Climate and hydrological variability: the catchment filtering role

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Response to Referee Comment RC-C4407-2014 – Anonymous Referee #1

The authors are extremely grateful to Anonymous Referee #1 for the time spent on our research study, his/her constructive and useful comments, and relevant suggestions that will greatly improve the manuscript. In particular, we would like to highlight the additional analytical work done in response to comment-2 from the Referee, which substantially improves and clarifies the analytical treatment of extreme flood peaks and the return period estimation.

Here are our responses to the specific issues raised by Referee #1. Please note that point 3 includes additional references in the paper for a better response to the Referee's comments.

1. On the variability of the land uses/watershed properties

It is clear that certain relevant aspects in the hydrological analysis have not been addressed in our study, and should guide further research on the topic.

As correctly indicated by anonymous Referee #1, certain dominant drivers of the hydrological response, like variability of watershed properties or land use changes, have not been considered in the research, although it should be noted that the proposed modelling framework has the potential to incorporate the above drivers to a certain extent, and thus, allow the effect of such variability to be assessed and compared. We also agree with the Referee that land-use change might have a more significant impact than climate change in certain hydrological conditions. However, investigating the role of land-use change would require certain specific assumptions, regarding the extension of the affected area and the perturbation behaviours, and therefore the general validity of our conclusions would be more limited. For this reason, we decided not to include land use change impacts in the context of the present study. The latter question is beyond the scope of the present study, being modelling efforts basically centred on the role of climatic variability and its effects on catchment hydrological response, with rainfall statistical properties and its future trends representing the major factors controlling flood frequency distribution.

However, and following the advice by Referee #1, the scope of the study (INTRODUCTION) will be explained in more detail in the reviewed version of the manuscript. Also, emphasis will be placed on the limitations in the final conclusions, with explicit reference to future studies focusing on the effect of watershed properties and the role of land use change using a similar modelling framework.

2. The analysis related to the number of events per year

This useful comment of Referee #1 has led us to reconsider the method used for return period estimation in the study. In accordance with the main objective of the study, i.e., the analysis of maximum peak flows, we now use in the revised manuscript the analytical approach based on the classic Annual Maximum Series (AMS) method, rather than the Peak Over Threshold (POT) analysis.

Given the distribution function of all peak flows that is derived from the rainfall series,

$$F_Q\,(q_P) = \begin{cases} 1-\left(1-\kappa I_a/\alpha\right)^{1/\kappa} & q_P = 0 \\ 1-\left\{1-\dfrac{\kappa}{\alpha}\left[I_a+\dfrac{t_C q_P}{2\lambda_P}\left(1+\sqrt{1+\dfrac{4\lambda_P S}{t_C q_P}}\right)\right]\right\}^{1/\kappa} & q_P > 0 \end{cases} \quad (1)$$

the distribution function of maximum annual floods can be expressed as (see, for instance, Viglione and Blöschl, 2009)

$$F_{Qmax}(q_{Pmax}) = e^{-\beta\left(1-F_Q(q_P)\right)} \quad (2)$$

where β is the annual number of rainfall events.

The first equation can be expressed in terms of return period (years) as:

$$T_{Qmax} = \frac{1}{1-F_{Qmax}} \quad (3)$$

Combining equations (1) and (2) and replacing them in (3), we can express the T-year maximum peak flow as:

$$q_{Pmax,T} = F_Q^{-1}\left[\frac{1}{\beta} ln\left(1 - \frac{1}{T}\right) + 1\right] \qquad (4)$$

Numerical results have been recalculated in the revised manuscript by using the above equation (4) for the T-year maximum peak flow estimation. Figures 1, 2 and 3 have been updated accordingly (see new figures at the end of this document).

The differences with respect to the previous analysis are not significant, and they affect low return period quantiles only. Indeed, both estimation methods (POT and AMS) converge for large return periods.

For the purpose of this study, the AMS method seems to be more illustrative and robust. On the other hand, it yields the same results. In the revised version of the manuscript, the end of section 2.3 will be modified to replace the estimation method for the return period.

