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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Hydrological functioning of West-African inland valleys explored with a critical zone model" *by* Basile Hector et al.

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Thank you for all the comments and questions regarding to our submission to HESS: Hydrological functioning of West-African inland valleys explored with a critical zone model". Many thanks to the four reviewers who raised relevant questions that we hope to address in this final response. We will mainly gather previous replies written in the debate phase and add our suggestions for changes in the manuscript.

RV#1 1. The experiments with low-K layers were interesting and provided some counter-intuitive findings. Did the authors conduct any experiments where the layers were discontinuous? If not, can they comment about how this might impact results?

=> Concerning the potential impact of discontinuous layers, this would indeed be an

interesting study in itself. There is an extensive literature on the topic, including with the same model (Atchley & Maxwell, 2011, Meyerhoff & Maxwell, 2011, Meyerhoff et al., 2014, Gilbert et al., 2016, among others). The target of the study was essentially to not focus on local heterogeneity to extract the main features and main behaviors of inland valleys.

However, there are still some discussion points that we should include in the paper: - The have noted the presence of dual-porosity soils, which we do not take into account in this study. It is likely that the dampening effect of the unsaturated clays contribute to play this role. - The valley thalweg is oversimplified, and the lack of recharge of the permanent water table by direct infiltration (see Fig. 4.a), is probably due to the homogeneity of the valley thalweg material, while in the real world, heterogeneity and clay lens topography certainly impact the spatial distribution of recharge, as explained p.12 l.19-22. - Figure 4.a and 4.b belong to different simulations, although both associated data are real world data of the same catchment. This means that we actually still miss some features: if we set a 'higher' permeability to the valley banks, it will result in the filling of the permanent water table in the valley thalweg, which is not observed. To successfully match the observations, we would definitely have to include lateral variations in permeability. But again, this was not the target of this study.

Modifications in the manuscript:

P. 5 L 7.: 'There is an extensive literature, using the same critical zone modeling framework that provides insights on the effect of lateral variability of soil properties through dedicated sensitivity studies (Atchley & Maxwell, 2011, Meyerhoff & Maxwell, 2011, Meyerhoff et al., 2014, Gilbert et al., 2016).'

P19 L 21: Furthermore, one should note that Fig. 4.a and 4.b show results from different simulations (reference and saprolite, respectively), although both associated water table levels are real world data of the same catchment. This means that some features are still missing in order to comprehensively reproduce the behaviors of this specific catchment. If a high permeability is set to the valley banks (as in the saprolite simulation), it will result in the filling of most of the valley thalweg by the permanent water table and the absence of the perched water table, which is not observed. On the opposite, in the low permeability scenario (reference simulation), the simulated water table on the valley banks mismatches the observed data. To successfully match all the observations, lateral variations in the permeability are needed, but this was not the target of this study, which was instead the extraction of main features and behaviors of inland valleys.

Added references Atchley, A. L. and Maxwell, R. M.: Influences of subsurface heterogeneity and vegetation cover on soil moisture, surface temperature and evapotranspiration at hillslope scales, Hydrogeol J, 19(2), 289–305, doi:10.1007/s10040-010-0690-1, 2011.

Gilbert, J. M., Jefferson, J. L., Constantine, P. G. and Maxwell, R. M.: Global spatial sensitivity of runoff to subsurface permeability using the active subspace method, Advances in Water Resources, 92, 30–42, doi:10.1016/j.advwatres.2016.03.020, 2016.

Meyerhoff, S. B. and Maxwell, R. M.: Quantifying the effects of subsurface heterogeneity on hillslope runoff using a stochastic approach, Hydrogeol J, 19(8), 1515–1530, doi:10.1007/s10040-011-0753-y, 2011.

Meyerhoff, S. B., Maxwell, R. M., Graham, W. D. and Williams, J. L.: Improved hydrograph prediction through subsurface characterization: conditional stochastic hillslope simulations, Hydrogeol J, 22(6), 1329–1343, doi:10.1007/s10040-014-1112-6, 2014.

2. Domain geometry. Did the authors experiment with other domain configurations? It would be interesting to see how changes in slope for the v-catchment "banks" changed response. Do the choices in slope represent something in the real catchment?

=> As stated P.9 L14-15, 'topographic slopes are gentle (mean N-S and E-W slopes correspond to those imposed on the virtual V-shaped catchment).'. This comment is

shared with RV2, and we will provide more response below (in final response to RV2), together with manuscript changes suggestions.

3. Boundary conditions. Perhaps I missed it, but how were the boundaries set for the tilted-V catchment? Did this have an impact on e.g. water table dynamics and fluxes?

=> No-flow boundary conditions where applied over the catchment sides (as stated P. 7 L. 22), but we did not precise that a no-flow boundary condition is also applied to the bottom of the catchment. We could add this precision. This choice is backed-up by the limited regional gradient as explained by 1) the low fracture connectivity within the bedrock (El Fahem et al., 2008) and 2) the low transverse hydraulic gradient at the larger scale (gradient of 0.01 m/m over about 3km) showing very little variations between the dry and the wet season, and suggesting limited larger-scale transverse flow which would affect the boundary conditions. These numbers are based on Hama Garba's Msc thesis (Hama Garba, 2016), available upon request.

Modifications in the manuscript: - P7. L-22: 'No-flow boundary conditions are applied on the catchment edges and bottom.

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