Review for "HydroBlocks-MSSUBv0.1: A Multiscale Approach for Simulating Lateral Subsurface Flow Dynamics in Land Surface Models" by Daniel Guyumus et al.

First, I would like to congratulate the authors for this paper and the original approach it is based on. They propose their solution to a hotly debated topic in the community : How are we going to represent lateral transports through the various aquifers in our land surface models while having to cope with relatively coarse resolution atmospheric forcing.

Obviously no study or paper is perfect and I have a few questions and suggestions. I encourage the authors to think about them when preparing a revised version.

Before coming to scales of decomposition of hydrological structures, there is one point which needs to be considered. This is the physical assumptions on the separation of vertical and horizontal water movements. This is not well described or justified in the manuscript. A graphic illustrating how over the 10m of simulated soils the vertical and horizontal fluxes are positioned would be very helpful. What is particularly worrying to me is that in the unsaturated zone the Richards equation is applied while we do not know where the Darcy law is used. Based on their respective assumptions, the Darcy law should only be applied to the water in the saturated portion of the 10m soil column. How this is organized in the model should be clearly explained to the community as it is at the core of the question of how to decompose the 3D movements of water. Do we need to go to a full 3-dimensional resolution of the Richards equation or can a clever decomposition of the horizontal and vertical dimensions work ? I would have a problem if the Darcy law is also applied to the unsaturated part of the soil !

The decomposition of the hydrological structures according to the scales is original and very effective. The entire paper shows how this facilitates the representation of the lateral flows. But to my knowledge there is no clear scale separation of the surface hydrological structures. So what is the basis for separating the regional, intermediate and tiled components ? From the graphics it is obvious that the regional units are atmospheric grids. What would happen if instead of being at about 25km resolution the atmospheric forcing would be at resolutions of 2.5 or 250km (some typical resolutions of atmospheric models used today) ? Is the decomposition numerically robust to other shapes for the polygons of the atmospheric grid (triangles or hexagons) ?

Generally I find the approach to represent the fluxes between RISFUs quite original and convincing. But I fail to understand how the hydraulic head differences are computed. Is it just the elevation difference between RIFUs or is the water table depth established in each soil column to compute the hydraulic gradients ? If it is the second option, then I would like to know which criteria is used to define the water table depth in each soil column. It would reassure me if Darcy is only used for the flux in the saturated zone and not in the unsaturated part.

Minor comments :

- line 90 : 1820 core-hours is not a pertinent metric as it depends on the type of cores used and the software environment. Relative differences are more meaningful.
- Figure 1 : Would it not be helpful to put references to the datasets used for the illustrations ?
- Line 124 : The observational product for soil types are described relative to the 10m soil depth of the model. More relevant would be to know which information on the vertical distribution of soil properties is available before projected onto the vertical discretization. Later then how this information is interpreted/used by the soil moisture model.
- Line 124 : How are the 10m of soil depth chosen ? Is this the observed bed rock depth over the region or is it arbitrary ?
- Line 141 : I have the impression that it is the clustering method which does the scale separation for you. It would be interesting to determine how the clustering methods respond to the choice of macroscale polygons. Here probably lies the answer to my second general concern expressed above.
- Line 183 : Please remind the reader here about the difference in hypothesis between the Richards and Darcy equations. The Darcy law does not take into account the forces which bound the liquid to the porous material and thus can only be applied in a saturated medium.
- Line 283 : It should only be done for the layers which are saturated.
- Line 341 : Is there not a case as well where the atmospheric conditions are assumed homogeneous ?

- Line 393 : It is not clear to me if in your scheme the rivers can also lose water to the surrounding riparian zones. This is a particularly important process when rivers cross shallow aquifers.
- Figure 13 : Write that you are using μ to designate means and σ variances. Your notation is not so common and thus can be confusing. Using them as functions could also help.
- Figure 14 : The green lines are not visible in all subplots of column c. Either explain in the legend that they are hidden beneath the black line or find another representation.
- Figure 14 : Why runoff and not discharge ? You are not illustrating the delays induced by the flow through the shallow aquifers which should have an important impact.
- Line 509 : Why introduce here effective saturation when volumetric soil moisture is the prognostic variable ? The variable is not clearly defined either. Is this the same thing as soil wetness, which more common in LSMs ?
- Line 536 : I do not understand the argument why the coarser model will accentuate gradients and then produce different fluxes. The distances are larger as well. The coarser model will have more numerical issues and thus generate different fluxes. But at this stage we do not know where the numerical challenges are at representing the subsurface flows. More generally we do not know which numerical scheme is used to solve the Darcy equation.
- Line 536 : Here the argument is made that the river discharge should be examined. Why is this not used as a metric earlier in this study ?
- Line 585 : I suspect this discussion will need to be revised as I believe the depth of the water table will be much more critical. Above the Richards equation can be applied with all its numerical difficulties. Below the Darcy flows can be used an simplifying the numerical solution. But as the authors note, above the water table vertical movement are dominant and thus there is no need to solve a 3D Richards equation.
- Line 614 : In the saturated zone the lateral flows are faster than the vertical ! In the vadoze zone it is the contrary.