

Interactive comment on “Riparian forest and permanent groundwater: a key coupling for balancing the hillslope water budget in Sudanian West Africa” by A. Richard et al.

Anonymous Referee #1

Received and published: 24 May 2013

Review “Riparian forest and permanent groundwater: a key couple for balancing the hillslope water budget in Sudanian West Africa”

General comments: The paper shows an interesting simulation on the role of groundwater sustaining riparian forest transpiration in a tropical country (Benin, Africa). The modeling is made using Hydrus 2-D. However, the results could be discussed in a more appropriate and balance way. There are many references available on the subject of riparian forests and streamflow/groundwater interactions. The authors should include them because they will strength the paper and they will also insert the paper in a broader context since riparian forests was also a matter studied in many other coun-

C1970

tries. The scientific results and conclusion could be presented clearer way. The paper needs to be better organized using a classical original research format (see comment below). With regard to the English, it also needs a substantial rewriting. This has to be done by a native speaker. For these reasons, the paper needs substantial changes before it is considered for publication. There is a lot of interest in the paper main topic. I really would like to reread this paper after changes are incorporated.

Central questions that might help the authors: What’s the paper novelty? Are your results in line with the current knowledge? Regardless the answer, you should discuss why? Is there somewhere where similar results were found? I recommend the classical original research article format: Introduction → Methods → Results → Discussion → Conclusion. Other possibility is to gather Results and Discussion.

Title: What do you mean with “a key couple for balancing the hillslope water budget in Sudanian West Africa”?

Abstract An English review is needed for this part. P5644 L5: “This is especially true” → in the introduction you said that it is assumed. P5644 L5-6: The riparian forest and groundwater coupling is not the only way forests transpire throughout the dry season (see Nepstad et al., 1994; Markewitz et al., 2010). Moreover, I suggest to the term groundwater/permanent water table instead of permanent aquifer. After the incorporation of the changes specified below, please, rewrite the Abstract. Introduction section Keep in mind the objective of the paper. The first paragraph (P5645 L4-20) is the clearest one in this section. The second one (P5645 L21-27 and P5646 L1-12) and the others seem to digress. Thus, this section needs to be reorganized substantially. Try to connect the ideas in the paragraphs leading the reader to finally understand the real purpose of the paper. Maybe a better organization of the paragraphs is enough but the way it is, it is confusing and hard to follow. I have made some comments on that, but, as I said, it requires a substantial effort to make it clearer. Is there any concrete information on the possible role of riparian forests contributing to the monsoon in the region? A study using tracers? If not, excluding this part is recommended. You should highlight

C1971

the novel that this paper brings about to the current knowledge. See the references.

Specific comments: P5645 L1-2: "The West African climate is characterised by strong interactions between the atmosphere, the ocean and the land surfaces": Please include a reference where the reader can find more information on this statement.

P5645 L2-5: "During the wet season, the ocean brings moisture to the continent through a typical atmospheric monsoon circulation driven by meridional energy and moisture gradients." Again, please include at least one reference where the reader can find more information on this statement.

P5645 L11-12: "It is suspected that this reservoir of water plays a major role for the WAM onset into the Sahel": Which reservoir? Please be specific to avoid different interpretation.

P5645 L16: Please include the word "of" after the word "understanding"

P5645 L16-19: Very long and possibly confusing sentence. Please break it into smaller ones and rephrase it.

P5645 L20: Please delete "to" after the verb "benefit"

P5645 L21: Is it possible to provide the full name before the first appearance of the acronym?

P5645 L19-20: What is a "better closing of the water balance"? I don't feel that this is a good justification for the study.

P5645 L23: What do you mean with "nested catchments"?

P5646 L3: What do you mean with "subsurface fluxes"? Baseflow? Please be specific.

P5646 L28-29: "Along these lines". Please rephrase it.

P5647 L17: "guessed to be so important". Please rephrase it. In addition, please include a reference(s) with regard to riparian forests and their role in evapotranspiration.

C1972

P5647 L18: Please include a "," after the word "rainfall".

P5647 L22-24: Please rephrase it.

P5647 L24-27: Very long and possibly confusing sentence. Please rephrase it.

P5647 L27-29: Please rephrase it.

P5648 L4-10: There is no need for this explanation about the structure of the paper. The final paragraph of the "Introduction" section is generally used to define the objective of the paper in the light of the context presented along the section. So, please, be concise and direct to expose your objective very clearly.

Comment on Figure 2. What's the riparian buffer width? Could you mention in the text?

