Recovering thermophysical parameters of a heated saturated porous media

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Abstract

This work is motivated by the studies of archaeological soils. The idea is to apply a numerical model to calculate the unsteady heat conduction in porous water-saturated soils subjected to intense heating from above. This particular geometry impose that heat conduction inhibits the usual behavior of fluids in the soil, because buoyancy proceeds towards the sides of the heated area. Therefore, in order to modelize the phase change phenomenon in the soil, we used the apparent heat capacity method [1] which allows us to avoid the tracking of the "dry/wet" front.

The inverse problem consists in the estimation of the thermophysical parameters of the soil. On the basis of the knowledge of heating curves at selected points from the alterated soil, the thermal conductivity, the apparent capacity and the porosity of the soil are simultaneously identified. In order to solve the problem the least squares criterion (in which the sensitivity coefficients appear) has been used [2]. Differentiating the least squares criterion with respect to the unknown parameters and using the necessary condition of minimum and the taylor series for the temperature function T, we obtain the system of equations which enables finding the values we are looking for. The so-called sensitivity coefficients must be determined and they will be used to solve the system of equations. After some mathematical manipulations we obtain a system of coupled non-linear equations which is a differential algebraic one.

On the stage of numerical computations, the spatial discretization of the system is obtained by using the vertex-centered finite volume method. The discretized problem to be solved may be written in vectorial form with adequate initial and boundary conditions using the method of lines where space and time dicretizations are considered separatly, leading to a semi-discrete system of implicit differential algebraic equations. The time integration method is performed by the `DASSL` solver which has been used to achieve stability and a prescribed accuracy by adjusting automatically the time step in fixed-leading-coefficient form. This latter solver has been modified to support a jacobian matrix in sparse format, solving the Newton method by using the `UMFPACK` library. Lastly, to achieve performance, the jacobian matrix is coded by hand. The code validation stage is based on the comparaison between the numerical results and the synthetic data which shows a good agreement.

References

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