Spatiotemporal variations of isotopes in snow and snowmelt in the subarctic setting at Pallas catchment, Finland

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Abstract

Due to the rise in global temperature, change in precipitation patterns is predicted particularly in Arctic regions. Such changes in patterns and modifications in typical snow to precipitation ratios will affect the snowpack thickness and the magnitude and timing of snowmelt. Stable water isotopes (δ^2H, δ^{18}O) are one of the latest tools in exploring and tracing such changes, however, snowpack isotope and particularly snowmelt isotope datasets are rarely available which hamper the high-resolution isotope based hydrological investigations in Arctic regions. In this study, we perform an investigation for evaluating spatiotemporal variations in stable isotopes of snowpack and snowmelt water.

Methods

Our Pallas research catchment is located in a subarctic setting in northern Finland. The measurements were made at 11 locations along a 2 km snow survey, which is established on the transect of the catchment, comprising of different landscape features: (i) forested hillslope, (ii) mixed forest and (iii) open mires. We sampled depth-integrated bulk snowpack isotopes and fixed 5 cm snow isotope stratigraphy profile in snowpits. For snowmelt sampling, we used a system of snowmelt lysimeter, deployed at 11 locations (shown in Fig 1). The bulk snow samples were collected biweekly, snowpit samples during the period of maximum snowcover thickness and during the start of peak melting, during the peak melting and after the peak melting. Snowmelt samples were collected at daily resolution during the melt season until the complete disappearance of snow with complementary measurements of snowmelt fluxes. The snow density and snow water equivalent were also measured.

