Referee comment on "Modeling the paradoxical evolution of runoff in pastoral Sahel. The case of the Agoufou watershed, Mali" by Laetitia Gal et al. (Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-623, 2016.)

This reviewer largely agrees with many of the comments already expressed by reviewers RC2 and RC4. Given the numerous issues expressed I feel the paper should be reframed and possibility retitled along the lines expressed by reviewer RC3 whose last suggestion was "Conclusions: this section should be rewritten after the revision of the manuscript, but it is important to bear in mind that in this case the model approach may be useful to "investigate" or to "shed some light on" the paradoxical evolution in the Sahel, but not to "understand" it." A new title might be something like "Exploration of the paradoxical evolution of runoff in the pastoral Sahel – Agoufou Watershed using available data and a watershed model."

The author could then stress that the model selected could be one of many for this investigation, but K2 was selected for x, y, and z reasons as a tool to investigate possible reasons for the paradoxical evolution of runoff in the Agoufou watershed. Within the constructs of the model, its structure, and the assumptions inherent in the model it was felt it could be used to conduct a relative ranking of various factors and watershed attribute changes contributing to the paradox. Using other models one might come to different conclusions or attributions but the authors could encourage others to conduct comparable "detective" investigations to better understand factor contributing to the paradox.

As pointed out by the other reviewers the uniform precipitation assumption for a basin this size constitutes a major simplification and calls into question the ability to carry our a defensible model calibration and validation. Al-Qurashi et al. (2008) applied K2 to a 734 km^2 arid watershed with 7 rain gauges where a "parameter set which gave best calibration performance over any combination of 26 events did not generally produce acceptable performance (defined as within 30% of observed) when used to predict the 27^{th} event". In this and similar situations, the authors noted that "data sets typically used for distributed (or semi-distributed) rainfall-runoff modeling in arid regions cannot provide an accuracy which justifies the effort and expense of this (K2) modeling approach. The limitations imposed by relatively sparse observations of rainfall are of particular concern" (Al-Qurashi et al., 2008, p. 104).

To remove this major limitation and use K2 as a tool to explore causes of the runoff increase this reviewer suggests taking a relative change approach as advanced by Goodrich et al. (2012) and Sidman et al. (2015) for post-fire watershed assessment in watersheds that often do not have any rainfall-runoff data available for calibration and validation. In this approach a pre-fire land cover map is used to parameterize the watershed and conduct a simulation with a spatially uniform design storm. The burn severity map is then used to alter model parameters based on prior research and analysis of the effects of burns on cover and soil hydraulic properties. A second post-fire simulation is then conducted using the same rain storm. The results can then be spatially differenced to analyze changes. For the author's study the present and past model parameterizations based on analysis of historic and current land cover and soils data are analogous to the pre- and post-fire conditions. The authors could pick one of their most trusted rainfall data sets (perhaps when they had high temporal resolution measurements) and use that rainfall input data set for <u>both</u> the past and present watershed model parameterizations. Given one of their conclusions (last paragraph) was that climatic and precipitation changes from past to present appeared to little or not impact on the findings this would further justify the approach noted above. By doing so the authors would isolate the analysis on watershed changes as they would be using identical input drivers. This would still be directly in line with the stated objectives of their study.

Technical Comments:

The authors have confused the meaning of the CSA or contributing source area. This is the drainage area required it initiate the head of a first order channel and effectively defines the level of geometric complexity of the watershed with a smaller CSA (percent of drainage area or absolute area) resulting in more watershed modeling elements. The channel source area modeling elements are those that drain to the head of a first order element. The remaining upland or hillslope modeling elements (planes – they can be curvilinear as well) contribute laterally to channel modeling elements.

Regarding the questions by other reviewers of K2 model sensitivity the author's should review and cite Yatheendradas et al. (2008) who conducted a thorough analysis of variance. In their analysis, model prediction uncertainties are dominated by precipitation input uncertainties (another reason in suggesting the approach noted above). For K2 model parameters a multiplier on the Ksat of overland flow model elements and the Manning's roughness multiplier on overland flow model elements were the most sensitive parameters while the channel roughness multiplier was also quite important.

Given this information it is odd that the authors selected the Ksat of the channels and not of the overland flow planes for calibration. Note that Ksat of channels and Ksat of hillslope elements do interact. The relatively low calibrated Ksat channel value that the authors found could easily be the result of a higher Ksat on the hillslope elements resulting in lower lateral runoff inflow into the channels.

Given the author's finding of the importance in the change drainage density and channel characteristics two items are suggested:

1. Did the author's use the default values for channel cross-sectional geometry? If so these value were derived from regressions relating X-S

measurements to easily derived variables from GIS operation on watershed data as obtained at the Walnut Gulch Experimental Watershed in SE Arizona, USA (Miller et al., 2000). The Walnut Gulch relationships are likely to be a poor representation of the channel cross sectional characteristics of the Agoufou watershed. It is suggested that the authors gather some field measurements from the Agoufou watershed. At least from several stream orders so they might be scaled across all the channels in the study watershed.

2. Instead of altering the aspect ratio of the overland flow (plane) hillslope elements a watershed discretization can be derived from for each (past and present) channel network (contact Shea Burns for details).

References

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