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Singing sand as an instability arising from a shear-plug flow

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Desert sand dunes can have the peculiar ability to emit a loud sound up to 110 dB, with a well-defined frequency: this is the song of the dunes. After the early travelers who first mentioned it (Darwin, Marco-Polo, ...) later scientific observations have shown that if not all dunes sing, all the singing dunes are composed of dry, well-sorted and coated sand; this sound occurs when the sand is sheared, and particularly on field during avalanches on a slip face of a singing dune? Several observations—recent and less recent—have shown that the sound frequency is likely equal to the shear rate of the flow, or at least is varying in the same way.
We have been able to reproduce these avalanches in laboratory on an inclined plane with singing sand from Morocco and Oman, which has made possible to study them more accurately than on the field. Signals of accelerometers measuring local vertical oscillations of the flowing surface show that the phenomenon does not require resonance in the depth or in the dune. Measures of velocity and flow rate during avalanches enhance the co-existence of a plug flow with a large shear band underneath, both strongly correlated to the sound emission. A new model has been developed, based on the mechanical interaction between the plug area and the transient force chains in the flow. This model predicts a threshold that depends on the compacity of the granular media and on the surface friction and adhesion properties of the grains, and the value predicted fits quantitively well the data collected from avalanches, as well as from other experimental set-up of singing sand.