Numerical modeling for flood risk assessment

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In flood risk assessment modeling Saint-Venant's shallow water equations (SWEs) must be coupled with other systems describing inflows from the interacting meteorological and hydrological phenomena such as rain and groundwater flows.

The SWEs must therefore be appropriately modified to accommodate source and sink terms; while modifications of the SWEs in this direction have been recently proposed, e.g., [2, eq.(1.3& 4)]. Our departur from the extant literature consists in proposing a mathematical model that is, to the best of our knowledge, novel as a natural extension of the SWEs that is consistent both in momentum and energy and therefore respects its kinetic formulations connections. For such equations kinetic schemes were developed in the late 1990s and throughout the 2000s [5, 1] and have proved crucial in modeling river flows over long (physical) times. We approach our model a "natural extension" of the classical Saint-Venant system as it is derived via matched asymptotic expansions from the Navier–Stokes model where we incorporate infiltration-recharge mechanism through boundary conditions inspired from the Beavers–Joseph–Saffman conditions appearing in fluid- solid interaction problems, where porous media models for underground flows are coupled with surface flows. We also deal with kinematic boudnary conditions modeling the recharge from runoff, side sources and direct rain. Crucially to obtain physically meaningful momentum balance, our approach requires the introduction of novel "friction" terms accounting for the inertial effects of recharge.

In this talk we describe the derivation of the model [4], the existence of weak solutions via the vanishing-viscosity method[3], and the derivation of a kinetic scheme with corresponding numerical testing [4].

References

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