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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Modeling the paradoxical evolution of runoff in pastoral Sahel. The case of the Agoufou watershed, Mali" *by* Laetitia Gal et al.

Anonymous Referee #4

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The paper deals with the "Sahelian paradox" phenomenon where despite a decrease of the precipitation in the Sahel during the last 50 years, an increase of runoff was observed. The Agoufou catchment (245 km^2) is taken as a study case, and the spatially distributed model KINEROS2 used to prioritize the different factors (dune crusting, drainage network development, vegetation changes, modification of soil properties, or a combination of some of these factors) that lead to this paradox.

My first feeling is that the title of the paper does not reflect its real content because the paper remains an application of a model on a catchment. Neither the catchment nor the model was chosen to demonstrate a hypothesis related to the "Sahelian paradox". Moreover the use of the model to prioritize the factors causing the increase of runoff remains a numerical modelling exercise without any validation using hydrological data. The model can give good results for the bad reasons. Consequently the conclusions of

the paper on the main factors causing the "Sahelian paradox" may be correct, but may also be not correct.

My comments concern:

i) The choice of the studied basin: The paper doesn't justify the basin choice in comparison to other catchments in the same region. Does the land use change and the consequences on the "Sahelian Paradox" observed on the neighboring catchments. In order to demonstrate (or not) the hypotheses and quantify the role of the different factors which lead to the "Sahelian Paradox", it would be preferable to choose the-catchments with internal stream-gauges and piezometers. An increase of runoff will be accompanied with a modification of the other hydrological processes especially the water table level and extension, and evapotranspiration. However, the paper doesn't deal with these two main hydrological processes due to the lack of data. Consequently, the available data are not sufficient to validate or not a given hypothesis.

ii) What we learn from data: The paper doesn't present a detailed analysis of the spatio-temporal data and do not discuss the evolution of the components of the water balance. The authors must first discuss what we learn from the data only, and in a second time what is the added value using the model.

iii) The available data: The main problem is that only "annual" water outflow is available, reconstructed by the author for some years (see Table 1)! Moreover, one rain-gauge is available on the catchment, and data at a fine time step (5 min) are only available for given periods. The lack of analysis of the spatio-temporal structure of rainfall at 5-min time step, and the use of an empirical method for temporal disaggregation is a weak point of the study. Moreover, the paper limits the analysis at the annual water balance and no information is given on flood events characteristics on 5-min time step: evolution from the 50th until now of the rainfall intensities, runoff coefficient, peakflows, lag time, etc. The data are not coherent: a fine DEM resolution (30m) vs annual flow and daily rainfall! I'm not sure that the available hydrological data are sufficient to give

responses to the important questions raised in the introduction!

iv) The uncertainty on data: The authors must discuss the uncertainty on the hydrological data (e.g. spatial distribution of rainfall, the annual runoff reconstructed) and the consequences on modelling results.

v) The choice of the hydrological model: The spatially distributed model KINEROS2 is used without any justification. I'm not sure that this model is the most appropriate for the available data (only one rain-gauge, and total annual runoff). The paper doesn't demonstrate that the prioritization of factors causing the "Sahelian paradox" are independent of the model choice. Comparing different models will give more arguments for the discussion.

vi) The calibration procedure: an important number of the model parameters were arbitrarily fixed and only two parameters were calibrated. The values of the calibrated parameters will depend on the values chosen for the fixed ones. The authors must justify the choice of the parameters to be calibrated, and discuss how a modification of the fixed parameters will impact the conclusions of the paper.

vii) The criteria function: Only the "Bias" (Eq 3), at the annual time step, was chosen as a criteria function. The paper doesn't present any simulated hydrographs, neither other values of the criteria function (especially criteria related to peakflows) in order to evaluate the performance of the model. Different criteria functions must be used.

viii) In order to study the "Sahelian paradox", it will be interesting to compare the components of the water balance on a large number of basins (and more especially embedded ones). Before undertaken a modelling exercise, an analysis of data is necessary in order to link (or not) the evolution of "hydrological" processes to the evolution of land use.

Other comments:

- Abstract: please indicate the catchment area in the abstract.

- P3, L11-15: The objectives of the paper are reduced to an application of a model on a given basin, and don't give responses to the main question related to the "Sahelian paradox".

- The title of the paper must be in accordance with the objectives announced.

- Section 2.1 "Study site": The hydrological data 'rainfall, runoff) and the spatial data (land use, soil, geology, DEM, etc.) must be presented in this section and nor as input to the KINEROS2 model. The authors must discuss what we learn from data before undertaking a modelling exercise.

- What is the uncertainty on the delimitation of units on maps (from Table 2) and consequently on the area of each class of land use in space and in time (Table 6)?

- How the drainage network was defined on Figures 3 and 4? How the channel network was interpolated in time between 1956 and 2011?

- The Manning coefficient MAN has a unit ((mˆ1/3 / s)

- Table 3: How these parameters were fixed? What is the sensitivity of the mode l results of these values are taken different?

- Figure 5: The grid used must be refined?

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