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Similarity solutions for a gravity current in the high Reynolds-number limit for the shallow-water equations

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This talk addresses the reliability of the shallow-water (Saint-Venant) equations for describing the motion of a gravity-driven surge supplied in fluid by a source placed at the inlet of a horizontal plane. Similarity solutions of the Saint-Venant equations are derived analytically. When the Boussinesq coefficient (weighting the convective inertial term in the governing equations) is prescribed in advance, the comparison of the solutions shows very good agreement. When this coefficient is set equal to unity (as is done in most models), we found that the Saint-Venant equations capture the main traits of the surge motion, but induce errors in the computation of the velocity and the flow depth, especially close to the body/head transition. This investigation also confirms that the front takes the form of an acute wedge, with a straight free boundary, and is separated from the body by a bore. Mathematically, this behavior is reflected in the phase plane representing the solutions by the unique and singular trajectory that the solution must follow to match the boundary condition at the front; this singular behavior explains why current numerical models fail in computing the front position and velocity when no ad hoc downstream boundary conditions are supplemented.