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Discussions

Interactive comment on "Flood design recipes vs. reality: can predictions for ungauged basins be trusted?" *by* A. Efstratiadis et al.

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We would like to thank Dr Brocca for his positive critique, as well as his constructive comments and suggestions. Below, we reply to these comments in turn.

1. By reading the abstract, it seems the SCS-CN method is based on field data from few experimental catchments. In contrast, the method is based on an extensive field activity, even though mainly for small agricultural fields and only in USA. As the authors well know, the main problem is not in the SCS-CN method itself, but on its application for purposes much different from the ones for which the methods was developed. This should be clarified in the manuscript.

In the manuscript, we wish to reveal problems arising in everyday engineering practice,

when simplified flood design tools for ungauged basins are applied. We focus particularly on three issues: (a) the blind use (misuse) of such methods, with reference to the rational formula; (b) the lack of local validation for certain of the commonly used regional formulas, with reference to the time of concentration, and (c) the lack of physical consistency, in terms of proper representation of the key hydrological processes, with reference to the SCS/SUH approach.

In order to explain our objectives synoptically, we state in the abstract that:

"In general, these "recipes" have been developed many decades ago, based on field data from few experimental catchments. However, many of them have been neither updated nor validated across all hydroclimatic and geomorphological conditions."

Indeed, this is a general comment with regard to common flood engineering recipes, not a specific critique of the SCS method. It is true that the SCS method, combined with the unit hydrograph concept (which is a rather old procedure) has been verified quite well in several areas worldwide, with specific characteristics (e.g., agricultural basins). However, it is not expected to work similarly well in all hydroclimatic and geomorphological conditions (e.g., in highly permeable basins –karst-type, which is ubiquitous in Greece). We shall add this clarification when we revise the paper.

2. In the analysis made on the paragraph 3.3 and Table 2, the different formulas for the computation of the time of concentration are compared in terms of peak discharge estimation for 32 flood events occurred across Cyprus. However, it is made implicitly the assumption that the results only depend on the selection of the time of concentration, but it is evident that also other components, mainly the selection of the runoff coefficient C, influence the values of the estimated peak discharge (as clearly described in the paper). Other factors include the rainfall duration, the selection of the areal reduction factor, the intensity-duration-frequency curves (ombrian curves), . . . Therefore, I found not correct to select the most appropriate formula for the computation of the time of concentration by using this procedure. Can the authors add more elaborations on

that?

In this study, we employed an inverse application of the rational method, testing four different formulas for the time of concentration. As shown in Table 2, the Giandotti formula yields by far the most realistic (or least erroneous) estimates of the observed peak flows. The remaining formulas are clearly inappropriate, as indicated by their significantly negative efficiency values; for instance, the Kirpich equation strongly overestimates the peak flows. Obviously, we agree that there are several assumptions behind the rational method that are governed by multiple uncertainties. However, the exceptionally better performance of the Giandotti formula against the other three formulas proves that these uncertainties play a rather secondary role in the overall predictive capacity of the rational method, since the key source of uncertainty in this method (thus the most sensitive input) is the time of concentration.

3. Besides the time of concentration, we found that the selection of the initial soil moisture condition is the most important factor influencing the estimation of the design flood values in Mediterranean catchments. Specifically, the (arbitrary) selection of different antecedent moisture conditions strongly affects the peak discharge and runoff volume. Therefore, more robust methods for defining the initial soil moisture conditions should be developed. For instance, with apologies for suggesting my own references, Camici et al. (2011) proposed a procedure based on the application of the Continuous Simulation approach as a tool to determine the "design soil moisture" condition to be afterwards incorporated into the more simple Design Storm method (widely used by engineers). I believe that this aspect should be better discussed in the paper.

