Journal: HESS
Title: Reducing the hydrological connectivity of gully systems through vegetation restoration: Combined field experiment and numerical modelling approach.
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This paper presents novel data that is relevant to understand the influence of vegetation cover on the connectivity of gully systems and on their capacity to retain runoff (and sediments). The paper is therefore well placed in HESS. Substantial conclusions are reached regarding the most sensitive parameters on runoff transmission and outflow volume of gully systems. However some general comments should be addressed:
The results of the experiments are clearly described and evaluated. The main influencing factors of vegetation on runoff transmission and outflow volume are identified. The modeling part is also a very interesting approach but it should be overworked regarding the following comments:

Reply to Comments of Reviewer2

1.
I think it would be helpful to specify for what reason the experiments were modeled and what should be learned from the modeling part (i.e. at the end of the introduction).
We now added a small section at the end of the introduction where we explain the main objectives of the hydrological modelling.

2.
I suggest being more precise when using the term “prediction”. Since the model is calibrated in the beginning, it would be better to use the term “simulation” for all model results related to the calibrated parameter sets.
REPLY: This issue was also raised by Reviewer1. We have systematically changed all terms relating to ‘prediction’ to ‘simulation’ throughout the text.

3.
Since the model is not really “physically based” it would be better to characterize it as “process based”
REPLY: The term ‘physically based’ model was changed into ‘process based’ model, which indeed better describes our kinematic wave model.

4.
A more detailed discussion of the results of the sensitivity analysis (chapter 4.2) would be helpful.
REPLY: This issue was also raised by Reviewer1, who suggested to further elaborate the sensitivity analysis. More particularly, it was suggested to change various input parameters simultaneously, to evaluate the effect of errors in various input parameters at once. In addition, it was suggested to do the sensitivity analysis for wet runs as well. In the new version of the manuscript, we now give the results of the sensitivity analyses as suggested by Reviewer1. We refer to our reply to Reviewer1 for more information.

5.
For the experiments the main influencing factors on infiltration are given in chapter 3.1 which are vegetation cover, runoff width and antecedent moisture content. Was it tested, if the model responds to changes within these parameters in the same range as observed by the experiments?
Our experimental data indicate that the cumulative infiltration coefficient is a function of the vegetation cover, antecedent moisture content and runoff width. About 78% of the variation in the cumulative infiltration coefficient can be explained by these factors. Similar conclusions can be drawn from the results of the kinematic wave model. The modeled results also indicate that runoff transmission in the gully channels is highly dependent on these three parameters. Although the goodness of fit of the process based model is lower than the one of the empirical model, the direction and the order of magnitude of the correlations is very similar. We now clarify the link between the experimental and the modeling results in the conclusion.

6.
Some concluding remarks merging the experimental and modeling results would be helpful.
REPLY: We now added a few sentences in the conclusion, which make the link between the experimental and the modeling results.

Specific comments:

Page 2538, line 21: the relation of vegetation cover to sediment storage is not investigated in the paper. Maybe a citation could be added, where this is shown? We now added the reference to our work on sediment storage in vegetated gully beds that was recently published in ESPL (Molina et al., 2009).

Page 2538, line 25: “the model is able to predict the transfer of runoff water generally well…” ® “The calibrated model is able to simulate the transfer of runoff water generally well…” Ok, was rephrased.

Page 2538, line 26: “predicted total outflow” ® “simulated total outflow” Ok

Page 2539, line 4 to 6: this conclusion could be only drawn from the results of the field experiments. Correct, this is mainly based on our observations during the field experiments. We have rephrased this sentence.

Page 2541, line 5 to 8: it would be helpful to specify the aims of the model application. We rephrased this section, and now specifically mention the added value of the modelization.

Page 2543, line 16 to line 21: in Table 4 roughness coefficients for each gully are shown. It would be helpful to mention, that the results of the roughness coefficient estimation are displayed in Table 4. Ok, we now make reference to Table 4 in this section.

