# Cryogenic soil processes in a changing climate

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## Akademisk avhandling

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**Abstract**
A considerable part of the global pool of terrestrial carbon is stored in high latitude soils. In these soils, repeated cycles of freezing and thawing creates soil motion (cryoturbation) that in combination with other cryogenic disturbance processes may play a profound role in controlling the carbon balance of the arctic soil. Conditions for cryogenic soil processes are predicted to dramatically change in response to the ongoing climate warming, but little is known how these changes may affect the ability of arctic soils to accumulate carbon. In this thesis, I utilize a patterned ground system, referred to as non-sorted circles, as experimental units and quantify how cryogenic soil processes affect plant communities and carbon fluxes in arctic soils. I show that the cryoturbation has been an important mechanism for transporting carbon downwards in the studied soil over the last millennia. Interestingly, burial of organic material by cryoturbation appears to have mainly occurred during bioclimatic events occurring around A.D. 900-1250 and A.D. 1650-1950 as indicated by inferred $^{14}C$ ages. Using a novel photogrammetric approach, I estimate that about 0.2-0.8 % of the carbon pool is annually subjected to a net downward transport induced by the physical motion of soil. Even though this flux seems small, it suggests that cryoturbation is an important transporter of carbon over centennial and millennial timescales and contributes to translocate organic matter to deeper soil layers where respiration proceeds at slow rates. Cryogenic processes not only affect the trajectories of the soil carbon, but also generate plant community changes in both species composition and abundance, as indicated by a conducted plant survey on non-sorted circles subjected to variable differential frost heave during the winter. Here, disturbance-tolerant plant species, such as *Carex capillaris* and *Tofieldia pusilla*, seem to be favoured by disturbance generated by the differential heave. Comparison with findings from a previous plant survey on the site conducted in the 1980s suggest that the warmer temperatures during the last decades have resulted in decreased differential heave in the studied non-sorted circles. I argue that this change in cryogenic activity has increased abundance of plants present in the 1980s. The fact that the activity and function of the non-sorted circles in Abisko are undergoing changes is further supported by their contemporary carbon dioxide ($CO_2$) fluxes. Here, my measurements of $CO_2$ fluxes suggest that all studied non-sorted circles act as net $CO_2$ sources and thus that the carbon balance of the soils are in a transition state. My results highlight the complex but important relationship between cryogenic soil processes and the carbon balance of arctic soils.

**Keywords**
cryoturbation, non-sorted circles, patterned ground, carbon sequestration, GIS, plant communities, photogrammetry

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