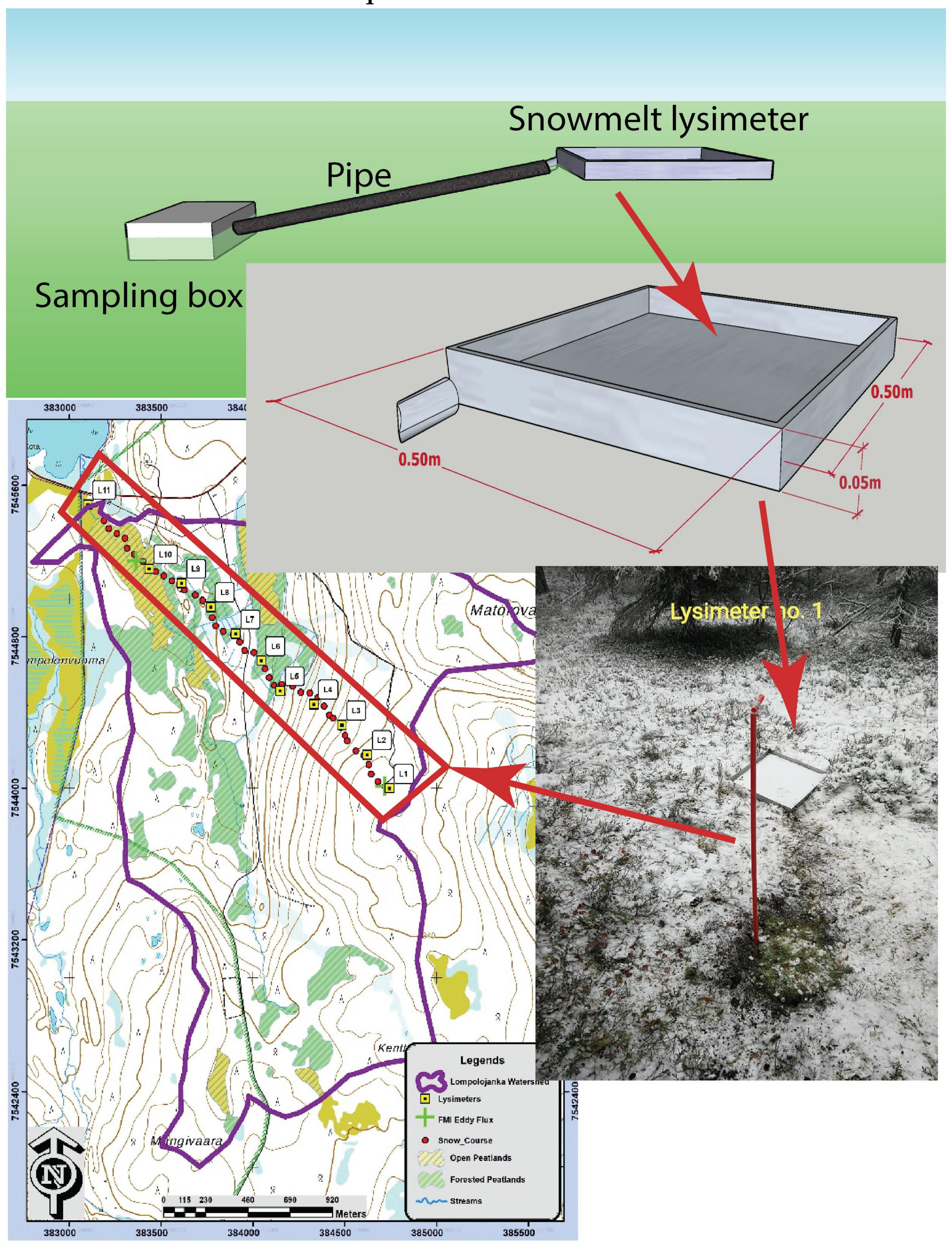

Fig 1. A snowmelt lysimeter system from a conceptual model and design to its installation in the catchment where it is deployed at 11 locations along the snow-survey transect

Results

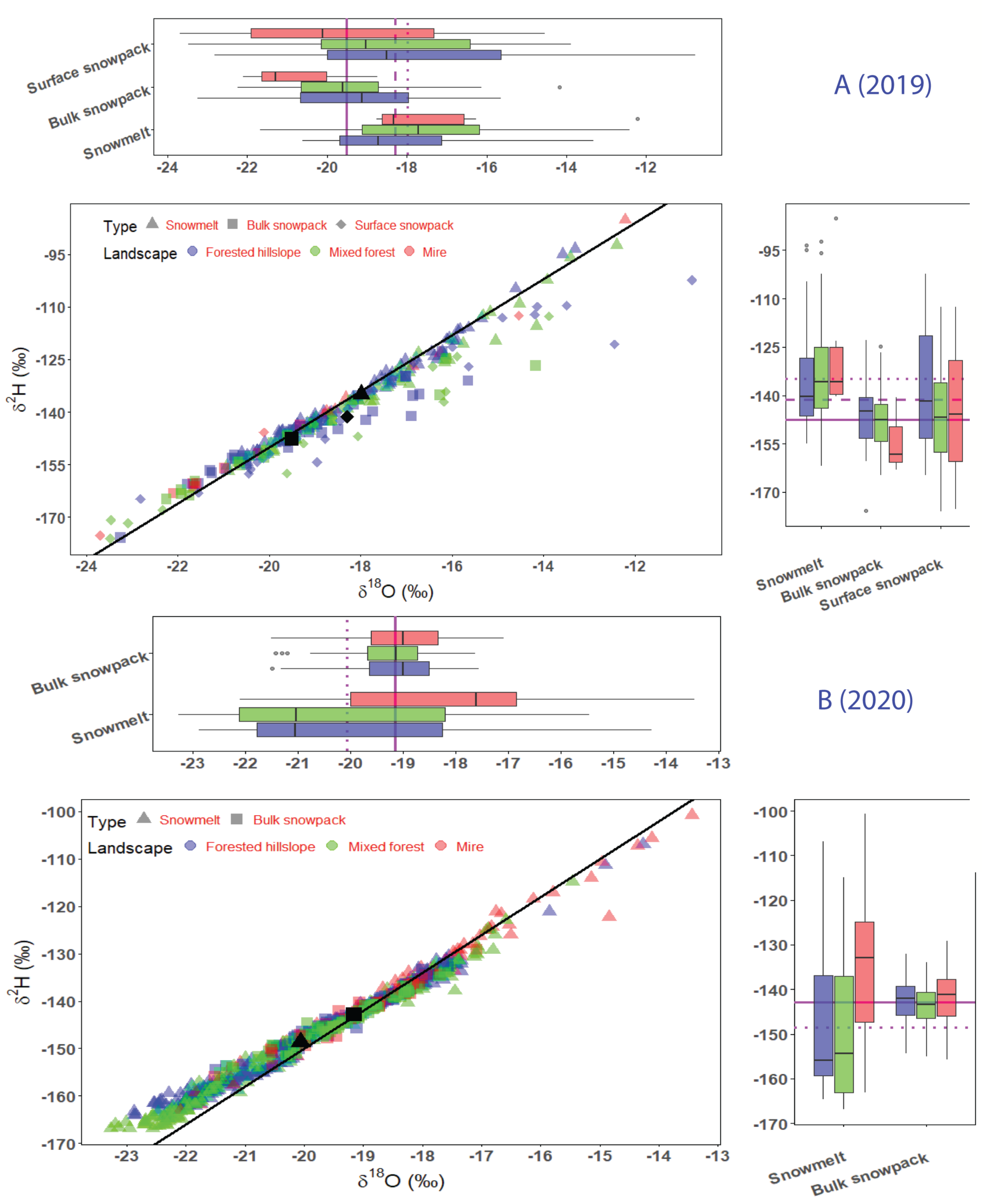

Fig 2. shows the dual stable water isotope and boxplots of (A) Surface snowpack, bulk snowpack and snowmelt for 2019 and (B) bulk snowpack and snowmelt for 2020

