A unified shallow water/Dupuit-Forchheimer approach to solve large scale Aquifer flows.

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Geophysical flows in an aquifer involve different regimes depending on the local media. Each regime, allowed to reduce the model of water dynamic, mainly : on the saturated underground regions, the Dupuit-Forccheimer model can be used ; on the unsaturated underground regions, the Darcy model can be used ; and in the lake and river, the shallow water model can be used. The domain decomposition strategy, where each model are solved in there own part, address the question of the transmission conditions, which are here particularly complex because of the different nature of the models and because the interfaces can evolve over time, or even appear or disappear.

We propose another approach based on the layerwise vertical discretization as it was done for shallow water flows [1], followed by a limite of large friction in the underground regions. Previous works dealing with each situations numerically[3] [2], yet use the same method to resolve the equation : a new primary unknown in the continuity equation. Neglecting the unsaturated regions, we finally obtain a unified shallow water/Dupuit-Forccheimer model, i.e. a model solved independently of the regions, which is reduced to the shallow water model or Dupuit-Forccheimer model depending on the regions, and with a complexity in order of the reduced models, in particular at the numerical level. This model is computed numerically thanks to a scheme derived from a shallow water scheme, both entropy satisfying and asymptotic preserving.

[1] Audusse, Emmanuel, Bristeau, Marie-Odile, Perthame, Benoît, and Sainte-Marie, Jacques. A multilayer saint-venant system with mass exchanges for shallow water flows. derivation and numerical validation. *ESAIM : M2AN 45*, 1 (2011), 169–200.

[2] Brenner, K., and Cancès, C. Improving Newton's method performance by parametrization : the case of Richards equation. *SIAM Journal on Numerical Analysis 55*, 4 (2017), 1760–1785.

[3] Godlewski, E., Parisot, M., Sainte-Marie, J., and Wahl, F. Congested shallow water model : roof modelling in free surface flow. *ESAIM : Mathematical Modelling and Numerical Analysis 52*, 5 (Nov. 2018), 1679 – 1707.

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