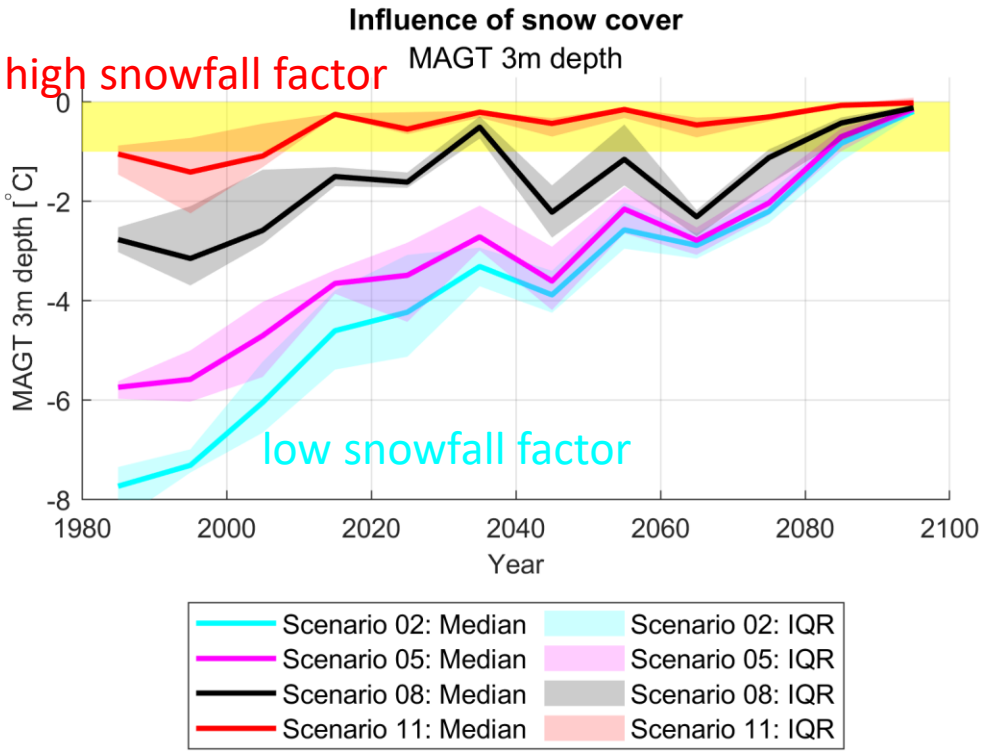


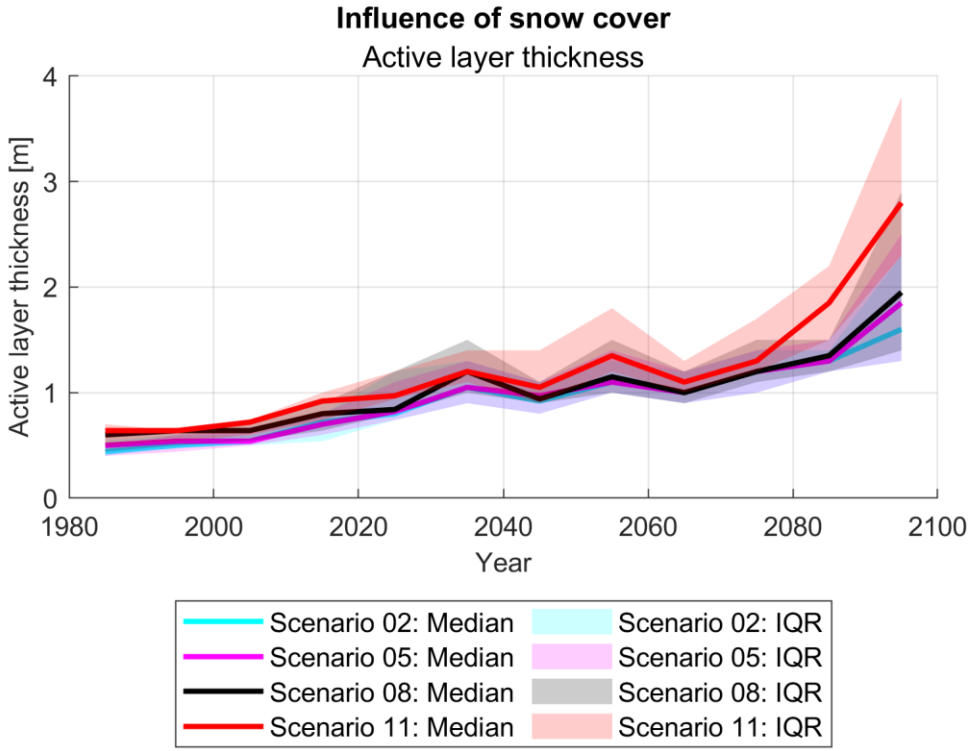
- MAGT and ALT are increasing
- MAGT: Little influence of the soil stratigraphy
- ALT: Highest ALT in well drained, blocky soils; lowest ALT for wet soils with an organic layer

Permafrost simulations for Adventdalen

Stratigraphy \ Snow	20%	50%	100%	150%
Drainage → dry	Run01	Run02	Run03	Run04
Normal	Run05	Run06	Run07	Run08
No drainage → wet	Run09	Run10	Run11	Run12

