Hydrol. Earth Syst. Sci. Discuss., 12, C503–C510, 2015
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Hydrology and Earth System Sciences Discussions
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HESSD
12, C503–C510, 2015

Interactive comment on "Flood frequency analysis of historical flood data under stationary and non-stationary modelling" *by* M. J. Machado et al.

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Received and published: 10 March 2015

Dear reviewer,

We appreciate very much this critical point of view to our non-stationary analysis of the historical flood period. We understand that from a conventional-type engineering approach, this paper using non-systematic data brings up a number of questions on how to deal with uncertainty inherent to documentary flood data. However, the reviewer should consider this work as a scientific-exploratory approach in the application of non-stationary analysis to centennial flood data series in a site with a complete and continuous record of peak over threshold discharges on the basis of documentary evidence.

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1.- In the opinion of the reviewer "Discharge time series are the worst one to make any kind of conclusions in term of climatological forcing. Rainfall and Temperature are surely better since they are direct measurements and the human effects are limited".

Response: This paper does not try to make conclusions of the climatological forcings in the region, and neither is a palaeoclimatological study. Our paper presents a long and complete record of censured discharges during the last 300 years, and tries to understand how statistical parameters may change or not under a non-stationary assumption. In the Iberian Peninsula previous papers have already demonstrated that runoff and peak discharge are influenced by North Atlantic mode of the atmospheric circulation, which we can express in term of NAO index (e.g. Silva et al., 2012). In our study site, we have got the same conclusion by matching flood magnitudes with NAO index, and therefore, it is evident that probability of flooding increase under NAO negative conditions.

2.- Another statement of the review is: "As the authors well known, homogeneity and uncertainty of measured data are not only a statistical hypothesis to be followed but also a philosophical constrain to include in the analysis. While the historical reconstruction is really accurate and fascinating, I do not think that can have a statistical relevance to support any general conclusion. Maybe it can be useful for local hydrological analysis to have an idea of the historical behavior of the river and so can suggest some operational rule for the dam."

Response: We think that such a critic is a general one applicable to any type of flood frequency analysis. Even modern floods are affected by such kind of uncertainty due to potential land-use changes, with a larger impact on small floods that on large floods. Regarding accurate measure of flood discharges, the statistical analysis with non-systematic records has been able to deal with such kind of uncertainties and there is large number of papers indicating the gain of using historical floods in flood frequency analysis (Leese, 1973; Stedinger and Cohn, 1986). As we deal with a methodological development, this study has a general interest to other sites worldwide, and particularly to European rivers.

3.- Another comment is “The uncertainty that affects historical values is not quantifiable and surely is variable event by event. Moreover, it is totally different to the systematic data uncertainty, that is still very high since they are indirect observations.”

Response: We agree the inclusion of information error into flood frequency analysis is a very interesting topic, but unfortunately there are few papers addressing it and also it is not covered in this paper. However, we don’t agree errors of historical data are larger than errors of systematic record in a gauge station. Historical data focus in medium and large floods and, in our experience, the errors for these floods in the systematic record can be similar or even larger. The main reason is that for the systematic record the data rely in the precision of the stage-discharge curve, which is usually calibrated only for low flows. On the other hand, historical floods usually are reconstructed using hydraulic models. Of course, it doesn’t mean they are free of errors, but probably their magnitude is smaller or at least not necessarily larger. Additionally, in case this reconstruction can have serious doubts, it has been demonstrated the historical information can be used as binomial censored (i.e., without defining their exact value, just the lower limit of censoring) without losing too much statistical gain (e.g. Francés et al, 1994). In this paper 46 historical floods have been treated as lower bound information, reducing in this way the potential negative impact of the information error.

4.- On the following comment: “As usual, the discharge time series are flagellated by human activities. Authors underlines that there is an abrupt changes in 1957 for the dam constructions, however I think their influence (statistically speaking) should be related to several years (i.e. 1952, 1953, 1954, 1955, show very low values). If I am not wrong we are talking about reservoirs of several cubic kilometers that affects 80% of the watershed. From the beginning of the construction to the end there are surely some effects on the discharges. Furthermore, the dam operations, at the beginning of the dam life, surely influences data. Maybe contemporaneously rainfall data would have been helpful for understanding what happened in these years as well as the

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reconstruction of natural discharge could be also useful."

Response: In our record at Aranjuez, low annual peak floods in that decade start on 1953 (62 m3s-1), 1954 (59 m3s-1), 1955 (64 m3s-1), and 1955 (97 m3s-1). However, it would be difficult to link these low discharge values to the dam construction itself because there are historical precedents of a sequence of years with low discharges due to droughts. In fact, during the previous decade to the starting dam operation, the rainfall in the whole Tagus catchment (see below figure) as well as the runoff produced upstream of the reservoir, were lower than average due to drought conditions. In addition, we don't think that adding these years to the dam regulation will produce any major change in our results, and we rather prefer to stay with the year of starting dam operations (1957) in the application of the Reservoir Index.

