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Hydrology and Earth System Sciences Discussions

Interactive comment on "Non-stationary flood frequency analysis in continental Spanish rivers, using climate and reservoir indices as external covariates" *by* J. López and F. Francés

J. D. Salas (Referee)

jsalas@engr.colostate.edu

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The referred paper deals with an important and current subject that should be on interest to journal readers. Flood frequency analysis has been traditionally applied to annual maximum floods assuming that the underlying frequency distribution is stationary and the yearly flood peaks are independent events. This paper questions those assumptions, particularly that of stationarity and suggests a modeling framework based on the GAMLSS approach, which enables using probability density functions with parameters that can vary through time or can be related to covariates such as climatic indices that reflect low frequency components, e.g. AO, NAO, and MO. In addition, the

effects of reservoir regulation on flood peaks are considered by using a dimensionless reservoir index. The prosed approach is illustrated based on data of 20 sites across the continental Spanish territory.

The paper is attractive because it brings novel concepts and methods and the results obtained provide useful information for eventually improving the traditional methods that are currently employed in practice. The paper is reasonable well structured and the procedures and results are well described. However, improvements can be made as suggested below. In addition, the paper may benefit by adding some useful references (some of them quite recent) on the subject and by further discussing the difficulties of using such non-stationary procedures for assessing new/future projects. The problem is complex and likely no definite answers are available, however, it may be worth making the effort to discuss it further beyond to what has been done in the current manuscript (section 4.4).

Some examples where the authors may consider rewording and rephrasing and corrections to typos, etc. are provided below:

Page 3104, lines 22-23: "One of the challenges facing the field of Hydrology is gaining a better understanding on flood regimes."

Page 3104, lines 25-27 (and next page): "Generally current methods of FFA assume that the flood series data are independent and identically distributed. . .. . .The assumption of stationarity has been a corner. . ."

Page 3105, line 4: Reference to Salas(1993) instead of (1992).

Page 3105, line 9: ". . .regimes in many regions. . ."

Page 3105, lines 11-12: I would suggest rewording ". . .which is consistent with studies that indicate an acceleration in the hydrological cycle. . .". Several of the alluded references suggest the effect of natural climate variability (e.g. Franks) or the effect of land use (e.g. Villarini) on flood magnitude and frequency.

Page 3106, lines 14-17: This paragraph needs rewording for similar reasons as the previous observation.

Page 3108, line 26: "...transferred to the flow regime in the..."

Page 3109, line 3: Replace the word "in" by the word "on".

Page 3109, lines 10-11: "....note that the annual maximum daily flows correspond to hydrological years, i.e. 1 October..."

Page 3109, lines 15-16: "A dimensionless reservoir index (RI) is proposed as an indicator of the impact of regulation strategies following the construction of dams on flood regimes in rivers of continental Spain. It is given by"

Page 3109, line 19: "...reservoirs..."

Page 3109, lines 22-23: "...obtained for RI at sites with altered regimes, where the different degrees of alteration for each site vary:..."

Page 3110, lines 11-12: "...rainfall. They are associated..."

Page 3110, line 14: "...such as the AO and NAO may have..."

Page 3110, lines 24-25: "...where major floods occur during the winter months as in the western basins. "

Page 3110, line 25. Which area?

Page 3110, line 26: "... where the air flows are..."

Page 3111, lines 6-7: "... links between the temporal evolution of flow and rainfall regimes and the evolution..."

Page 3111, lines 15-18: "Climate indices for the winter period (December to February) were used as external covariates in the non-stationary models because it was observed that the greatest influence of low-frequency atmospheric circulation patterns on the variability of river flood regimes in continental Spain occurred in those months

(Trigo...."

Page 3111, lines 26-28: "...the first two Principal Components (PCs)..... The retained PCs show that..."

Page 3112, line 10: "...GAMLSS (Rigby...."

Page 3112, line 13: "..... covariates such as time..."

Page 3112, line 15: "....the flood frequency analysis in the study sites: the stationary model (model 0), in which the distribution parameters do not depend on covariates, i.e. the parameters are constants, the time-varying model (model 1), where the distribution parameters vary as a function of time only, and model 2 incorporates ..."

Page 3112, line 20: "...can vary as a function of ..."

Page 3112, line 26: Is the symbol "p" here the same as the symbol "p" in line 22?

Page 3113, line 8: "terms in Eq.(2)..."

Page 3113, line 16: For a detailed discussion...?

Page 3113, line 21: "...On the contrary, as degrees..."

Page 3113, line 23: "...case in representing the dependence..."

Page 3114, line 20: " ...adequately describe the symmetric..."

Page 3115, lines 10-11: "... that temporal trends and external forcing can affect the ..."