Methods section

Please avoid using terms (i.e. "base case") that might be confusing for the reader.

P5648 L17-18: "cultivated area associating crop and fallows". Please rephrase it.

P5648 L19: "free water areas". Please define it or rephrase it.

P5648 L20-22: Could you provide the width of riparian forests?

P5648 L23: What are the cultivated crops? Wheat? Corn? Sugarcane? Could you include this information?

P5648 L26 P56491: Please rephrase it. Avoid using the term "falling".

P5648 L2-5: If the flow is intermittent it is not permanent. Please rephrase it.

P5648 L5-6: "High waters" Please define it or rephrase it.

P5649 L13-14: Can you provide a more precise soil classification using for example the US Soil Taxonomy or other taxonomic system? In addition, "weathered gneiss and micaschist, fractured bedrock substratum" are not soils.

C1973

P5649 L15-19: OK. I see some soil classification. I guess it is the FAO system. Please include the system of soil classification.

P5649 L18: What is “bas fonds”? Please explain it to the reader.

P5649 L19: What is a “horizon base”?

P5649 L20-21: “The horizon is sandy, mainly sandy loam” Please rephrase it.

P5649 L24-25: “The aquifer is mainly made up of silty and clayey saprolites”. You are referring to the grain size distribution of the saprolite not the aquifer. Please rephrase it.

P5650 L3-4: There is no need to define upper and lower limits of the hillslope. Catchment boundary → water/topographic divide in parenthesis.

P5650 L4: What kind of sensors did you used? Please tell the reader in detail. The same thing for the rain gauge.

P5650 L5: “hydrological terms”. Please rephrase it.

P5650 L5-19: Since the hydrological data is the basis for a modeling, you should provide more details on the instruments used. You should not tell the reader to look for more details in other references.

P5650 L6: What’s a soil moisture station? Can you describe the soil moisture sensors used? How often do they record soil moisture?

P5650 L7-9: Please try to be concise and avoid repetition.

P5650 L20: “Soil physics properties” → Soil physical properties. Which soil physical properties? Please cite them explicitly.

P5651 L6-7: If you have some rainfall data to define a “dry” or “normal” year. Please include a mean and standard deviation and then you can describe rainfall levels in 2006 and 2007. In this sense, the reader is able to identify if they were dry, normal or wet

C1974

years.

P5651 L9: What is a “significant rainfall”? Please rephrase it.

P5651 L8-11: Given that you’re reporting annual levels from 2006 and 2007, you report it using the verbs in the past and not in the present. Please rephrase it.

P5651 L4-18: This part needs a substantial rewriting. Please try to be concise and provide detailed information on LAI only if it adds to the paper. Otherwise, I suggest to simplify this part by removing excess information.

P5651 L20-21: Be concise. You could simplify the sentence saying that the topography and soil conditions along the hillslope are similar.

P5651 L21: The sentence “The finite. . . is used” is lost in the text. Please connect it to the other phrases.

P5653 L10: “above 50 cm”. Above what? Please rephrase it. Besides, try to use meters instead of centimeters. And be consistent throughout the paper.

P5653 L11: “20 m large”? Do you mean height? “Root extent may be larger” Please rephrase it.

P5653 L10-13: Please rephrase it. It’s not clear.

P5653 L17: horizon base? What do you mean?

P5653 L24: Please use meter instead of centimeter.

P5654 L9: Please delete “Base case”

P5654 L11: Please rephrase “Soil parameters were locally measured”

P5654 L12-13: Please rephrase

P5654 L11-26: Please rephrase and pay attention to the verbs that should be in the past

C1975

P5655 L2: variable or parameter?

P5655 L18: "Evaluated". Do you mean validated?

P5655 L11: Is it really necessary to call 2006 as "base case"? I don't think so.

P5655 L20: What was the period of time that "virtual experiment" was performed? 2007? Be express it.

P5655 L22-24: The water budget is a calculation. You used it to evaluate other things like evapotranspiration... please rephrase this part and include these things that you really wanted to measure through the use of the water budget.

P5655 Table 2 is okay. But $T_p(t) = T_{p,base}(t)$ and something alike is not clear for the reader. Is it really necessary to keep this part within the Table? If so, please specify like you did with PRSD and LBC

P5656 L3-4: See the comment P5655 L22-24

P5656 4-5: include in the end of the phrase "in the riparian area" or something like this. Be specific.

P5656 L3-19: It's very clear for the reader the "virtual experiment". However, don't forget to include verbs in the past form, okay?

