Upscaling Methods for Environmental Research

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Abstract: Upscaling methods combine microscopic and macroscopic descriptions of complex phenomena. These methods are based on mathematical techniques for upscaling of models posed in complex domains, including asymptotic and numerical analysis for a rational derivation of macro-scale models starting from the micro scale models. The application of these methods allows constructing new materials with given properties, creating new more adequate and more precise models pertaining to the scale under consideration.

In this paper, we present mathematical analyses and numerical upscaling schemes for two different processes in mangrove ecosystem: (1) modelling the dynamics of mangrove trees from the individual level to the aggregated level (landscape scale) by simulating many times the behavior of individual objects (individual trees) using individual based model, and averaging over a large number of them, then derives functional responses (involving effective coefficients and equations) for the entire levels and (2) modelling the pollutant uptake by mangrove trees, the upscaled model is derived from a 3-dimensional single tree model by fitting a compartment model in form of ordinary differential equations to data obtained by spatial integration over the domains of the 3-dimensional model. These equations are imbedded as reaction terms into the shallow water equations for riverine transport. The model is applied to the dispersal of pollutants in an estuary.

The theoretical results on the mathematical analysis of upscaled models are presented together with the numerical and computer experiments. These results illustrate the capabilities of existing upscaling procedures and demonstrate the levels of accuracy attainable using the various approaches.

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