# Collapse of a frozen wet granular column due to thawing

Nicolas Ramirez Ramirez*[1,2], Mattèo Fournier[1], Wladimir Sarlin[1,2], Maria Veronica D'angelo[1,3], Axel Huerre[2], and Thomas Séon[1]

[1]Institut Franco-Argentin de Dynamique des Fluides pour l'Environnement (IFADyFE) – Centre National de la Recherche Scientifique - CNRS, Consejo Nacional de Investigaciones Científicas y Técnicas [Buenos Aires], Universidad de Buenos Aires [Buenos Aires] – France

[2]Matière et Systèmes Complexes – Centre National de la Recherche Scientifique, Université Paris Cité – France

[3]Grupo de Medios Porosos [Buenos Aires] – Argentine

**Résumé**

The degradation of permafrost driven by rising global temperatures leads to a variety of ground instabilities, including landslides, surface subsidence, ground cracking, and slope failures. These processes involve the loss of mechanical stability of frozen cohesive soils during thawing. In this work, we investigate the stability of frozen wet granular columns as a controlled laboratory model to study such thaw-induced instabilities.

Cylindrical columns composed of glass beads and water in the pendular state (few percent of liquid mass) are frozen and subsequently allowed to thaw under controlled thermal conditions. We systematically varied the initial geometry (height, H, and radius, R, of the column), grain size, and water content to identify the conditions governing the transition between stability and collapse.

We observe the existence of three stability regimes, identified in the H–R phase diagram.
For small radii, a constant regime is found, in which the critical stability height is independent of the column radius, suggesting that stability might be controlled by local grain-scale interactions, with cohesion dominating over global geometry.
At intermediate radii, a linear regime emerges, where the critical height increases linearly with the column radius. This behavior indicates that, although the cohesive strength of the material is finite, increasing the column radius increases the number of grains at the base that share the load, allowing a proportionally taller structure to be supported.
For larger radii finally, a second constant regime appears, in which the critical height no longer depends on the column radius, suggesting the existence of a limit to the effective cohesive support that can be mobilized in the system.
These results reveal a complex interplay between geometry, cohesion, and system size in thaw-induced granular instability. They provide a robust experimental basis for future theoretical and modeling efforts aimed at describing stability transitions in frozen granular materials.

*Intervenant