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Rill patterning on sloping snowpacks induced by Hortonian runoff
ELISA MANTELLI, CARLO CAMPOREALE, LUCA RIDOLFI, Politecnico di Torino — The morphological instability leading to rill formation over snowpacks is addressed in the present study. First, Hortonian saturation of a surface thin layer of snow is demonstrated to occur during the rising-intensity stage of rainfall events because the velocity of the water wavefront in the unsaturated snow is proportional to rainfall intensity. Therefore, a slowly downward-propagating shockwave is formed, behind which Hortonian saturation eventually occurs, and a turbulent water film moving along the maximum slope direction is allowed to develop above the snowpack surface. The linear stability analysis of the system made up of the water film and the saturated snow layer is then performed, and the dispersion relation obtained analytically. A spanwise morphological instability corresponding to rills is detected and investigated as a function of slope, friction coefficient, Reynolds number and wavenumber. The maximum instability wavelength is shown to have a purely hydrodynamic origin and to be originated by the interplay between pressure perturbation, free surface response and Reynolds stresses. Field work has been also performed, that confirms the validity of the presented model.

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