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Interactive comment

Interactive comment on "A consistent implementation of the dual node approach for coupling surface-subsurface flow and its comparison to the common node approach" *by* Rob de Rooij

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I appreciate that Anonymous Referee #2 feels that my research is a valuable contribution to the scientific literature.

I agree with the Referee that highly non-linear problems can only be solved using a very high spatial resolution (and in fact also requires a very fine temporal resolution). It is true that the proposed dual node approach does not resolve this requirement and I agree that the requirement of a very high resolution will probably never be solved. However, in my opinion this not mean all the errors and ambiguities associated with

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numerical limitations are the same. More precisely, as explained in my manuscript the common node approach violates the principle of head continuity at the land surface if the topmost cells are not sufficiently thin and inconsistent dual node approaches also inhibit inconsistencies (for example dz/dz is not unity) which can only be removed by using very thin cells and very small coupling parameters. The proposed dual node approach is an improvement as the approach itself does not require a very fine discretization to be consistent. Of course the vertical hydraulic gradient at the land surface as computed with the proposed dual node approach is only solved sufficiently accurate when using a very fine spatial resolution. But a loss of accuracy is not the same as a loss of consistency. It is less serious and this is shown by simulation results on coarser grids.

I do not agree that it is inappropriate to compare the non-linear iterations of the coupling schemes. Rather than reporting the CPU times, I have chosen to compare the number of these iterations which in essence is the same. I think it is completely fair to subject the approaches to a comparison in efficiency as long as both approaches are subjected to the same error norms and time-stepping parameters. The only problem, I admit is to make this completely transparent without a lengthy explanation of the model code. But, this lack of transparency is partially compensated by showing the rate of changes in water depth at the moment of ponding which are different depending on the coupling scheme. I think it is important to illustrate that the number of iterations can be linked to this rate as it explains why the dual node approach can be more efficient.

Since I acknowledge that the coupling approach of An and Yu (2014) is a properly implemented dual node approach, I don't really understand the concern of the Referee considering the fact that the proposed dual node approach is not novel. To the best of my knowledge, I do not claim to have invented this approach. Instead, I point out its advantages.

In combination with the comments of Referee #1, I agree with Referee #2 that I should add some information about how the common node approach is implemented. Also I agree that I could try to change the tone a bit. It is / was not my intention to denigrate other models. Instead I tried to be precise and to clarify the differences between them.

I would also like to discuss a bit further the thought-experiment of the Referee. So we consider the dual node approach, a topmost subsurface cell under almost fully saturated and the addition of an incremental amount of water. What happens in terms of changes in pressure head and the initiation of runoff depends on the rate at which the amount of water is supplied (i.e. the infiltration rate) and the vertical hydraulic conductivity of the subsurface (i.e. infiltration rate giving rise to either excess saturation or excess infiltration) as well as the rill storage height. As explained towards the end of section 4, under the conditions of excess infiltration ponding starts when the pressure head in the topmost cell is smaller than zero. Saturation in this cell will be reached if the water depth stays above zero for some time. Similarly, it can be shown (last part of section 4) that under the conditions of excess saturation ponding starts when the pressure head is above zero but below dz/2. In general runoff will be initiated if the water depth exceeds the rill storage height. Under no circumstances, however, will the pressure head in the topmost cell jump from negative to dz/2. What does happen is that topmost cell when p>0 can only accommodate additional water volumes by means of the specific storage such that that the rate of change in pressure head may be very fast.

In general, the initiation of ponding as well as runoff are sudden changes in the system that can be regarded as discontinuities and which are extremely difficult to solve. If ponding starts there is a sudden extra storage capacity at the land surface. If runoff starts there is a sudden introduction of additional surface flow terms. This activation / deactivation of storage and flow terms is a challenge and again I agree with the Referee that these challenges are difficult to solve and that my manuscript does not offer any solutions for these. However, that would set a high bar to cross.

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