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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Droughts and floods over the upper catchment of the Blue Nile and their connections to the timing of El Niño and La Niña Events" *by* M. A. H. Zaroug et al.

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ageel_bushara@yahoo.com Received and published: 24 October 2013 The comment was uploaded in the form of a supplement: http://www.hydrol-earth-syst-sci-discuss.net/10/C5835/2013/hessd-10-C5835-2013-supplement.

1) Sometimes the authors mixed between the Blue Nile and the Nile. E.g., on page 10972 line 5, flow over the Nile basin. On the same page line 9, Nile should be changed to Blue Nile. Done, thanks. Page 10977 line 13, Nile River should be changed to Blue

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Nile Done, thanks. and on the same page line 19, the upper catchment of the Nile should be the upper catchment of the Blue Nile. Done, thanks. Page 10978, line 20 Upper Nile catchment should be upper Blue Nile catchment. Done, thanks. Page 10979, line 2 the upper Nile catchment should be the upper Blue catchment. Done, thanks. Heading 3.2 (page 10979) it should be .,..in the upper Blue Nile catchment. Done, thanks. Page 10980, line 10, the Nile River should be Blue Nile River. Done, thanks. The focus of study is on the Blue Nile. It's true that the Blue Nile is a main tributary of the Nile River. Agreed.

2) The introduction is more about the Nile River rather than the focus of the study: on Blue Nile. Line 24 on page 10972, . . .to the main Nile discharge (Ref). Please put a reference as indicated in the parenthesis. The reference is added: 60-69 % to the Main Nile discharge (Dumont, 1986b)

3) Page 10973, lines 14 to 16, these two natural extreme disasters. . .. . . You need a reference for that. References and text are added to the second paragraph in the introduction.

4) Page 10973, lines 24 to27, Eltahhir (1996). . . . . .the Nile floods. This sentence relates El Nino to floods. As discussed later in the paper is that El Nino is related to droughts. The sentence was made clearer by changing "El Nino oscillation" to "ENSO".

5) Page 10974 line15, however, no study focused on the June to September rainfall in Ethiopia. This is not true, Seleshi and Zanke (2004) have focused on the analysis of rainfall in Ethiopia in the same period (see line 9 on the same page). The sentence was amended to "none of these studies focused on the June to September rainfall in Ethiopia". Please give strong reasons for the importance of your study. In the last paragraph of the introduction: "In this study, we analyze river flow and rainfall observations with the goal of evaluating the impact of El Niño on drought and flood conditions in the upper catchment of the Blue Nile. Not all El Nino and La Nina events are the same (see Figure 1), they have different timing and character. In fact, different events start in dif-

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ferent times of the year and their sequence exhibits different impacts. In this paper we focus on the dependence of occurrence of droughts and floods in the upper catchment of the Blue Nile on the timing and sequence of El Nino and La Nina events. In particular, we attempt to identify the sequence of Pacific Ocean seasonal SST conditions that most affect drought and flood conditions over Ethiopia in order to provide recommendations for possible use as input to seasonal water resources forecasting systems. This would have great economic and social value for the management of water resources in the region." It would be good if you define El Nino and La Nina El Nino is defined in page 5, line (25-27). This definition is moved to the introduction, page 3, line 16 (An El Nino/ La Nina is the phenomenon in the equatorial Pacific Ocean characterized by a positive/ negative Sea Surface Temperature (SST) defined as a three-month average of SST departures from normal (for the 1971-2000 climatology) in the Niño 3.4 region (5°N–5°S, 120°–170°W) greater than or equal in magnitude to 0.5 °C/ -0.5 °C for a minimum of 6 consecutive months or longer (Trenberth 1997)). The definition of SOI is also added in the text (The Southern Oscillation Index (SOI) is a measure of air pressure difference between Tahiti in the east and Darwin, Australia to the west as compared to historical average of the same difference. Negative differences indicate an El Niño condition as lower pressure in the eastern Pacific is associated to warmer water and weakened easterly trade winds, and positive SOI corresponds to negative SST index and La Niña.)

