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Dense avalanches hitting structures: demarcating depth-dependent impact pressures from velocity-squared impact pressures

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Predicting the magnitude of the impact force that snow avalanches can exert on structures still remains a challenging question.

In fast flow regimes, the impact pressure is mainly driven by the kinetic energy of the flow: it scales as one-half the product of the flow density and the square of the avalanche speed, and the effect of the shape of the structure is encapsulated in the so-called drag coefficient. Recent measurements on well-documented snow avalanches that have impacted different types of structures have confirmed the existence of another impact force regime at lower speed for which the pressure exerted on the obstacle is independent of the avalanche speed but rather controlled by the lithostatic pressure associated with the typical flow thickness. These measurements have also shown that the depth-dependent force could reach values that are many times greater than the lithostatic force.

The present paper proposes a general analytic form for the impact force of dense avalanches on structures. The approach is based on the application of mass and momentum conservation equations, in their depth-averaged forms, to a control-volume which surrounds the influence zone of the obstacle. A criterion to distinguish between the depth-dependent force regime and the velocity-square force regime can be derived. It is demonstrated that the size of the influence zone of the obstacle, relative to the dimension of the obstacle and/or the avalanche thickness, is a key ingredient (in addition to the traditional Froude number) to demarcate the depth-dependent impact forces from the velocity-square impact forces. Further developments are needed to unravel the size and shape of the influence zone (of any kind obstacle for any type of flowing snow), and then to be able to hone the proposed criterion. However, the present study takes a step forward for a better characterization of avalanche impact forces on structures.