A generalized level set technique for the simultaneous reconstruction of geological regions and region-specific model-based internal permeability profiles of petroleum reservoirs from production data

Rossmary Villegas
Modelling and Numerical Simulation Group,
Universidad Carlos III de Madrid
rvillega@math.uc3m.es

Abstract

During the water flooding process of secondary oil recovery, water is injected into the petroleum reservoir at injection wells in order to enhance oil recovery at other production wells. The physical process is modeled here by a two-phase incompressible flow system of oil and water. The goal in the inverse problem is to reconstruct the different geological regions as well as the unknown model-based internal permeability profiles from the water-/oil-production data gathered at the wells. Here, the model used for the characterization of each of the regions (of unknown shapes) will be different for different regions. For example, in our numerical experiments one of the regions follows a linear parameterized model, whereas the other one follows a smoothly varying pixel-based model. We present a novel level set technique whose goal is to reconstruct simultaneously the correct interfaces of these different geological regions as well as the different internal model-based permeability profiles in each of these regions from few production data. This mixed inverse problem is solved by an iterative tech-

nique which employs an adjoint solver for back-propagating residual values from production wells into the reservoir. Using this technique, only one forward and one adjoint problem needs to be solved per iteration in order to extract gradient directions simultaneously for the level set function identifying the different regions, for the parameterized region values in one of these regions, and for the pixel-based profile in the corresponding other region. Numerical experiments in 2D are presented which demonstrate the performance of our new technique in realistic situations.