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Analogue modelling of the influence of ice shelf collapse on the flow of ice sheets grounded below sea-level

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The sudden breakup of ice shelves is expected to result in significant acceleration of inland glaciers, a process related to the removal of the buttressing effect exerted by the ice shelf on the tributary glaciers. This effect has been tested in previous analogue models, which however applied to ice sheets grounded above sea level (e.g., East Antarctic Ice Sheet; Antarctic Peninsula and the Larsen Ice Shelf).
In this work we expand these previous results by performing small-scale laboratory models that analyse the influence of ice shelf collapse on the flow of ice streams draining an ice sheet grounded below sea level (e.g., the West Antarctic Ice Sheet). The analogue models, with dimensions (width, length, thickness) of 120x70x1.5cm were performed at the Tectonic Modelling Laboratory of CNR-IGG of Florence, Italy, by using Polydimethilsyloxane (PDMS) as analogue for the flowing ice. This transparent, Newtonian silicone has been shown to well approximate the rheology of natural ice. The silicone was allowed to flow into a water reservoir simulating natural conditions in which ice streams flow into the sea, terminating in extensive ice shelves which act as a buttress for their glaciers and slow their flow. The geometric scaling ratio was 10(-5), such that 1cm in the models simulated 1km in nature; velocity of PDMS (a few mm per hour) simulated natural velocities of 100-1000 m/year. Instability of glacier flow was induced by manually removing a basal silicone platform (floating on water) exerting backstresses to the flowing analogue glacier: the simple set-up adopted in the experiments isolates the effect of the removal of the buttressing effect that the floating platform exerts on the flowing glaciers, thus offering insights into the influence of this parameter on the flow perturbations resulting from a collapse event.
The experimental results showed a significant increase in glacier velocity close to its outlet following ice shelf breakup, a process similar to what observed in previous models. This transient effect did not significantly propagate upstream towards the inner parts of ice sheet, and rapidly decayed with time. The process was also accompanied by significant ice thinning.
Models results suggest that the ice sheet is almost unaffected by flow perturbations induced by ice shelf collapse, unless other processes (e.g., grounding line instability induced by warm water penetration) are involved.