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Microbial cell retention in a melting High Arctic snowpack, Svalbard

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Introduction
The melting snow pack represents a highly dynamic system not only for chemical compounds but also for bacterial cells. Microbial activity was found at subzero temperatures in ice veins when liquid water persists due to high concentration of ions on the surface of snow crystals and brine channels between large ice crystals in ice. Several observations also suggest microbial activity under subzero temperatures in seasonal snow.
Even with regard to the spatial and temporal relevance of snow ecosystems, microbial activity in such an extreme habitat represents a relatively small proportion in the carbon flux of the global ecosystem and even of the glacial ecosystems specifically. On the other hand, it represents a remarkable piece of mosaic of the microbial activity in glacial ecosystems because the snow pack represents the first contact between the atmosphere and cryosphere. This topic also embodies vital crossovers to biogeochemistry and ecotoxicology, offering a quantitative view of utilization of various substrates relevant for downstream ecosystems.
Here we present our study of the dynamics of both solvents and cells suspended in meltwater of the melting snowpack on a high arctic glacier to demonstrate the spatio-temporal constraint of interaction between solvent and bacterial cells in this environment.

Method
We used 6 lysimeters inserted into the bottom of the snowpack to collect replicated samples of melt water before it comes into contact with basal ice or slush layer at the base of the snow pack. The sampling site was chosen at Midre Lovénbreen (Svalbard, Kongsfjorden, MLB stake 6) where the snow pack showed melting on the surface but the basal ice was still dry. Sampling was conducted in June 2010 for a period of 10 days once per day and the snow profile was sampled according to distinguished layers in the profile at the beginning of the field mission and as bulk at its end. The height of snow above the lysimeters dropped from the initial 74 cm to the final 38 cm. The major ion composition (IC), pH, conductivity and cell abundances were measured.

Results and conlusions
The removal of microbial cells from a high arctic snowpack resembles an elution sequence similar to that of hydrophobic compounds a process that helps glaciers retain a microbial biomass upon their surface, even after the demise of the snow cover. The snowpack and the glacier surface therefore act as an accumulator of cells during the melt season.
This suggests that wet snowpacks, even on the surface of high arctic glaciers, are likely to be dynamic ecosystems in their own right. In our study, a clear ion elution sequence was observed that resembled earlier reports and caused high concentrations of ions in snowpack runoff at the start of the snow melt, which rapidly decreased as snow melt proceeded. Chloride, sulfate, nitrate, sodium and potassium experienced a 50 % elution before 20 – 25 % of the snowpack water content was lost. By contrast, cell removal only reached the 50 % level after ∼70 % snowpack depletion.
In contrast to our expectations, the calculated cell budget between the initial and final snowpack (including the cell loss by elution), revealed a significant increase of the total cell numbers, i.e. more than twice the original number. Assuming aeolian deposition processes to be low, this suggests cell proliferation as a contribution to the observed "retention effect".
Precipitation was the major cell contributor to the snowpack upon Midtre Lovénbreen. An overall low cell concentration was therefore found within the snowpack stratigraphy, where snow layers frequently showed cell abundances similar to those of cloud water. This was in contrast to the nearby and more wind exposed sites examined in the Kongsfjorden area in 2007. However, layers of higher dust deposition were concomitant with one order of magnitude higher cell abundances, indicating that wind dispersal from locally exposed rocks supplements

the atmospheric cell input.