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Hydrology and Earth System Sciences Discussions

Interactive comment on "Rainfall-runoff modelling and palaeoflood hydrology applied to reconstruct centennial scale records of flooding and aquifer recharge in ungauged ephemeral rivers" *by* G. Benito et al.

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Author's answers to comments by Referee 1 The authors agree with all the minor comments indicated by Referee 1, and those will be changed on the manuscript accordingly. In this reply we address the major change suggested by the reviewer.

1.- According to the reviewer's suggestion we will add at the end of the abstract the following sentence: Alluvial aquifer storage capacity limiting potential recharge by the

largest floods is a common problem in arid environments, with the largest infiltration volumes favoured by increasing depth to groundwater levels or river length.

Author's answer to comments by Referee 2

The authors thank Referee 2 for all comments made; here we address the most critical points:

1.- Volume units The authors agree with the reviewer. In fact, Mm3 stands for millions of m3, as it is a classical way to report recharge in groundwater studies. The units will be changed to Hm3.

2.- Hydrological modelling time discretization The sentence "modelled daily discharge and annual flood series" is referring to Fig. 4a and Fig. 4b. However, we understand that this may be confusing. The previous sentence will be deleted and a new sentence will be inserted in page 9639 line 21.

. . ...to generated discharge data. Daily discharge and annual flood series (1965–2006) were estimated (Figs. 4a and 4b) using the TETIS model based on hourly and daily rainfall provided by seven rain gauge stations distributed throughout the catchment. The model performance. . ..

3.- Stationarity The authors agree that stationarity may be a question of concern with long flood records. The Lang's test was performed for the flood records from both upper and lower sites, in both cases falling within the 95% tolerance interval (see attached Fig. 1), hence confirming stationarity. These analyses were not included in the discussion paper to help keep the paper concise.

A new paragraph (see below) will be added to address this issue at the end of page 9645. For high return period quantiles, parametric models are recommended, mainly because their predictive ability which is not supported by the sample data. A parametric statistical model is the combination of a cumulative probability distribution function (cdf) and a parameter estimation method. The new paragraph reads as follows:

“Frequency analysis of a 500-yr flood record introduces the question of flood stationarity, since cyclic and systematic climatic and land-use conditions may affect the assumption of statistical parametric models on which the random variable (flood discharge) is independent and identically distributed (see discussion in Redmond et al. 2002; Francés, 2004). A good alternative to deal with stationarity for non-systematic censored samples is to analyse the temporal pattern of the peak over threshold (POT) series. Lang et al. (1999) proposed a stationarity test that assumes the POT flood series can be described by a homogenous Poisson process. The stationarity test consists of computing the tolerance interval of the number of floods (mt) within an time interval [0; t]. A rejection of the test occurs for data outside the 90% tolerance interval (95% and 5% quantiles) which implies the non-compliance with the Poisson process hypotheses (i.e. non-independent and non-homogeneous values). Lang's stationarity test was passed for the Rooifontein combined flood record covering the period 1317-2006 with a lower threshold discharge of 94 m3s-1; and for Messelpad flood record over the period 1526-2006 for a threshold discharge of 460 m3s-1. Therefore, the POT flood series for the Buffels River are suitable for conventional flood frequency analysis.”

4.- Section 5.

Following the comment on this section, we have carried out an estimation of the annual maximum flood estimated from statistical integration of quantiles with and without palaeoflood data. Note that the statistical distribution function was adjusted to the peak discharge, not to recharge value which is later calculated routing the dimensionless hydrograph along the aquifer reach. A first step consisted on estimating the annual peak discharge from the TCEV distribution based on the expression developed by Beran et al (1986). The mean peak annual discharges (see data in Table below) are consistent with the annual discharge resulting from the TETIS rainfall-runoff model. The dimensionless hydrograph for small floods (<50 m3s-1) was then used to estimate the infiltration associated with the annual discharge peak flow (see Table). The annual recharge estimated from statistical integration of the TCEV distribution based on

combination with palaeoflood data (0.1 Hm3) is $\sim$10% lower than the one obtained from moments based only on systematic data (0.11 Hm3). These recharge values from maximum daily annual floods are considerably lower than the sustainable long-term recharge 0.7–0.87 Hm3 yr$-$1 (equivalent to annual average recharge) estimated based on the period 1962 to 1981 (Marais, 1981; Benito et al., 2009). Note that annual average recharge results from multiple flows whereas annual peak flows are referred to one individual flood. The combination of multiple floods potentially contributing to the annual recharge is outside the scope of this paper (i.e. what is the probability of having a second, third or N events within a single year). This recharge associated to maximum peak annual flood can be added in the text of the paper, as it may be relevant to indicate the recharge volume associated to such flood magnitude.

Systematic+palaeoflood Systematic data Annual mean peak flow(m3s-1) 0.543 0.590 Recharge from dimensionless hydrograph (Hm3) 0.099 0.108

Reference cited: Beran, M., Hosking J. R. M., and Arnell, N. (1986). Comment on ‘Two-Component Extreme Value Distribution for Flood Frequency Analysys’ by Fabio Rossi, Mauro Fiorentino and Pasquale Versace. Water Resources Research 22 (2), 263-266.

-RMSE values will be changed by the Nash-Sutcliffe index that was 0.782 for the calibration process.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 9631, 2010.

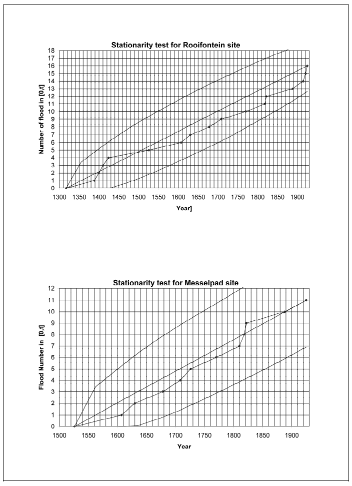

Fig. 1. Poisson test on the time flood process at Rooifontein and Messelpad sites. Note that the flood series (central line connecting points) remain within the 95% tolerance interval (outside enveloped curves).

Fig. 1.