Page 2543, line 24: why is equation (3) given here? It is not used again. This comment was also raised by reviewer1. We have deleted this equation.

Page 2550, line 25: "predicted" ® "simulated" Ok

Page 2551, line 2: "predict" ® "simulate" Ok

Page 2551, line 1 to 3 and Figure 5(a): why is there a slight tendency of the model to under predict the outflow volumes for some experiments, since each model run was calibrated? Can this be explained? This is now discussed in the text. The gully bed of active and transient gully systems typically consists of a thin layer of sediments deposited on top of impermeable bedrock. In our model, we use the Philips equation to estimate infiltration rates. This equation is particularly suitable for homogeneous, deep soils or sediment deposits. As this assumption is not fully fulfilled for active and transient gully systems, the infiltration processes are not adequately modeled.

Page 2551, line 25: "predictions" ® "simulations" Ok

Page 2551, line 7 to 17: it should be mentioned within this paragraph, that the model results of the San Miguel 2 experiments are displayed in Figure 4. It is shown in Figure 4 that the recessing limb of the hydrograph is poorly predicted. I suggest a more detailed explanation why the rock outcrops in the gully bed are poorly represented by the model and why this results in an under prediction of the outflow volume.
Reviewer1 also expressed this comment, and we have replied to this in more detail above (see Reply to Reviewer1 - General Comment #2). The poor model prediction of the outflow rate of the San Miguel2 is mainly related to the poor representation of the infiltration processes by the Philips equation. We now clarify this in the text.

Page 2550 to 2551, chapter 4.1: I suggest giving the spectrum of the variation of K and S in the text. What is the difference between wet and dry conditions?
We now added the range of the values of K and S that were used for the model calibration, for wet and dry conditions.

Page 2552, line 2: it is unclear why Fiener and Auerswald (2005) are referenced here. Are the authors' observations in agreement with theirs? We clarify this now in the text, and have added a sentence : 'This observation is in agreement with the study of Fiener and Auerswald (2005) for grassed waterways.'

Page 2551 to 2553, chapter 4.2: I suggest a discussion of the results of the sensitivity analysis at the end of chapter 4.2.
This issue was also raised by Reviewer1, who suggested to further elaborate the sensitivity analysis. We refer to our reply to Reviewer1 for more information.

Page 2553, line 11: it would be helpful to give a short explanation how the correlation analysis was carried out (for what parameters) before explaining the results. We now added a sentence at the beginning of this paragraph to explain the methods that we used.

Page 2553, line 11 to 12: I suggest giving a band width of the weak correlation of S in comparison to K in the text. Ok, we now added the range of correlation coefficients in the text.

Page 2553, line 17: give a number (i.e. model efficiency) for decreasing model performance.
We now give the model efficiency for this model.

Page 2553, line 18 to 19: it would be again helpful to give a band width of the correlation of K* in comparison to K in the text and to mention how it has changed. Ok, we now added the range of correlation coefficients in the text.

Page 2554, line 9 to 13: give some references here. We now added two references to Le Bissonnais et al. (2004) and Fiener and Auerswald (2003).

Page 2554, line 17 to 18 and page 2555, line 1 and 14: I suggest to use the term "process based model" than "physically based model" Ok

Page 2554, line 23: give a number for the poor model efficiency We now give the model efficiency for this model.

Page 2555, line 26/27: "predicts" ® "simulates" Ok

Page 2556, line 3: "predict" ® "simulate" Ok

Page 2556, line 2 to 3: S and K were calibrated Ok, this is now clarified in the text.

Page 2556, line 5 to8: I suggest some concluding remarks, why these model parameters are difficult to predict.
We now added a sentence to clarify this issue: "Our observations indicate that this is largely related to the high spatial variability in gully bed characteristics."

