Modeling the generation of shallow water waves by the gravity-driven collapse of a granular column

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Tsunamis are among the most destructive natural disasters for human coastal settlements. While events generated by earthquakes are well known, several past or potential occurrences of high amplitude waves arising from large-scale landslides have also been reported in the last decades. The famous 1958 Lituya Bay tsunami, featuring the highest recorded wave runup of 524 m, is reminiscent of the need for understanding how these disasters arise, and relevant approach to this end is to model experimentally the landslide as a flow of granular materials [1].

Recently, the generation of impulse surface waves by the collapse of a rectangular granular column into water was investigated experimentally. The wave amplitude A was found to depend on the geometry of the column (height H_0 and width L_0) and on the water depth h_0 in a non trivial manner. The relative wave amplitude A/h_0 was shown to be governed mainly by the global Froude number $Fr_0 = (H_0/h_0)^{1/2}$ with a non negligible effect of the aspect ratio of the column $a = H_0/L_0$ [2], but A/h_0 can also be related to the final immersed deposit [3].

We propose here a predictive model based on the scaling laws known for the spreading dynamics of a gravity-driven collapse of a granular column [5] and on the scaling laws recently identified for the shallow water wave generation by a granular piston [4]. We then compare the model to a large dataset of experiments. The model reproduces well the influence of each initial parameters H_0, L_0, and h_0, and gives an accurate prediction for shallow water waves. It allows to explain the main role played by the global Froude number Fr_0 and the aspect ratio of the column, but also the final immersed deposit. These results provide a simplified, yet comprehensive, description of the generation of tsunamis begotten by large-scale landslides, rockfalls, or cliff collapses.

Références

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