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Grain-scale Precursor Events during Shallow Landslide Initiation using a Stick-Slip Fiber Bundle Model

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The abruptness of shallow landslides masks the progressive nature of the transition from stable to unstable mechanical state through a series of local grain-scale deformations along the shear plane followed by rapid propagation and coalescence of these weak zones marking the onset of global failure. The difficulty in identifying this progressive behavior in shallow landslides lies in our incapacity to observe the evolution of this process owing to its rapid and apparently random occurrence in nature. Building on laboratory shear experiments that link granular motion with force chain failures that emit transient, high frequency, pressure waves (acoustic emissions) we model granular interactions and deformations within a shear zone using a stick-slip fiber bundle model. The fibers represent a network of strong contact forces between grains (the force chains) that hold and resist shear motion. Fibers fail when shear deformation exceeds the strength of fibers resulting in stress-drops or stick-slip events akin to force chain failures when shear motion overcomes frictional contact forces. Like acoustic emissions emanating from force chain failures, statistics of fiber failures is shown to evolve during unjamming leading to criteria for the imminence of global failure. Links are drawn with progressive failure of shallow landslides.