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FAST MOVING FRONTS - 2009

March 2009

PDF

Yuguang Chen & Louis J. Durlofsky talk with *ScienceWatch.com* and answer a few questions about this month's Fast Moving Front in the field of Mathematics.

Article: A coupled local-global upscaling approach for simulating flow in highly heterogeneous formations
Authors: Chen, Y;Durlofsky, LJ;Gerritsen, M;Wen, XH
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SW: Why do you think your paper is highly cited?

Upscaling is a numerical technique which is routinely applied in simulating flow in subsurface formations. Upscaling is used to coarsen highly detailed geological descriptions to scales that are suitable for flow simulation, while maintaining the impact of important fine-scale flow features.

This paper introduced a new class of upscaling methods—local-global upscaling, in which global coarse and local fine-scale flows are solved together. Traditional upscaling methods fall into the category of local methods, which are efficient but lack accuracy due to the need for assumed local boundary conditions. On the other hand, existing global methods can provide better accuracy. But this type of method requires solving global fine-scale flow, which can be computationally intensive. The local-global upscaling method combines the advantages of both local and global methods. It can effectively capture the global effects, but avoids solving the global fine-scale problem.

The impact of local boundary conditions is a well-known issue in upscaling and in multiscale modeling in general. Local-global treatments provide a new means to efficiently address this issue, which may explain why other researchers have cited this paper.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

Yes, the paper describes a new methodology to compute coarse-grid properties for flow simulation models. The results are more accurate than those from existing methods with comparable efficiency. The procedure also addresses the issue of global flow dependency of upscaled properties.

SW: Would you summarize the significance of your paper in layman's terms?

The simulation of fluid movement in subsurface formations, such as aquifers and petroleum reservoirs, involves the computational solution of the governing flow equations. The input model often contains millions of grid blocks (discrete data volumes) which are used to represent the subsurface geology more realistically. However, current flow simulators cannot handle these models efficiently, meaning that the computational time for flow simulation is prohibitively long.

Coauthor
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Upscaling is applied to reduce the number of grid blocks used in the simulation model, while at the same time preserving the flow response of the original high-resolution model as closely as possible. In the petroleum industry, for example, upscaling is routinely applied in oil reservoir evaluations. The subsequent flow simulations are then used to make decisions regarding oil and gas production.

Our paper presents a new upscaling methodology to generate the upscaled properties. Flow results using this technique can be much closer to those of the target high-resolution model than results using standard methods.

SW: How did you become involved in this research and were any particular problems encountered along the way?

In recent years, techniques for the more realistic description of subsurface formations were developed. The resulting geological models can involve complex connectivity of rock properties (permeability) and present high contrasts in permeability values. For these cases, standard local upscaling methods may give large errors. This motivated us to develop more accurate procedures. The local-global upscaling method developed in this paper is well suited for these highly heterogeneous reservoir models.

During the development of this method, we found that the use of upscaled transmissibility (the numerical analog of permeability) provided superior accuracy to the use of coarse-scale permeability. The switch from the use of permeability to transmissibility provided improved accuracy and robustness.

SW: Where do you see your research leading in the future?

This general methodology is finding applications in this and related fields. Consistent with the ideas behind local-global upscaling, global coarse solutions can be used together with local fine-scale calculations for a variety of problems. Some examples include the treatment of more general flows driven by source/sink terms (e.g., wells), upscaling of multiphase flow parameters, modeling flow systems involving more complex physics, capturing full-tensor effects in rock properties, and the development of more accurate and robust multiscale simulation techniques.

SW: Do you foresee any social or political implications for your research?

Our research is focused on computational methodologies. We expect new techniques that apply these ideas to be used in practical applications such as petroleum reservoir simulation.

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