6) In Data and Method section, you cannot have one heading (2.1), please delete 2.1 heading. Done, Thanks. The missing data of Eldiem station in the period 1997-2001 was filled using the nearest station, Elrosieres. The filling method has to be reported in some details. It seems that you use the Elrosieres values to fill Eldiem because you mentioned that there are no contributing tributaries in Elrosieres – Eldiem reach. If yes, in this case you neglect the contribution of local rainfall, rainfall amount is relatively high in this area. Further, the infiltration in the river reach is also neglected; the distance between Elrosieres – Eldiem is 120 km, as you mentioned, and that is long distance. Part of the following discussion will be added to the text: The contribution

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of inflow/losses to the river between Eldiem and Elrosieres is very small compared to the contribution of the runoff from the whole upper catchment of the Blue Nile. In this study we accumulate the daily discharge of June, July, August and September at Eldiem station, and the accumulated daily discharge at Elrosieres during the same period is almost similar to Eldiem. Conway (1997), made water balance model of the Upper Blue Nile in Ethiopia. He used Elrosieres record for 1912-1963, before construction of the Elrosieres dam, and Eldiem for 1964-1987 to provide a continuous time series. He found good agreement between two gauges during their period of overlap (annual correlation= 0.97). You use GPCP dataset with 2.50 resolutions. This resolution is too course in such mountainous region, I would rely on the other high resolution products. Because of the uncertainty in the observational rainfall dataset, we use three different dataset as indicated in the second paragraph of section 2; two of them are high resolution: "For this reason, we use multiple precipitation datasets: the global dataset of monthly precipitation from the Global Precipitation Climatology Project (GPCP) version 2.2 (Huffman et al. 2011), which is a satellite/gauged-merged rainfall product available from January 1979 to December 2010 with a resolution of 2.5°; The Climate Research Unit (CRU, land only) $0.5^\circ \times 0.5^\circ$ resolution monthly precipitation dataset (Mitchell et al. 2004), which is a purely gridded gauge product; and the University of Delaware (UDEL) monthly global gridded high resolution station (land) data ($0.5^\circ \times 0.5^\circ$ resolution) available from 1900-2010 (http://www.esrl.noaa.gov/psd/). " In figure 8, the GPCP showed a higher correlation with Nino 3.4 compare to the flow of the Blue Nile. While it is true that GPCP spatial resolution is relatively coarse, this data set extends for a long period of about 30 years. This is much longer than other data sets such as TRMM which has a higher spatial resolution but significantly shorter length of about 15 years.

7) Page 10976, line 16 there is space between with and some; written withsome. Done, thanks.

Line 22, while the number drought and flood. The sentence should be while the number of drought and flood. Done, thanks.

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8) In figure 3, it seems the extreme drought of 1984 is associated with La Nina. It's important to discuss the link between El Nino/ La Nina and such extreme drought. In figure 3 we tried to show the discharge of the Blue Nile and its association with El Nino and La Nina. From figure 3, table 3 and table 2, we infer that, El Nino is not always associated with drought and La Nina is not always associated with flood. 1984 was not an El Nino year although it was a very dry year. This drought seems to be associated with some other climatic processes. Seleshi (1991) suggests that one of the processes associated with Ethiopian rainfall is the movement of moist air from the high southwest Gulf of Guinea to the low northeast center of Arabia. Gray et al., (1992) that extra August to November (ASON) precipitation at Guinea may lead to more rain in the Sahel during the following year, and on the other hand, a dry ASON period may lead to drought in the Sahel several months later. Vizy and Cook (2001) found that both warming and cooling of the Gulf of Guinea in summer suppress convection over northeast Africa. Eldaw et al., (2003) found that the Blue Nile River JASO flow is significantly and positively correlated with the previous year ASON Guinea precipitation, and the Guinea precipitation is another potential predictor of the Blue Nile River flows with 11 months of lead time and r = 0.63 for the period 1953 to 1989. So, from the above studies about Gulf of Guinea, 1983 and 1982 were below average there, and they may be related to the severe drought in 1984. It is beyond the scope of this study to investigate years for which the Nile variability is independent of ENSO. These years may provide a subject for future research.

9) Figure 4 is not clear, Done, thanks. you mentioned in line 9, page 10976 is that the fig. shows monthly precipitation while in the fig is written monthly discharge. It was a mistake, and corrected from precipitation to discharge. The text above the fig "Monthly averaged discharge in El diem station during El Nino, La Nina and normal years" should be removed. Done, thanks. How did you calculate the time in months that shown in x-axis of fig. 4, please explain in some details. The text which describe figure 4 is improved to: .... depicted in Figure 4, which shows the monthly discharge (June-July-August-September) averaged over all El Nino (1965, 1986, 1969, 1972, 1982, 1983,

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1986, 1987, 1991, 1992, 1995, 1997, 2002, 2994 and 2009), La Nina (1970, 1971, 1973, 1974, 1975, 1985, 1988, 1989, 1998, 1999, 2000, 2007, 2008 and 2010) and normal years (1966, 1967, 1976, 1977, 1978, 1979, 1980, 1981, 1984, 1990, 1993, 1994, 1996, 2001, 2003, 2005, 2006, 2011 and 2012).