To reply to the Referee, in section 3 of the paper the sentence "*According to Eq. (8), a 20% increase in β implies a 16.7% decrease in the flood return period*" has been replaced. After the proposed incorporation of the AMS estimation method for T, a 20% increase in β implies a decrease in the flood return period ranging from 0% (for low T values) to 16.7% (for high T values). In the revised version of the manuscript, this issue will be better addressed as suggested by Referee #1.

3. On the variability induced by initial abstraction and concentration time

The initial abstraction value is directly obtained using a factor k=0.2, which is taken from practical recommendations (Ferrer Polo, 1993). Concentration time value has been determined based on a wide hydrological experience in many small catchments of rapid response in the Mediterranean East and South East coast of Spain (Olivares Guillem, 2004; Camarasa Belmonte, 1990). It can be considered a realistic, representative value for a typical ephemeral river of the region. The main idea is to define a set of parameters to be kept constant for the given hydrological conditions, which can essentially be representative and typical of fast responding catchments in semi-arid Mediterranean regions. As stated before, studying the effect of the variability of such parameters is beyond the scope of the paper, although it will be underlined in the revised version of the manuscript as a main research line to be pursued using the proposed modelling framework, following the suggestion by Referee #1.

Additional references

Camarasa Belmonte, A. M.: Génesis de avenidas en pequeñas cuencas semiáridas: la Rambla de Poyo (Valencia), Cuad. De Geogr., 48, 81-104, 1990.

Ferrer Polo, J.: Recomendaciones para el cálculo hidrometeorológico de avenidas, Centro de Estudios y Experimentación de Obras Públicas, Madrid, 1993.

Olivares Guillem, A.: Modelación hidrológica pseudo-distribuida del barranco del Carraixet: aplicación al episodio de octubre de 2000, Cuad. De Geogr., 76, 155-182, 2004.

Viglione, A., Blöschl, G.: On the role of storm duration in the mapping of rainfall to flood return periods, Hydrol. Earth Syst. Sci., 13, 205-216, 2009. doi:10.5194/hess-13-205-2009.

