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Biogeosciences Discussions

Interactive comment on “Percolation properties of 3-D multiscale pore networks: how connectivity controls soil filtration processes” by E. M. A. Perrier et al.

Anonymous Referee #1
Received and published: 22 June 2010

The paper addresses the problem of straining efficiency in filtration processes. The model proposed exploits the multiscale nature of the pore size distribution, extending to the 3D case a method published by two of the Authors (Bird and Perrier 2009) for the 2D case. The Authors use (1) analytical renormalisation methods and (2) numerical methods, to study the CFS (critical filtration size) as a function of the structural and geometrical parameters of the network.
The paper is relevant to Biogeosciences and the results are worth being published.

The authors would like to thank Anonymous Referee #1 for these positive comments

However, the Authors should consider the following points: (1) In the Introduction (3001, line 18), the Authors state "we provide an improved algorithm for numerical simulation". The algorithm is never explained in the paper. On page 3005, line 20, I find: "An algorithm has been developed and has been validated". Since the results in section 3 (Numerical experiments) rely on such new algorithm, I think it would be worth spending a paragraph explaining the novelty of the algorithm and the advantage with respect to "classical" percolation algorithms.

We agree : The algorithm was not described in the submitted manuscript. We checked that the results are identical to those obtained with classical algorithms, namely as regards the values for the percolation thresholds found in textbooks. The improvement consists first in taking advantage of the fractal hierarchical structure to avoid neighbours computer search at the finest level. This results not only in reducing computational time but also in sparing computer Memory, which leads to the possibility of accounting of a greater finite number of iterations in the present study than what could be achieved using a standard algorithm. Secondly the hierarchical iterative space partition used by the novel algorithm will enable the parallelisation of the code to be run on computer clusters in further applications where the new algorithm should be also superior even in the random non fractal case. A brief but more detailed description of the algorithm will be included in the revised manuscript.

(2) Section 2 deals with iterated maps, fixed points etc. without providing all the necessary background, so that, e.g., when "tangent bifurcation" is mentioned (page 3004, line 20) the reader can only have a vague idea of what a "bifurcation" is. The previous paper (Bird and Perrier 2009) managed to explain these basic points, and I think that the Authors should provide a similar explanation here.

We agree : We only referred to the previous paper in the submitted manuscript. We will include the necessary background in the revised version in order to enable the readers to better understand the new paper independently of the first one.

(3) I find the mathematical wording of the last paragraphs of section 2 quite unsatisfactory. I understand that the purpose of the section is to give a "mainly qualitative" theory that is going to be improved with numerical simulations. Still, I think that assertions like "only 2 levels enable the

pore network to percolate with a probability close to 1" (page 3004, lines 7-8), and "the probability... drops toward zero within only 6 iterations" (page 3004, lines 8-9) should be made more quantitative. What do "close to 1" and "toward zero" mean here? I assume that a threshold is used, e.g. $1 - 10^{-6}$ for "close to 1" and 10^{-6} for "toward zero". The values used for the threshold should appear in the text. Moreover, writing, e.g., that "for high values of q... only two levels enable the pore network to percolate" lacks precision, since the only example is given for q = 0.4.

We agree : We will introduce in the revised version a more rigorous style and we will quantify what we call “close to 1” or “close to 0”.

I think that for even higher values of q (say, q = 0.8) the number of required levels (according to some threshold) could be just 1,

Yes, as soon as q>0.3116077..., that is as soon as the first level prosity exeeds the monoscale percolation threshold, only 1 level is enough for the pore network to percolate

and for lower values of q it could be 3 or more. The Authors should explain more precisely how the number of iterations depends on q.

Yes, we will comment in a more detailed way Table 1a which gives the relationship between the number l of iterations and the q values.

Moreover, I think that the numerical value of the threshold ("near q = 0.3" on page 3004, line 11) should be given with at least two digits of accuracy.

We will look for a way to improve the precision of the q value where the solid renormalisation curve becomes tangent to the first bissector from an analytical analysis of the first and second derivative of fsolid(p) which leads to non trivial equations. Even if a numerical value can be calculated, we will have to explain more clearly that two or more digits of accuracy are not relevant since the theoretical values obtained from the renormalization theory are only qualitative in the present multiscale study as in the standard monoscale studies. .

Interactive comment on “Percolation properties of 3-D multiscale pore networks: how connectivity controls soil filtration processes” by E. M. A. Perrier et al.

Anonymous Referee #2

Received and published: 19 July 2010

General Comment

An interesting and good paper as generating soil structures with given pore size distributions and connectivity is useful for many avenues of research including assessing the effect of biological and chemical processes without having to depend on experimental or CT derived data. The work presented is a natural extension of the 2009 paper (Multiscale percolation properties of a fractal pore network in Geoderma) and is applied to filtration. The topic is relevant for the journal.

The authors would like to thank Anonymous Referee #2 for these positive comments

Specific Comments

Figures need more explanation. They only make sense when reading the Geoderma r2009 paper and it would be better if from the text and more detailed legends there is sufficient information to access information presented in the figures by readers that did not have a multifractal background. These also need labelling and captions for each figure within a figure.

We agree : We will include the necessary background in the revised version in order to enable the readers to better understand the new paper independently of the first one (Geoderma 2009). By the way labelling and captions for Figure 1 were present in the submitted manuscript and disappeared when it was put online. We will include the .pdf version when resubmitting the revised manuscript and will explain the problem that may have occurred when the latex file was recompiled by the Biogeosciences Editorial Office.

“An algorithm has been developed to better handle percolation in large 3-D fractal structures (accounting for the presence of large clusters of connected voxels) and has been validated by comparison with classical algorithms.

Can this algorithm be presented (at least in a summary style) and results of comparison of classical methods presented. What are the novel aspects of this algorithm and how does it differ from classical approaches?

We agree : The algorithm was not described in the submitted manuscript. We checked that the results are identical to those obtained with classical algorithms, namely as regards the values for the percolation thresholds found in textbooks. The improvement consists first in taking advantage of the fractal hierarchical structure to avoid neighbours computer search at the finest level. This results not only in reducing computational time but also in sparing computer Memory, which leads to the possibility of accounting of a greater finite number of iterations in the present study than what could be achieved using a standard algorithm. Secondly the hierarchical iterative space partition used by the novel algorithm will enable the distributionof the code to be run on computer clusters in further applications (where the new algorithm should be also superior even in the random non fractal case). A brief but more detailed description of the algorithm will be included in the revised manuscript.

A reference to the techniques used for measuring pore size distribution should be provided.

We agree : We will give more information and references to the readers who can be unaware of such techniques.