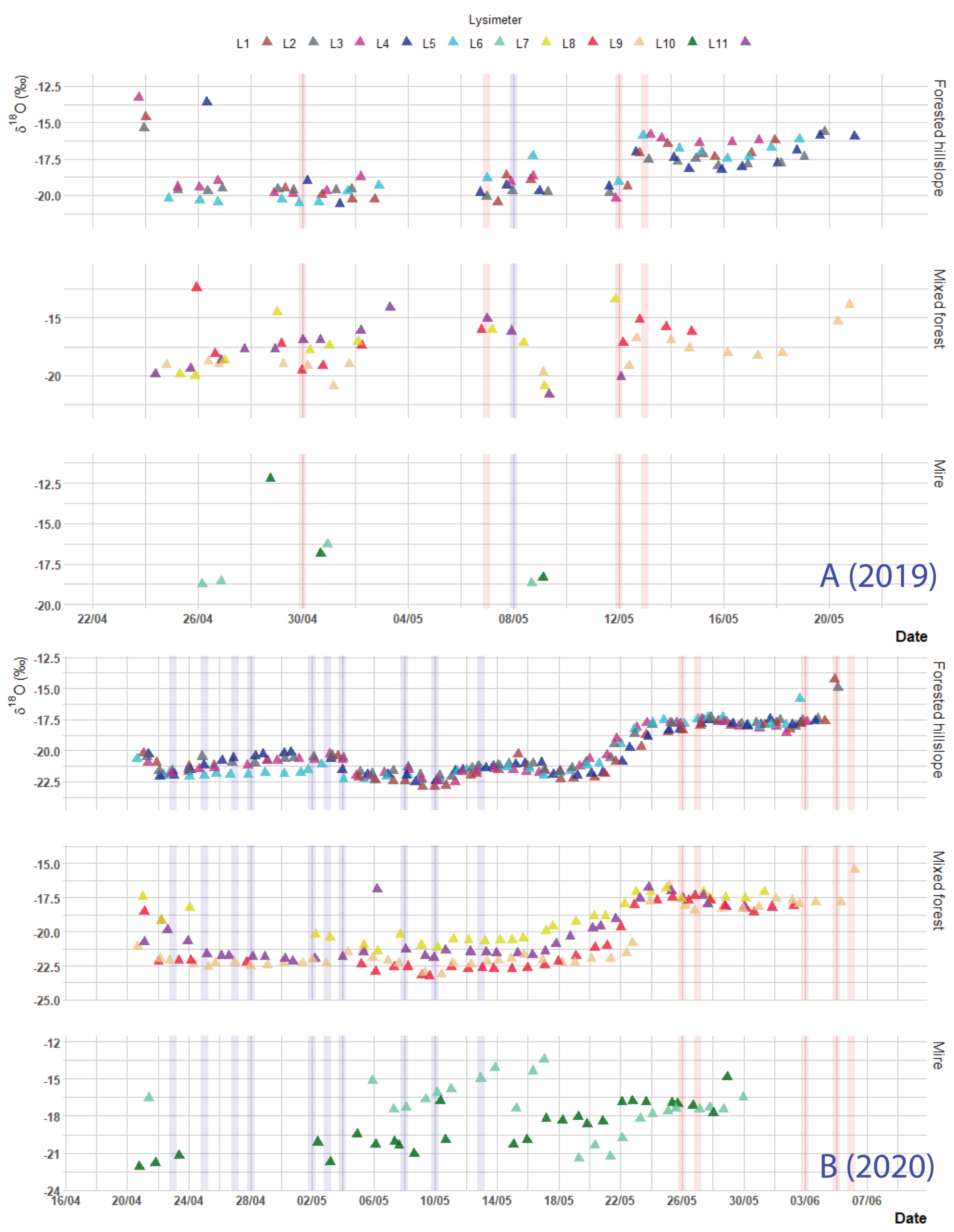

Fig 3. shows the temporal evolution of δ^{18}O isotope of snowmelt, where snowmelt lysimeter-based samples are grouped into three landscape fature types: (i) forested hillslope, (ii) mixed forest and (iii) open mires for the year (A) 2019 and (B) 2020