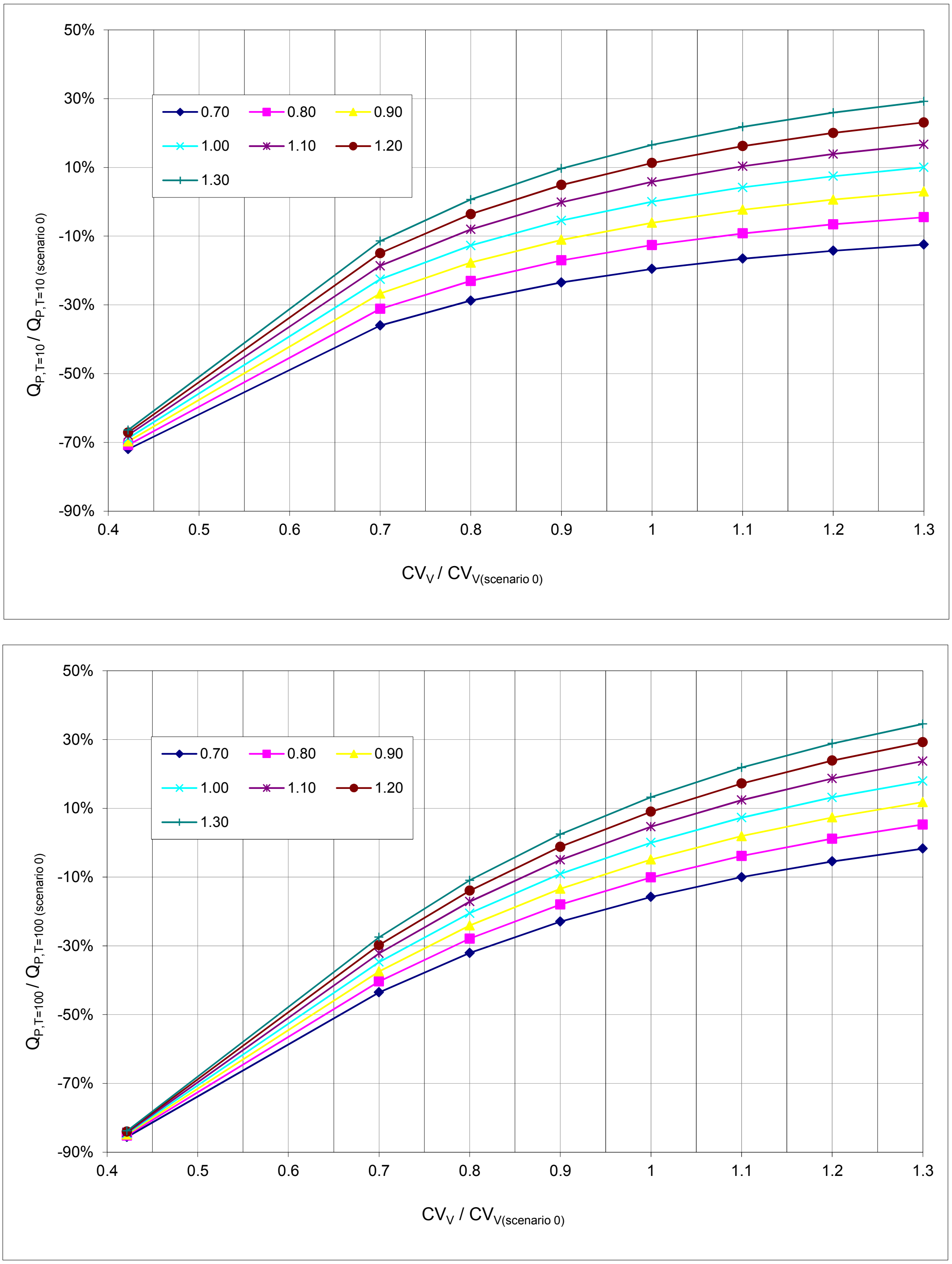

Figure 1. Flood quantile variations for changes in β and CV_V. Catchment parameters are set to S/μ_V=3.5 and t_C=1 h. Cases T=10 years (top) and T=100 years (bottom).

