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Centrifuge modelling of solifluction process for permafrost and non-permafrost areas

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Under one-sided freezing in seasonally frozen ground, the process of solifluction includes (a) near-surface needle-ice creep, (b) frost creep due to heaving normal to the ground surface and thawing parallel to gravitational force and (c) gelifluction, related to the excess of meltwater under thawing reducing internal friction and cohesion in the soil. Under two-sided freezing in the active layer of cold permafrost regions, ice lenses are generated at the active layer base, which on thawing induce additional plug-like displacement of the active layer over the permafrost table.

Solifluction processes associated with one-sided freezing were simulated at reduced scale under a 10g gravitational field in the Cardiff University Geotechnical Centrifuge Laboratory. The 10 cm thick and 12˚ steep silty soil model was frozen under 1 g, and with an open water system through a basal sand layer allowing ice segregation in the soil layer. In the two-sided freezing model, a cold permafrost table was simulated by a basal cooling system using vortex tubes to allow for active layer freezing from the permafrost table upwards and from the ground surface downwards. Pore pressure and temperature profiles were measured with miniature pore pressure transducers and thermocouples, respectively, and heave-thaw settlement was monitored using LVDT's and laser technology. Soil creep velocity-profiles were determined by the deformation of originally straight columns. The slope surface deformation based on a grid of markers at the soil surface was monitored during thawing with an automatic camera. Here we present first results of centrifuge experiments comparing the solifluction process under two-sided and one-sided freezing conditions. Results are compared to ongoing field measurements from Dovrefjell, Norway and Svalbard and full-scale laboratory experiments in the CNRS Cold Laboratories, Caen, France.