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## Experimental debris flows and rock avalanches under different gravities – To the Moon and Mars in an airplane

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On Earth, hillslope processes are typically driven by gravity and lubricated by liquid water. The slope angle, availability of water, and material composition ultimately determine the type of mass-movement, the flow dynamics, and the morphology of the resulting depositional landforms. Therefore, terrestrial hillslope landforms have served as our guide in the interpretation of hillslope landforms and their formation processes on other planetary bodies (e.g. the Moon, Mars). However, pioneering work has shown that gravity has a significant effect on the dynamic angle of repose (Kleinhans et al., 2011), the transition of bedload to suspended load in fluvial sediment transport (Braat et al. 2024), and the settling speed of fine sediment in water (Kuhn et al., 2015). This raises the questions *if* and *how* gravity affects the non-linear flow dynamics of hillslope mass movements and the morphology of their depositional landforms.

In this study, we experimentally explored the effects of gravity on the dynamics of dry mass movements and those lubricated by a liquid. We performed rotating drum experiments under varying gravity (from  $\sim 0.1g$  to  $2g$ , with  $g=9.81\text{ms}^{-2}$ ). The lower and hyper-gravity conditions were created by flying, respectively, parabolic trajectories and steep turns with a Cessna Citation II aircraft (PH-LAB), in which the rotating drum set-up was installed. In the rotating drum (diameter=50 cm), we tested how dry and wet granular flows responded to different gravity by measuring flow depth, density, compaction and dilation, and internal grain dynamics. Reference experiments with varying drum-rotation speeds were performed under Earth gravity to determine the relative effects of centrifugal force versus gravity, and aircraft vibrations.

Preliminary analyses show that gravity changes the dynamics of both dry and wet granular flows in our drum, and that these effects are more pronounced for wet granular flows. Under higher gravities ( $>1g$ ), the granular flows become more compacted, which pushes the water out of the mixture and decreases the water content of the granular flow itself. As a result, the interparticle friction increases and the centre of mass shifts upslope in the drum. At lower gravities ( $<0.7g$ ), the granular flows dilate, increasing the pore space in the sediment-water mixture, resulting in an

increase in air in the inter-particle pore space. This increases the relative importance of flow resisting forces relative to lubricating forces within the mixture, shifting the center of mass of the mixture upslope. The results under varying gravities seem to imply that, for a given ratio of sediment to water, an optimum gravity exist for peak water-lubricated granular flow mobility.

Comparison of the results under varying gravity with those of the reference experiments with varying drum rotation speeds under 1g confirm that gravity has a unique effect on the flow dynamics of granular flows. In particular, on the dilation of the flowing mixture and the interparticle behaviour. However, as changing drum-rotation speed also shifts the centre of mass of the flowing mixture, further analysis will focus on the combined effects of dilation, shifting centre of mass, and the steepening slope in the drum for all experiments.