See attached Figure 1. Total rainfall in the Tagus River Basin in hm3. Source: Water Authority of the Tagus River Basin.

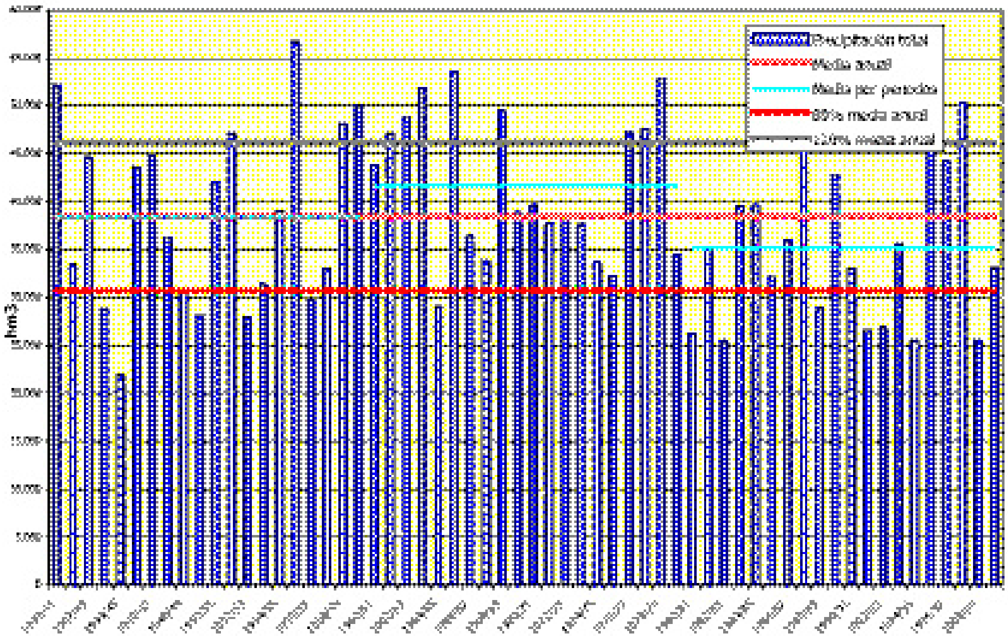
See attached Figure 2. Annual runoff produced upstream of the Entrepeñas and Buendia reservoirs. Note the decrease in runoff during the decade preceding the starting of dam operation in 1957.

5.- Regarding the last comment "Finally, I kindly disagree with the authors when they say (page 540 - lines 7-11) that the land use changes are out of scope of the paper. In my opinion, this is one of the most important reasons of non-stationarity in a discharge time series that usually is much more relevant than a potential climate change (hydrological change, in my opinion, is more impacting than the climate change). Maybe this watershed is not affected, however, it is important to support it showing land use maps of the past comparing it to the present ones."

Response: Our text in the paper it was not intended to diminish the importance of land use changes on catchment hydrology, but to indicate that we cannot cover in our paper all the aspects influencing flood peaks. Moreover, including several maps with land use and cover changes in this paper will make it more difficult to read and it is not going to provide further insight into our methodological analysis. As indicated in the paper, the area upstream of the reservoirs corresponds to forest and shrubs and the population density has been historically very low. In a general map (next figure) we have marked in a red rectangle the area upstream of the reservoir sites, and it shows in green colours the cover by forest and shrubs, typical of a mountain region. In any case, we will improve this sentence in the final manuscript.

See attached Figure 3. Land use of the Tagus River Basin. The red rectangle shows the area upstream of the study reach, which is dominated by green colour corresponding to forest and shrubs. Source Tagus River Basin Authority.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 525, 2015.



hm3
Precipitación total
Media anual
Media por periodos
80% media anual

Fig. 1.

