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PARTIALLY SATURATED OSCILLATORY FLOW IN A SANDY BEACH (NUMERICAL MODELING)

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Summary. In this paper, numerical modeling of oscillatory flow in 1D porous column is developed, validated and interpreted in terms of space-time scales in order to assist in the design and interpretation of a laboratory experiment. The aim is to study the interaction between surface flow (waves and tides) and partially saturated subsurface flow (water table and capillary zone) in a sandy beach.

Surface/subsurface flow interactions concern a wide range of applications, from beach morphodynamics (swash zone), to habour engineering and hydrology (e.g., man made structures such as porous dykes and earth dams).
In the context of beach dynamics, here, two types of periodic forcing are considered for the laboratory experiment:

1. low frequency / long tidal waves (approximated as quasi-static reservoir oscillations);
2. high frequency / short waves (complex nonlinear surface wave dynamics, including: overspill, run up/run down processes, and erosion near the swash zone).

In this paper, we focus first on the case of tidal oscillations, using Richards's equation for unsaturated or partially saturated flow, with oscillatory pressure-based boundary conditions. The numerical simulations and analyses are conducted as follows:

- Validation test for the numerical procedure through 1D infiltration problem.
- Analyses of sudden recharge and drainage on a 1D porous column.
- Analyses of forced oscillations in a partially saturated 1D column, and interpretation in terms of space-time scales: forced oscillation period Tp; capillary length scale λ_{CAP}, gravitational time scale t_{GRAV}, saturated hydraulic conductivity K_{SAT}.

Furthermore, the resulting oscillations of the free surface height Z(t) are analyzed and the simulations illustrate the effect of wave frequency on the phase delay. In addition to that, the pressure evolution and the phase lag along the 1D column are also investigated.

These numerical simulations and analyses are being exploited for designing the Darcy-scale physical models in the laboratory (including a 1D partially saturated column experiment, as well as a more complex 2D slab experiment with sloping beach and wave generator), the latter being aimed at both tidal oscillations and short wave regimes.