P5656 L5-8: It's okay to do this with LAI. However, don't forget to adress this limitation on the discussion part of the paper.

RESULTS

You should include in the discussion section that the calibration was made for 2006 which was dry year. What are the implications for the model performance during a wet year like 2007? Please discuss it.

P5656 L24: "prescribed" please rephrase it.

P5656 L25: "Soil physics parameters" → see comment above.

C1976

P5656 L26: Please delete "as already mentioned earlier" or rephrase it.

P5656 L5: If you know the lateral extent of the root is around 20 m, why didn't you use it?

P5657 L11-12: "The 2006 calibrated simulation reproduces correctly the internal dynamics of the vadose zone" I can not see this, especially with regard to Fig.5 c, d, d'

P5657 L12: Please delete "as can be seen from the graphs on Figure 5".

P5657 L20: include it was not good for the rainy season

Please delete "illustrating the annual evolution for the bottom and the middle of the hillslope."

P5657 L14: Figure 5: I see the point to keep a and a' identical in the same figure.

P5657 L15-16: Please rephrase it.

P5657 L19-20: Please rephrase it.

P5657 L14: If they are identical, please, leave only one. There is no need for repetition.

P5658 L6: "amplitude"? Do you mean range? Amplitude of what? Water table depth? If so, please, be specific.

P5658 L8-15: Visually, I really think the model simulated the evapotranspiration very well.

P5658 L20: all year long → please delete "the"

P5658 L22: Fig.8 → seepage can not be seen very clearly. Is it possible to make it clearer?

P5658 L24: "larger" → higher

P5658 L25-26: "installation of the rainy season" → please rephrase it.

C1977

P5658 L29: see the comment P5658 L20

P5659 L6: "pumping the missing water from the water table" → please rephrase it.

P5659 L12: evaluation or validation?

P5659 L13: "variable" or parameter? "Fitted"? Do you mean calibrated?

P5659 L18: what's "resp. higher"? What's "resp. middle"?

P5659 L20: "the annual dynamics is quite well simulated" → I don't agree (see Fig. 9c)

P5659 L22: "as for the year 2006" → please rephrase it.

P5659 L27: "the maximum is reached too late" → please rephrase it.

P5660 L10-13: Good! Whenever possible, try to make this link between years (simulation x validation).

P5660 L24: "unrealistic dream" → please rephrase it.

P5660 L24: "dispose"? What do you mean?

P5660 L26: vegetation and aquifer do not control the water budget. They may affect the water dynamics (hydrological processes) which can be evaluated by calculating the water budget.

P5661 L3: "The virtual experiment bears on year 2006". Please rephrase it.

P5661 L3-5: This is very interesting!

P5661 L5: delete "the" before the word "year".

P5661 L5-6: "the hillslope generated seepage all the year long" → When? 2006? 2007? Please be specific.

P5661 L3-13: please avoid repetition. These data is already presented in Table 3. So there is no need to mention what in there in the text. If you want you can leave the

C1978

text and delete Table 3, but I wouldn't do so, since it synthesizes the results of your simulation. This is the central part of the paper. Be concise and discuss this table in Discussion. Then, you could include references that are or are not in line with your simulation.

P5661 L16-20: You should discuss the fact that LAI variation is not included in the simulation. What would be its impact in case it had been included? Why rooting depth has a weak impact on annual evaporation? Or evapotranspiration?

5 Synthesis and conclusions

Where is the Discussion section? You should create it before the Conclusion section. This part is very long. I would create a discussion and then I would make a shorter conclusion with the core findings.

P5661 L22: "Position of the problem" → please rephrase it or delete it

P5661 L24: Please replace "they" by "trees"

P5662 L1: You should include a reference that says what you said is assumed. Likewise, I don't think this approach strengthens the paper.

P5662 L2: What 's a "healthy monsoon"?

P5662 L4: "pump" → please rephrase it.

P5662 L6-7: nothing interacts through the water budget. The water budget is a calculation. Please see comment above.

P5662 L8: Please delete "outmost"

P5662 L10: "the table level" → please rephrase it.

P5662 L12: which scale? Please be specific.

P5662 L14: "fictive" → please rephrase it.

C1979

P5662 L10-24: This part should be in the discussion.

P5662 L21-24: You have already said it earlier. So please delete it.

P5662 L26-27: this sentence has to be rephrased. Moreover, “80% and 90% of the annual water budget”. Do you mean 80% and 90% of the annual rainfall?

P5663 L20: “potential transpiration” → please define it or reword it.