Permafrost simulations for Adventdalen



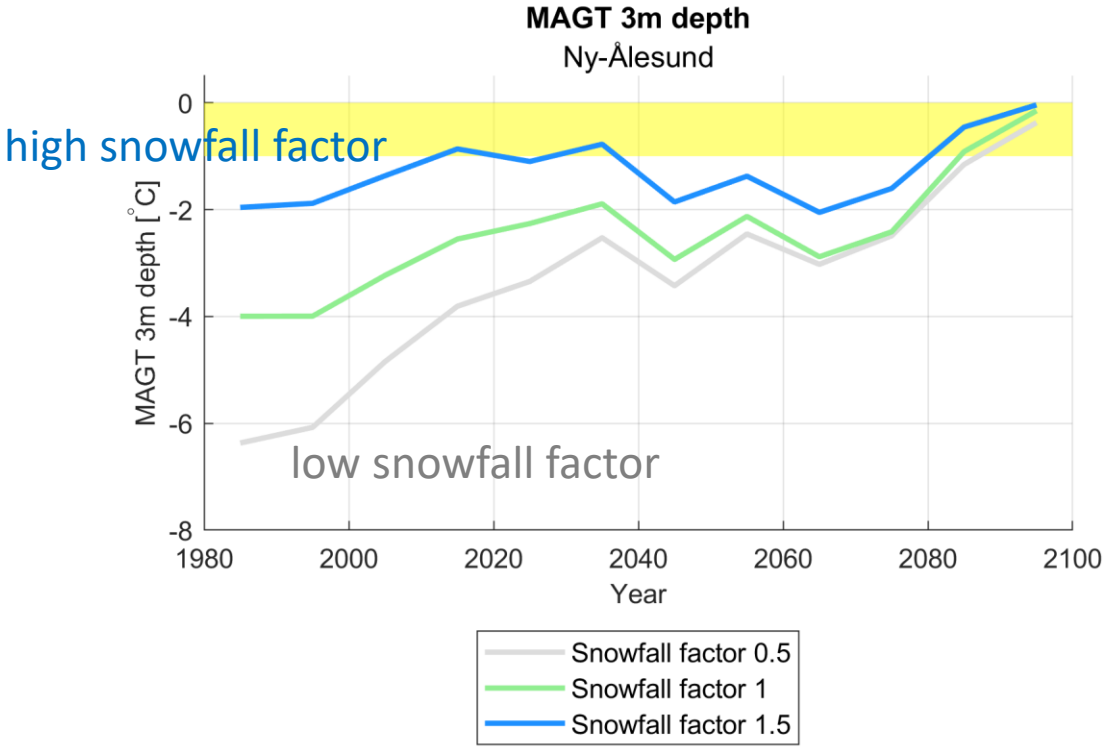


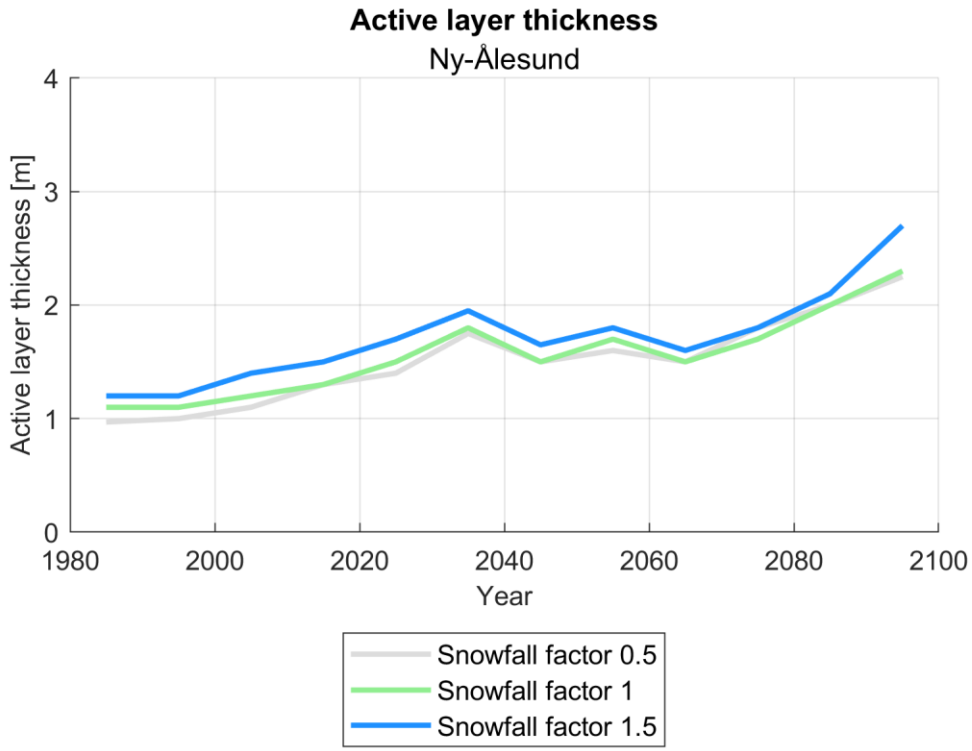
- MAGT and ALT are increasing
- ALT: Little influence of the snow cover
- MAGT: highest MAGT with high snowfall, lowest MAGT with little snowfall;
  scenarios converge towards the end of the century

Permafrost simulations for Ny-Ålesund

Snow / Stratigraphy	50%	100%	150%
Normal	Run13	Run14	Run15

Permafrost simulations for Ny-Ålesund





- MAGT and ALT are increasing
- Slight cooling from the 2040s to 2060s
- ALT: Little influence of the snow cover
- MAGT: highest MAGT with high snowfall, lowest MAGT with little snowfall; scenarios converge towards the end of the century

Summary

- Temperature loggers in Ny-Ålesund show the effect of the buildings
  - Data available for 2022-2024
  - Higher temperatures beneath heated buildings with no air circulation
  - Higher temperatures beneath thick snow deposits
  - Data published in Cold Regions Science and Technology

- Simulations for Adventdalen and Ny-Ålesund
  - Set of simulations available to represent different settings for Adventdalen and Ny-Ålesund
  - Influence of varying soil parameters and snow conditions is accounted for