Page 2556, line 8 to 11: the influencing gully characteristics mentioned here are derived from the experimental results (chapter 3.1). The results of the correlation analysis of the optimized parameter values and gully characteristics are given in chapter 4.3. Some concluding remarks merging the experimental and modeling results would be helpful.
We added a few sentences in the conclusion. The results of the statistical analyses of the experimental data nicely fit with the results of the correlation analyses of the fitted parameter values. This further confirms the robustness of our conclusions.

Page 2570, Figure 5: I suggest "simulated outflow" than "predicted outflow" in the description of (a). It would be helpful to add the results of the goodness of fit parameters to the Figures (a), (b) and (c). The measured outflow volume should be put to the x-axis and the simulated volume to the y-axis in (a), (b) and (c). Then the under or over prediction of the simulation is clearly shown. We now added the model efficiency to the Figures, and put the measured or observed outflow volume on the X-axis.

Technical corrections:

Page 2538, line 27: "the most sensitivity parameters" ® "the most sensitive parameters" Ok, was changed.

Page 2540, line 21 and line 23: writing of "stabilization" varies between "z" and "s". We now systematically use the term 'stabilization'.

Page 2540, line 23: delete "most likely" Ok, was deleted.

Page 2540, line 25: "quantitative measures" ® "quantitative observations" or "quantitative measurements" Ok, we replaced 'measures' by 'measurements'

Page 2540, line 29: delete ","Ok, was deleted

Page 2541, line 15: "southern" ® "Southern" Ok.

Page 2541, line 18 to line 21: "The region is characterized by a tropical mountain climate (Dercon et al., 1998), and mean annual rainfall measured at the station of Cochapamba-Quingeo is about 810mm, but it is known be significantly higher at higher altitudes." ® "The region is characterized by a tropical mountain climate (Dercon et al., 1998). Mean annual rainfall measured at the station of Cochapamba-Quingeo is about 810mm, but it is known to be significantly increasing at higher altitudes." Ok.

Page 2541, line 26: delete ","Ok.

Page 2542, line 6: "has accelerated" ® "have accelerated" Ok.

Page 2542, line 9: delete "…and vegetation restoration" because this is again mentioned and explained in the following sentence Ok.

Page 2543, line 14: "Manning's resistance coefficient" ® "Manning's roughness coefficient" Ok.

Page 2544, line 17: "The model describes…" ® "The model processes…" Ok.

Page 2545, line 11: delete ","Ok.

Page 2546, line 14: "Delectic" ® "Deletic" (see References) Ok.

Page 2547, line 13: delete "," after "obtained" Ok.

Page 2548, line 1: a, b are already defined in line 3, page 2547 Ok. These definitions were deleted.

Page 2548, line 3: give a Reference here We added a reference to the work by Jaber and Mohtar (2002) on the stability of finite element schemes.

Page 2549, line 8: "tranmission" ® "transmission" Ok.

Page 2549, line 25: "when dry" ® "when they are dry" Ok.

Page 2550, line 1: "adds roughness" ® "increases roughness" Ok

Page 2551, line 7: "shows error" ® "shows an error" Ok

Page 2552, line 22: add "When" at the beginning of the sentence Ok

Page 2552, line 28: "sensitivity"® "sensitive" Ok

Page 2553, line 22 to 23: explain abbreviations of equation 12 Ok. All the variables are now described below the equation.

Page 2555, line 20: delete ","Ok

Page 2558, line 3 to 4: delete Le Bissonnais et al. This Reference is not cited in the paper. We have added the reference in the text (introduction), as this study shows interesting data on the efficiency of grassed waterways.

Page 2560, Table 1: delete "component" Ok

Page 2561, Table 2: add, that the other experiments (without asterisk) are wet run experiments We re-arranged Table2.

Page 2569, Figure 4: the Figures as well as the font size are small and therefore difficult to read
Page 2570, Figure 5: the font size of the Figures is small and therefore difficult to read
The figures have been improved taking into account the suggestions of the reviewers.

Page 2571, Figure 6: add abbreviations of the varied parameters (S, W, K, n) to the Figure description Ok