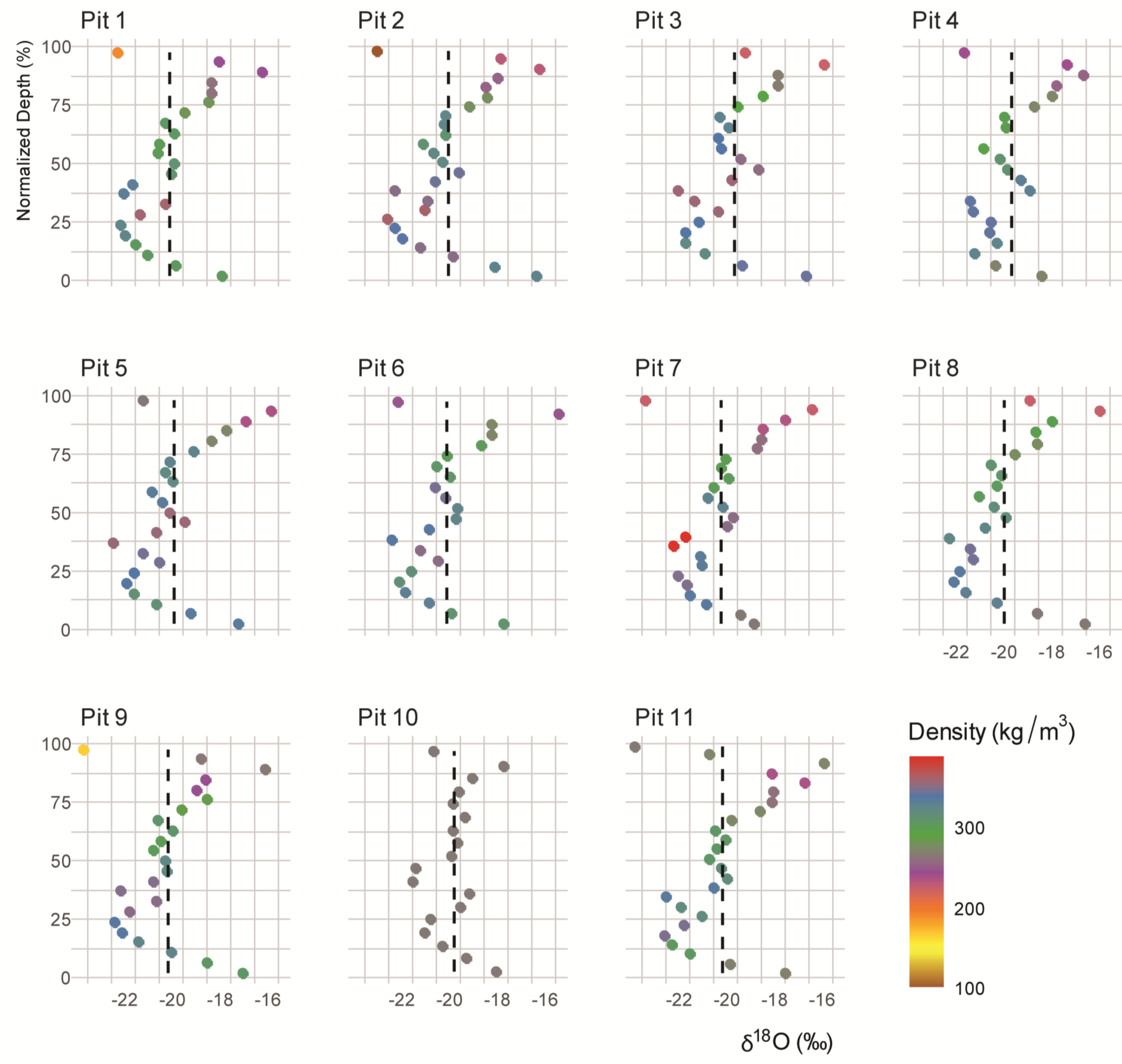

Fig 4. represents normalized fixed 5 cm snow stratigraphy δ^{18}O isotope profiles at 11 locations, where Pit 1-5, Pit 6 and 10 and Pit 7-9 were excavated on a forested hillslope, mixed forest and mires, respectively. Additionally, densities are represented by different colors, where gray color shows unavailability of densities. The mean values are represented by dashed black lines

Conclusions

- We present extensive stable water isotope datasets of the snowpack and snowmelt
- We observed different mean values of snowmelt isotopes relative to the bulk snowpack and surface snowpack isotopes
- Snowmelt isotope values vary more than the bulk snowpack isotope values
- Snowmelt isotopes can be relatively more depleted than the bulk snowpack isotopes before peak melting and after peak melting, the snowmelt isotopes can be relatively more enriched
- The snowmelt isotopes show that the isotopes are initially depleted in heavier isotopes but with the progress of melting, they start to become enriched
- The snow isotope profiles show that the isotopes at the snow-air and snow-ground interfaces are enriched in heavy isotopes as compared to the middle of the snowpack
- Our unique high-resolution datasets of snow and snowmelt isotopes can be used in many applications; such as for evaluating post-depositional modification of isotope signal in the seasonal snowpack, developing tracer-aided mass and energy based snow models
- The establishment of snowmelt isotope dataset, showing spatiotemporal variability of snowmelt isotopes, is an important step forward in tracer based plant-water uptake studies and hydrological analyses in snow-influenced catchments.

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Science with Arctic Attitude