Deletion of Nondominant Effects in Modeling Transport in Porous Media

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(Received: 8 February 1990; revised: February 1991)

Abstract. A methodology for eliminating nondominant effects in models that describe transport phenomena in porous media is presented. The methodology is based on the introduction of dimensionless numbers and on a proper evaluation of the order of magnitude of terms. These dimensionless numbers are redefined as characteristics of transport and transformation phenomena in porous media. It is shown that different time scales and different length scales may have to be employed for different variables. A method for evaluating the order of magnitude of the error of prediction when terms are deleted, is presented.

Key words. Porous media, modeling, scaling, dimensionless numbers, dominance.

Nomenclature

Roman Letters

\(a_{0k} \) Component of porous medium dispersivity

\(a_L \) Longitudinal dispersivity of an isotropic porous medium

\(c \) Concentration. As subscript, a symbol denoting a characteristic value

\(C_s \) Specific heat of a solid at constant strain

\(C_v \) Specific heat of a fluid at constant volume

\(D^E \) Coefficient of dispersion of \( E \) in an \( \alpha \)-phase

\(D^\gamma \) Coefficient of molecular diffusion of a \( \gamma \)-phase component in an \( \alpha \)-phase

\(D^\gamma^\alpha \) Coefficient of molecular diffusion of a \( \gamma \)-component in an \( \alpha \)-phase within a porous medium.

\(e \) Density of \( E \) (= amount of \( E \) per unit volume of a phase)

\(f \) As subscript, a symbol denoting a fluid

\(g \) Gravity acceleration

\(k_{ij} \) Permeability component

\(L \) Length of a domain

\(L^{(u)} \) Length assigned to a variable \( u \)

\(n \) Porosity

\(p \) Pressure
1. Introduction

The behavior of an extensive quantity in a porous medium domain is usually governed by a large number of processes of transport and transformation. Hence, the macroscopic partial differential equation that describes the contributions of the various processes to the balance of the considered extensive quantity may become rather complicated and difficult to solve. However, in many instances, only a small