We definitely agree with this comment about the importance of initial soil moisture conditions on the estimation of flood flows, which we also mention in our paper. In particular, on p. 7404, line 25 we state that:

“Several researchers have revealed the limitations of the SCS-CN method with respect to soil moisture and proposed further parameterization to better represent the initial

soil moisture conditions (e.g., Ponce and Hawkins, 1996; Michel et al., 2005; Sahu et al., 2007)”

We thank Dr. Brocca for suggesting the improved methodology by Camici et al. (2011) that aims to remedy this key shortcoming of the SCS-CN method. We will reference it in the revised manuscript. In order to eliminate the impacts of initial soil moisture conditions in our analyses, we calibrated the parameters of the SCS method. In this respect, we obtained at each catchment a wide range of CN values that partially reflect the variability of the soil conditions. Of course, this range is a combination of multiple uncertainties of both the model and the data. It seems rather evident that only a continuous simulation, comprising soil moisture accounting, can explicitly represent the influence of initial soil conditions on the flood quantities (peak discharge, runoff volume). This is clearly mentioned in our last conclusion (p. 7408, line 1):

“By analyzing several flood events in two catchments in Greece and Cyprus, we illustrated the intrinsic shortcomings of the SCS/SUH procedure, when applied in semi-arid areas. This empirical analysis also confirmed that the implementation of a soil moisture accounting scheme is essential for a proper modelling of flood generation.”

4a. Finally, in the paragraph 4.3 (Figure 1) it is shown that the SCS/SUH method fails in simulating flood hydrographs for two basins in Cyprus. However, this can be related to errors in the input rainfall data, or in the discharge values (e.g. in the determination of the rating curve), and not to the SCS/SUH method. I expect that the authors should show an alternative method able to simulate the flood hydrographs for which the SCS/SUH method fails.

We should note that in the current paper we only present certain preliminary results from few representative flood events, in order to highlight the major problems with the use of common flood engineering tools. In fact, in the context of a shortly concluding research project (http://deucalionproject.gr/), we have studied dozens of flood events in several basins that generally agree with the conclusions of the paper. Extended investigations indicated that the inconsistencies of the SCS/SUH method (i.e., the erroneous assumption of surface flow dominance) can be moderated by properly tuning the time parameters of the synthetic unit hydrograph (i.e., time to peak and base time). In a forthcoming paper, we will report the details of this research and will propose appropriate formulations that ensure more realistic estimations.

4b. Moreover, it is well known that the SCS-CN method works well for simulating flood hydrographs characterized by a single flood peak. Therefore, in the two events shown in the upper panels of Figure 1 (note that the time step is not reported in the x-axis) occurred in the Sarantapotamos catchment, the second rainfall pulses should be not considered. By removing these rainfall pulses, the simulation of the flood should be significantly better.

We are aware that the purpose of the SCS-CN method is not the reproduction of historical hydrographs but the construction of hypothetical events for use in flood design studies. In most routine flood design studies, the shape of the corresponding design hyetograph is very simple. In fact, a continuous (single-pulse) storm event is considered with a single rainfall peak, thus generating a single flood peak. However, if a Monte Carlo approach is adopted, using ensembles of synthetic storm events provided by stochastic models, the latter will have arbitrary temporal distributions, comprising both single and multiple pulses within the same storm event. The fact that the SCS-CN method has not been designed to handle complex hyetographs is another drawback that will also be discussed in the revised paper.

4c. For instance, Massari et al. (2013) found the SCS method able to satisfactorily reproduce several flood events occurred in the Rafina basin in Greece.

We thank Dr. Brocca for providing this information that involves a similar study in Greece. Yet, after carefully reading the article by Masari et al. (2013), we do not find the performance the SCS method satisfactory, as indicated from the comparison of the simulated hydrographs against the observed ones (Fig. 4, page 11030). In fact,

visual inspection of the results leads us, in most cases, to the same conclusions as our analyses of flooding in the Sarantapotamos and Peristerona basins: the peak flows are significantly overestimated, while the falling limbs are represented very poorly. As thoroughly discussed in the manuscript, this is an intrinsic problem of the SCS method that has its origin in that method's conceptual basis.

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