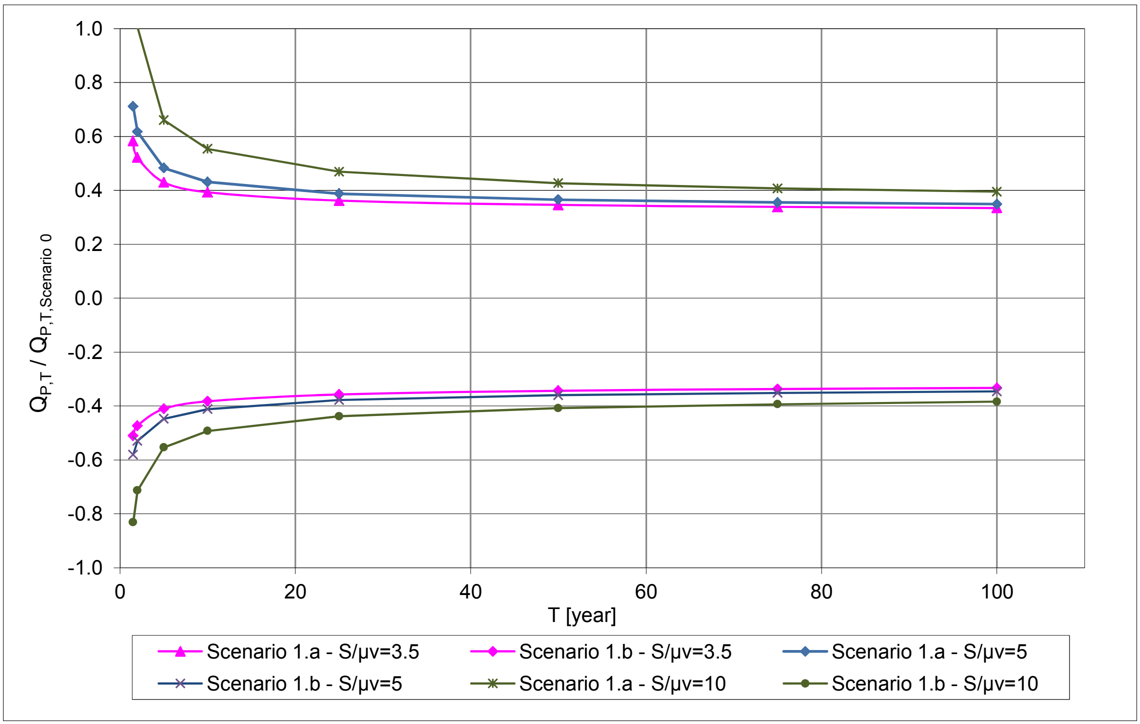

Figure 2. Flood quantile variations for scenarios 1.a (+30% μ_V) and 1.b (-30% μ_V) and for S/μ_V=3.5, 5 and 10.

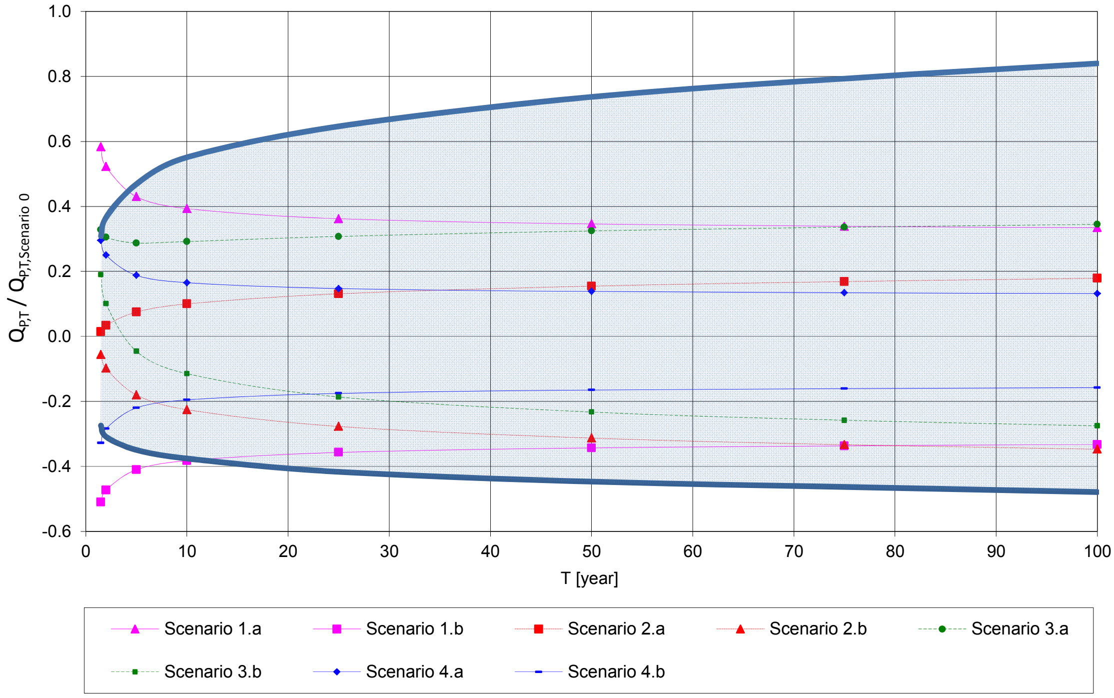

Figure 3. Flood quantile variations for scenarios defined in Table 1 and ξ=0.05 confidence interval for scenario 0 peak flow distribution (shaded area). Catchment parameters are set to S/μ_V=3.5 and t_C=1 h.