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A scalable parallel depth-integrated adaptive numericalframework with application to flow-like landslides

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Hydrogeological instability is among the effects of climate change with major impact on people and built environments security. Among instabilities, landslides are responsible for significant human and economic losses worldwide [1, 2].

Landslide dynamic is characterized by a broad range of velocity-scales, from the steady creeping slip to a catastrophic avalanche passing through the intermittent rapid slip. During these phases, the landslide undergoes different mechanical behaviours. In particular, during the triggering phase, the landslide behaves roughly like a rigid body and the driving process is the pore-pressure diffusion that causes the intermittent slipping of the involved material. Once the landslide is initiated, it follows various behaviours, e.g. we may have a flow-like motion typical of debris and mud flows, where the landslide follows a visco-plastic behaviour and the overall process becomes advection dominated.

We propose a scalable multi-core implementation of a two-dimensional depth-integrated fluid dynamic model for the simulation of flow-like landslides such as debris and mud flows. The governing equations are solved on adaptive quadtree meshes, thanks to the library [3], via the classical two-step second order Taylor-Galerkin scheme [4, 5] with a classical flux correction finite element strategy to avoid spurious oscillations near discontinuities and wetting-drying interface. To prevent filtering out the landslide dynamics we provide an adaptive time discretization startegy. To avoid excessive refinement in non-interfacial regions, we implement an interface tracking strategy that ensures detail preservation at the wetting-drying interface. Finally, after proving the validity of the proposed numerical framework on idealized settings, to show the efficiency of the overall implementation, we report some scalability results on both idealized and real scenarios.

REFERENCES

[1] Haque U, Blum P, Da Silva PF, et al. Fatal landslides in Europe. *Landslides* 2016; 13(6): 1545–1554.

[2] Haque U, Da Silva PF, Devoli G, et al. The human cost of global warming: Deadly landslides and their triggers (1995–2014). *Science of the Total Environment* 2019; 682: 673–684.

[3] Burstedde C,Wilcox LC, Ghattas O. p4est: Scalable algorithms for parallel adaptive mesh refinement on forests of octrees. *SIAM Journal on Scientific Computing* 2011; 33(3): 1103–1133.

[4] Löhner R, Morgan K, Zienkiewicz OC. The solution of non-linear hyperbolic equation systems by the finite element method. *International Journal for Numerical Methods in Fluids* 1984; 4(11): 1043–1063.

[5] Quecedo M, Pastor M, Herreros MI, Fernández Merodo JA. Numerical modelling of the propagation of fast landslides using the finite element method. *International Journal for Numerical Methods in Engineering* 2004; 59(6): 755-794.