Geoscientific Model Development Discussions

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Comment on gmd-2022-185

James Craig (Referee)

Referee comment on "A simple, efficient, mass-conservative approach to solving Richards' equation (openRE, v1.0)" by Andrew M. Ireson et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-185-RC1, 2022

The paper entitled "A simple, efficient, mass conservative approach to solving Richards' Equation (openRE, v1.0)" outlines a straightforward implementation to solve the one-dimensional Richards' equation using off-the-shelf ODE solvers, with a novel amendment to effectively track the cumulative mass flux through the boundaries. The approach is rigorously compared to approaches and test cases from the literature. The paper is very well-written and structured. The contribution is somewhat novel (I have colleagues teaching solution of the advection dispersion equation using method of lines with basic ODE solvers at the undergraduate level; this is not a super-new idea), but the degree of rigour in assessment of the various libraries, tolerance and time step choices, and introduction of the SFOM flux tracking method puts this into the range of publishable contribution for a technical note in GMD.

Some minor nitpicking comments that the authors may want to consider here

1) the use of Q_j->j+1 (introduced in eqn 18) seems like subscript overkill - why not just Q_j ?

2) it would be useful to report the domain extent and model simulation duration for Mathias' solution in section 3.1.3 (these are implicitly in the figure, but would provide a more complete problem statement in the text)

Some other things to consider in the future:

1) I envision the method of lines may perform even better in relation to other methods for

cases with non-constant space steps and layering of different media. It would have been nice to see a case study in this vein, but I would by no means require it here. Just something worth toying around with.
2) The use of arithmetic mean for calcualting hydraulic conductivity for the 1-D problem struck me as strange - the effective resistance to flow is typically treated using the harmonic mean for such problems by default (and this is well-documented even in the source they provided).
3) It would be very interesting to see how this approach performs in the more relaxed domains simulated in land surface schemes, with inherently much larger space steps by default. That is, you are looking at the perfect limits against analytic solutions, but how does this approach do 'in the trenches' for practical problems where we can't afford the burden of 0.001s time steps and 0.0025 m space steps? Is it worth the effort of deploying for these types of problems?

I have been reviewing papers for 20 years and this is only the second initial submission where I have recommended acceptance 'as is'. Thanks for making my job as reviewer easy.