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The sinking rate of a buoyant triangular solid into a viscous substratum: Analytical solutions and coupled discontinuum-continuum numerical simulations

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We present an analytical solution for the sinking rate of a buoyant, flat-based rigid body that is placed upon a linear viscous layer. This solution enables us to determine the rate of subsidence of a sand dune, for example, into a salt layer. This early loading may lead to the initiation of local depocentres which may influence the later sedimentary and structural development. Furthermore, the analytical solution can be used for validating numerical modelling schemes. In the present study a coupled numerical approach is used for modelling the sinking of an initially triangular solid into a viscous substratum. The viscous layer is modelled using the finite-volume method code FLAC whereas the solid is modelled using the distinct element method as implemented for circular particles in PFC2D. Mechanical coupling is achieved across the FLAC-PFC2D (i.e. welded top-salt) boundary by (i) applying FLAC nodal forces, which are computed from out-of-balance particle forces, and (ii) assigning interpolated nodal velocities to particles that straddle the boundary. In contrast to the analytical solution, the rigid load in the numerical simulations is comprised of discrete particles with an elasto-frictional-plastic contact law. The numerical results are nevertheless in good agreement with the analytical solutions and support the dependencies of the sinking speed on various geometrical and mechanical parameters, such as substratum thickness, sand dune size and density difference. The coupled numerical models presented here provide the basis for more complex scenarios characteristic for salt tectonics, such as synsedimentary deformation, for which a selection of results is shown.