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Triggering and flow conditions in Martian gullies – numerical simulation using RAMMS

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Gullies are kilometre-scale alcove-channel-fan systems that occur on steep slopes in mid-latitude to polar regions on Mars. They have formed by repeated deposition of hundreds to thousands of individual mass flows, which have been proposed to range from dry grain flows to aqueous debris flows. The most likely candidate for triggering these flows is slope failure in the gully-alcoves, which could be induced by sublimation of CO_2-ice (resulting in a dry flow) or by active-layer detachment (resulting in a wet flow).

To understand the current- and paleo-climatic conditions on Mars, and the role of volatiles therein, the conditions during triggering of the gully-forming mass flows need to be understood. While final flow deposits can be observed on some gully-fans, morphological expressions of initial failures are generally absent. Terrestrial observations tell us that mass flows can erode large amounts of bed material when flowing down a slope, and therefore small-volume initial failures could form large mass-flow deposits on the gully fans. As such, final deposit volumes cannot directly inform us about initial failure volumes and conditions.

We modified the RAMMS debris flow and avalanche model to permit its use under Martian conditions, and then used this model to back-calculate and infer the initial conditions of mass flows in multiple gullies across Mars for both dry and wet initial conditions. These simulations enabled us to constrain the initial failure volume as well as the flow conditions of mass flows in Martian gullies. We used the calculated initial flow volumes to constrain: 1) the total number of flow events required to form the studied gullies; 2) the amounts of CO_2 or water needed to trigger mass flows in these gullies, and 3) combined those to constrain the climatic conditions required for gully formation. In addition, we compared the frictional parameters of the flows in Martian gullies to those of a wide range of terrestrial mass flows, to determine which types of terrestrial mass flows best represent flows in Martian gullies and would form the best Martian analogues in future studies.