P5664 L1-2: Be aware that riparian is a position in the landscape. So be specific when you say “riparian transpiration system”. In addition, define “couple transpiration system”.

I think there is a paradox between P5663 L25-27 and P5664 L8-10. Please reexamine it.

P5664 L14: What’s “transpiration efficiency”? Reword it or define it.

P5664 L14: “On the opposite” → By contrast

P5664 L16: Please do not use the term efficient cause it has other meaning in plant physiology.

P5664 L19: Please rephrase “all along the year”.

P5664 L20-21: “It is the signature of deep rooted persistent vegetation”→ please rephrase it.

P5664 L21: Delete “persistent”

P5664 L21-22: superficial → surface

P5664 L24: “annual transpiration signal” → please rephrase it

P5664 L26: “transpiration is mainly supplied by the riparian forest” → please rephrase it

P5665 L19-21: please rephrase it and explain better the results found by Séguis. 6 –
C1980

34 mm d-1 is an enormous value!

P5665 L23: “emptying the downslope water table”. Please rephrase it. In addition, include the daily riparian evapotranspiration that you estimated to compared to Séguis et al. 2011 estimates.

P5666 L12: Do you have any observation from the field to tell the reader it the absence of seepage is realistic? If so, please do it.

P5666 L14-16: I agree, otherwise there wouldn’t be streamflow generation. But if first and second order streams are surrounded by riparian forests, where do you think streamflow is generated?

As you said earlier, this modeling exercise was not aimed to be really accurate. Thus, the decoupling between groundwater and river might be a consequence of such “simplified hillslope representation” though some papers have shown the riparian forest water use on streamflow/groundwater (please see the references). You should discuss these uncertainties.

P5666 L17: Rephrase this first phrase.

P5666 L23: “slope forest” → please rephrase it.

P5666 L17-26: There are many studies in the literature that analysed the riparian forest evapotranspiration. You should look for them and include it.

P5666 L27: What’s “rapid and drastic evolution of the vegetation cover”?

P5667 L1: “inner growth” → please rephrase it.

P5667 L4: In addition, the model assumes that all rainfall events infiltrate. This not a very realistic assumption since croplands usually show higher overland flow generation compared to native primary forests. Thus, land-use change is followed by changes in water flowpaths in most cases.

Figure 6. Please indicate the observed data in the graph. Do not use the method (i.e. flux tower).

Figure 9. Please rephrase the captions and avoid repetition of the same graph (a and a')

Figure 11. What's a saprolitic soil?

Recommended references:

Brown, A.E., Zhang, L., McMahon, T.A., Western, A.W., Vertessy, R.A., 2005. A review of paired catchment studies for determining changes in water yield resulting from alteration in vegetation. *J. Hydrol.* 310, 28–61.

Dye, P.J., Poulter, A.G., 1995. A field demonstration of the effect on streamflow of clearing invasive pine and wattle trees from a riparian zone. *S. Afr. Forestry J.* 173, 27–30.

Gribovski, Z., Kalicz, P., Szilágyi, J., Kucsara, M., 2008. Riparian zone evapotranspiration estimation from diurnal groundwater level fluctuations. *J. Hydrol.* 349, 6–17.

Gribovski, Z., Szilágyi, J., Kalicz, P., 2010. Diurnal fluctuation in shallow groundwater levels and streamflow rates and their interpretation – a review. *J. Hydrol.* 385, 371–383.

Ingebo, P.A., 1971. Suppression of channel-side chaparral cover increases streamflow. *J. Soil Water Conserv.* 26 (2), 79–81.

Dunford, E.G., Fletcher, P.W., 1947. Effect of removal of stream-bank vegetation upon water yield. *Trans. Am. Geophys. Union* 28 (1), 105–110.

Scott, D.F., 1999. Managing riparian zone vegetation to sustain streamflow: results of paired catchment experiments in South Africa. *Can. J. Forestry Res.* 29, 1149–1157.

C1982

Salemi, L.F., Groppo, J.D.; Trevisan, R., Moraes, J.M., Lima, W.P., Martinelli, L.A. 2012. Riparian vegetation and water yield: A synthesis. *J. Hydrol.* 454-455, 195-202.

Nepstad et al. 1994. The role of deep roots in the hydrological and carbon cycles of Amazonian forests and pastures. *Nature*, v.372, p.666-669.

Markewitz et al. 2010. Soil moisture depletion under simulated drought in the Amazon: impacts on deep root uptake. *New Phytologist*, v.187, p.592-607, 2010.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 5643, 2013.

C1983