Page 3115, line 12: Replace the word "presents" by the word "includes".

Page 3115, line 18: "...models that incorporated..."

Page 3115, line 19: "... PC1 is clear as the...."

Page 3115, line 20-21: "...Table 5 that PC1 is a significant .....sites, while it is a

significant covariate for only 3 sites for parameter. . .”

Page 3115, line 23: “. . .that AO, MO, and NAO exert in. . .”

Page 3115, lines 24-25: “. . .observed for PC2, which is an explanatory. . .”

Page 3116, lines 2-3: “. . .It seems that skewness coefficient and other higher order moments are less sensitive to climate. . .”

Page 3116, line 4: “. . .show for station. . .”

Page 3116, line 6: “. . .panel), and the PC1. . .”

Page 3116, line 8: “. . .basins. In addition, the lower panels of Fig.3 show for station 1427 (northern basin) the strong. . .”

Page 3116, lines 9-10: “. . .discharges (lower left panel). A high degree of. . .”

Page 3116, line 16: “. . .models. On the contrary, the parameter. . .:

Page 3116, lines 18-19: “. . .2 for nine representative study sites, which are based on the residual plots and the estimates of the first four moments of the residual. The results. . .”

Page 3116, line 21: “. . .residuals (for a sample size 58 the critical. . ...)

Page 3116, line 25: “Figure 5 shows the observed values and the estimated... . .. . .percentiles for nine. . .”

Page 3116, lines 26-27: The sentence needs rewording.

Page 3116, lines 27-28: “. . .assuming temporal dependence only (model 1) show a pattern. . .”

Page 3117, line 1: “. . . sites, particularly during. . .”.

Page 3117, line 1: Do you mean 1970?

Page 3117, lines 12-13: “. . .flood series is clear and corresponds with AIC and . . .”

Page 3117, lines 14-15: “. . .shows the effect of climate and reservoirs to modulate. . .”

Page 3117, line 16: “. . .the temporal trend models, the results of model 2. . .”

Page 3117, lines 17-18: “. . .flood frequency. The results of flood frequency in the western basins of the continental Spain show. . .”

Page 3117, lines 19-20: “Increasing trend in the period 1995-2005” is not evident from Fig.5.

Page 3117, line 22: Replace the word “on” by the word “the”.

Page 3117, lines 24-25: The last sentence of the paragraph is not clear.

Page 3118, line 1: “..linked to mechanisms different than those. . .”

Page 3118, line 7: “. . .40-year period. Incorporating. . .”

Page 3118, line 16: “. . .clear that higher floods are linked. . .”

Page 3119, line 5: “. . .significant variability (increases and decreases). We can. . .”

Page 3119, line 21: “. . .suggests the urgent need for FFA that. . .”

Page 3119, lines 22-25: The last two sentences of section 4.3 are right on the spot. However, it would be appropriate citing some key references right on the subject such as:

Olsen, J. R., Lambert, J. H. and Haimes, Y. Y. (1998). “Risk of Extreme Events Under Nonstationary Conditions.” Risk Analysis 18(4), 497-510.

Sivapalan, M. and Samuel, J. M. (2009). “Transcending limitations of stationarity and the return period: process-based approach to flood estimation and risk assessment.” Hydrological Processes, 23, 1671-1675.

Salas, J.D. and Obeysekera, J., 2013. “Revisiting the Concepts of Return Period and

Risk for Nonstationary Hydrologic Extreme Events", accepted for publication in the ASCE J. Hydrol. Eng., 10.1061/(ASCE)HE.1943-5584.0000820 (Apr. 1, 2013).

Page 3120, lines 9: "...the temporal-trend models..."

Page 3120, lines 12-14: The last sentence of section 4.4 is fine but it would be useful further elaboration here because future conditions are unknown. The key question is how to use the proposed non-stationary models to help designing a flood related hydraulic structure to perform for the next say 30-year period? This may not have a definite answer since the problem is complex but it would be useful making additional comments here.

Page 3120, lines 22-23: "Departures from the assumption of stationarity in the flood series in rivers of continental Spain are clear and this..."

Page 3121, lines 1-2: "...low-frequency climatic forcing and the effects of dam regulation over over the last 50 years."

Page 3121, lines 6-7: "... in the significant negative correlations between the winter climate indices such as AO, MO, and NAO..."

Page 3121, line 13: "... runoff (e.g. more..."

Page 3121, line 18: "..... effect on the variance....."

Page 3122, lines 11-14: The sentence referring to non-stationary and return period should be rephrased considering the comment made above in relation to Page 3119, lines 22-25.

Fig. 5: "...show the estimates of the median and the..."

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 3103, 2013.