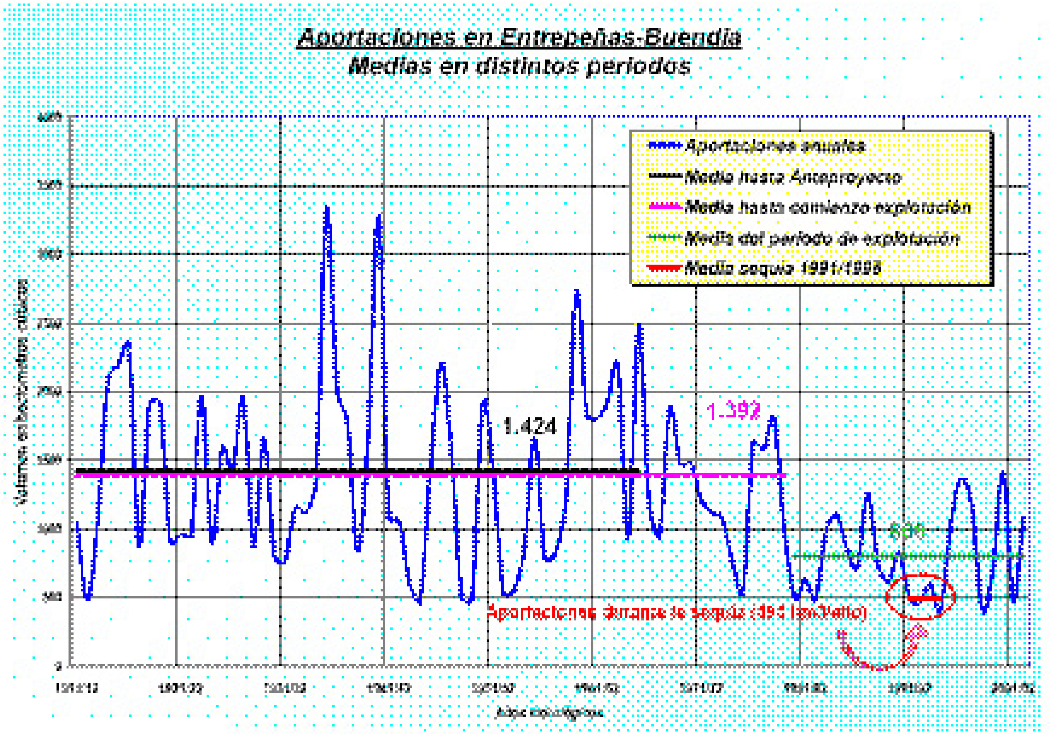

Aportaciones en Entrepeñas-Buendía
Medias en distintos periodos
Aportaciones anuales
Media hasta Anteproyecto
Media hasta comienzo explotación
Media del periodo de explotación
1.424
1.392

Fig. 2.

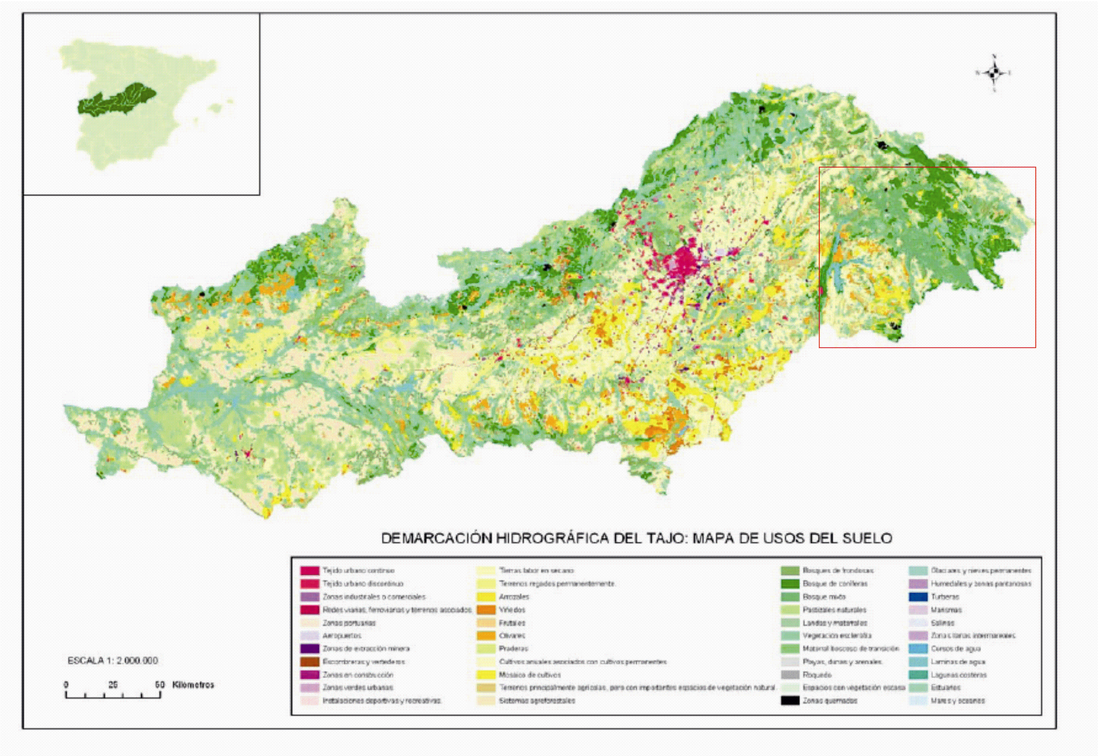


Fig. 3.

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