10) For fig 5, please use different line types for the thresholds and delete the title above the fig. The title was deleted. You could move x-axis to cross y-axis at -15000. The x-axis was moved to -15000. Page 10976 lines 23-25, this classification is in line with. . .. Electricity of Sudan (Ref). Please give a reference as indicated in the parenthesis. The reference was added. MOWRE, 2011. Page 10977, line 1-2, There are nine cases. . .. . ., this sentence is not clear and to be rewritten. The sentence was rewritten: "There are nine cases of extreme drought, five floods, and seven droughts". In fig. 5 and for extreme drought, four extreme years could be considered on the threshold; only five years could be considered as extremely dry years. The threshold for extreme drought is stated in page 6 line 17.

11) The quality of fig. 6 is bad and you don't need to have a title above each fig; Discharge anomalies . . .from 1982 to 2009 was repeated in all figures (6a, 6b, and 6c). Done, the titles were removed, and the quality improved. Lines 3 and5, page 10977, Nino3.4 should be Nino 3.4 (space between Nino and 3.4). Done, thanks. The discharge anomalies don't change with season as illustrated in figs 6a-6c. Why? any explanations for that. The discharge is fixed during JJAS. The season of the discharge was added to the caption of figure 6. Line 6 on the same page you wrote. . .is evident in the middle panel of Fig 6. It's also evident in the lower panel of Fig 6. Why you select the middle panel? This section was rewritten after calculating the correlation and the coefficient of determination in table 1 as shown below: Table 1. The coefficient of determination and correlation for the linear fit between Nino 3.4 index in different seasons and the JJAS discharge anomalies at Eldiem station for the period 1965 – 2012. JJAS precipitation SST index R2 Correlation JFM 0.01 -0.08 AMJ 0.15 -0.39 ASO 0.29 -0.53

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12) Table 1, the unit of length should be written; length (months). I would classify the table into zones: AMJ as extreme drought JJA as drought JAS as transitional zone (mixed behavior) ASO as No drought zone The unit was added (season). These classifications are mentioned in the last paragraph in page 7.

13) Table 2, the unit of length should be written; length (months). I would classify the table into zones: AMJ to JJA as variable zone (transitional) JAS as extreme flood zone ASO as no flood zone The unit was added (season). These classifications are mentioned in the second paragraph in page 8.

14) Page 10978, line 16, AMJ,JJA, and JAS, 67% of the times. . .... From table 2 if you count the extreme flood and flood events (that are 7 events) and divide that with the total events (12), the percentage will be 58 and not 67. In this analysis, we look at the effect of the start of La Niña in the flood of the upper catchment of the Blue Nile. La Nina may last for two or three years. But we are interested on the impact of the start of La Nina. Here we have 6 events when La Nina starts in AMJ, JJA and JAS. Among them, there are four extreme floods. So, the percentage is 67%. Line 17 page 10979 why you did not use the whole dataset, from 1965 to 2012? The observational discharge data are available from 1965 up to 2012. But the free observational rainfall data are not available from 1965 up to 2012.

15) You reported that 67% of cases in which El Nino was followed by La Nina there were extreme floods in the Blue Nile. Can you give interpretations for that? This is an interesting aspect of the system, such that when an El Nino is followed immediately by a La Nina then the likely result is a major flood. It seems that the momentum in the changing dynamics in those years is strengthened due to the persistent cooling through the two events.

16) Please remove the titles on top of figs 7-9. Done, thanks.

17) This study needs further discussions on the results and the findings of this study have to be compared with the literature. Figures need to be discussed in more details.

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Done, thanks

References: Conway, D. (1997). A water balance model of the Upper Blue Nile in Ethiopia. Hydrological Sciences Journal, 42(2), 265-286. Dumont, H. J., 1986b. The Nile River system. In B. R. Davies & K. F. Walker (eds), The Ecology of River Systems. Kluwer, Dordrecht, pp. 61–74. Eldaw, A. K., Salas, J. D., & Garcia, L. A. (2003). Long-range forecasting of the Nile River flows using climatic forcing. Journal of Applied Meteorology, 42(7), 890-904.

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Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C6602/2013/hessd-10-C6602-2013-supplement.pdf

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