

Model-based study of the role of rainfall and land use land cover in the changes in Niger Red floods occurrence and intensity in Niamey between 1953 and 2012

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Response to the review #1

First we would like to thank you for your comments and for helping us improving our manuscript.

Responses to major comments:

Concerning your worry about our “conclusion that LULC is closely related to the hydrologic change in this region” and the need to back up this conclusion with more observational evidence: this paper is a complement to several observation-based studies (see citations below) which have shown the evidence of an increase in floods occurrence in Niamey and have also shown i) on the one hand that there have been LULC changes in the region and that LULC impacts strongly the runoff in this region and could explain the increase in floods and ii) on the other hand that rainfall variability has been strong in the region and could also explain flood occurrence variability. Because observational studies alone are not able to discriminate between these 2 factors, the objective of this model based paper is to understand the impact of the observed rainfall variability on the Niger River regime in Niamey from 1953 to 2012, and to investigate the impact of other factors driving hydrology in Sahel and which have been reported to change during the studied period (such as LULC or drainage area).

1.a LULC change evidences : What is known about eco-hydro-climatic changes in the Sahel is reminded in the introduction. LULC changes have been observed by several authors, and some are cited in the paper from page 12042 line 24 to page 12043 line 1 (Seguis et al. 2004, Leblanc et al. 2008, Descroix et al. 2009 and 2012, Valentin et al. 2004, Peltier et al. 1995, Hiernaux and Le Houérou 2006), we will add Amogu et al. 2010 in the revised version. Observations about changes in the drainage area are also reported in page 12043 from line 4 to 7 (Leblanc et al. 2008, Amogu et al. 2010), and we will add a more recent citation (Mamadou et al. 2015). We will make it more clear in the revised version that those changes have been observed and reported already. The objective of the present paper is not to provide new evidence about these changes but to investigate their impact on the hydrological regime and how they contribute to explain the observed changes in flood occurrence, together with rainfall variability.

1.b The reason we concentrate on these 3 driving factors (LULC change, drainage area changes, rainfall variability) is: i) because those 3 factors have been reported to change in the region (see 1a above) and ii) because it has been shown that in the Sahel and more particularly the Niamey area under study here, the main driving factors for hydrology are surface conditions (and whether or not rainfall exceeds the infiltration capacity of the soil) (Collinet and Valentin 1979, Albergel et al. 1987, Cazenave and Valentin 1992, cited in 12042 lines 27-28). Rainfall, drainage area and surface condition (LULC) being the main hydrological drivers in Sahel,

and previous studies (1.a) having shown their evolution, we focused on these 3 factors. Note also that there is no reported evidence of other changes that could be relevant here.

1.c The purpose here is not to prove that a single and particular combination of LULC change and drainage area is the ‘true one’ but rather to provide a sensitivity study in order to understand better the observed hydrological changes and their drivers. The LULC changes as investigated here are not supposed to be a perfect representation of the real environment; they are a simplified representation of what has been observed: there was more vegetation and less bare soil in the 50’s and 60’s. Note that further investigations with a dedicated model and a more precise/realistic representation of vegetation are planned for the future

Similarly for changes in the the drainage area. We chose to mimic in a simplistic manner what is known of the conditions in the 50’s 60’s with no contribution of the River’s left bank, and of the north of the Gorouol basin. This configuration is only aimed to illustrate and quantify the impact of drainage area reduction.

2. We will provide a better description of the CPC product in the revised version, as suggested. The evaluation of CPC, KRIG and PERSIANN-CDR products against a reference is provided in the Appendix but not much commented in the present manuscript; in the revised version we will make more references to the appendix results in the main text.

3. Concerning the pro and cons of the 3 rainfall data sets, we will elaborate a bit more on the evaluation results provided in the appendix. Some comments on the “smoothing” effect of products like CPC, that suffer from the gauge network sparseness, were already made in Casse et al. 2015 but we will remind it. Note that the sensitivity of the hydrological model results to the rainfall forcing is investigated and discussed in more details in Casse et al., (2015) which is why we did not well on this in this paper.

The reason we used 3 products is to show that for the period where the 3 data sets are available, the results for the 3 products are very consistent; showing that the conclusions do not depend on the product (page 12044 line 9-10-11).

4. Concerning the lack of reference to previous work on the Niger. We are a bit surprised by this comment given that a major part of the introduction is dedicated to the description of previous works on hydrological changes in the Niger river/Sahel area and their drivers. Paragraph starting in page 12042 line 20 and ending in page 12043 line 11 describes results of previous researches based on observations. Paragraph starting in page 12043 line 12 and ending in the same page line 27 reports studies based on modeling. This paper is clearly not the first related to Niger basin hydrological changes; it is the first to “include the most recent period and the record Red floods of 2010 and 2012” (page 12043 line 23-24). Concerning the use of hydrological modeling to better understand the role of LULC and rainfall on hydrological changes in sahelian basins, only few studies have taken into account both sources of change ; and only one focused on the hydrograph in Niamey station : Aich et al. (2015) (plus the previous Casse and Gosset 2015). Following your comment we will modify the discussion/conclusion to better compare our results to previous studies and highlight our findings.

Minor edits:

We will include all the edits you suggest in the revised version.