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Study of a 1D laminar fan near threshold

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Alluvial sediment transport is often modelled using either linear or non linear diffusion equations. These equations are then used to study the evolution through time of alluvial systems and their dependance on various parameters (such as discharge, subsidence or uplift), initial and boundary conditions . Much of these equations though are valid only for the case when the shear stress exerted by the flow is significantly larger then the critical shear stress for motion inception. In nature however flows most often occurs at conditions where the boundary shear stress on the bed is at or near threshold shear stress. It is for instance well known that the shear stress exerted by the flow on gravel beds is only slightly (∼20 %) above the critical value necessary to put grains in motion. It is therefore interesting to study alluvial sediment transport at or near incipient motion. In order to do this we here study theoretically the problem of a simple 1D laminar alluvial fan. The fan has a downstream moving boundary whereas the position of the upstream boundary remains fixed. The fan is fed with a constant flux of sediment and water. Boundary conditions are fixed by the sediment transport relationship for the upstream boundary and by assuming that all sediments are trapped within the fan for the downstream boundary. We use conservations equations together with a Charru et al. (2006) transport law to describe the evolution of the fan surface. We then derive the conservation equations of the fan. Using Taylor expansion and rescaling of coordinates we derive an self-similar solution for the fan shape and discuss the influence of the boundary conditions and parameters. This solution is amenable to experimental test and verification.