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Hydrology and Earth System Sciences
Discussions
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Interactive comment on "Probability distributions for explaining hydrological losses in South Australian catchments" *by* S. H. P. W. Gamage et al.

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Response to reviewers' comments on Manuscript ID HESSD, 10, 4597-4626, 2013

In this document below we have listed each of the reviewer's comments. This is followed by our response.

Response to Reviewer #1 (Dr. Golian):

Comment 1: "The paper aims to identify suitable parametric and non-parametric probability distributions on initial loss (IL) and continuous loss (CL) data of four catchments in South Australia (SA) region. There are some ser[i]ous controversies over the work.

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The main issue is the lack of innovation or scientific improvement of previous works."

Response 1: The main aim of this paper is to improve the estimation of design losses for South Australian (SA) catchments. The presented work contributes to ongoing research on losses in Australia for updating Australian Rainfall Runoff (ARR) – A Guide for Flood Estimation in Australia. Also the presented work improves event based Rainfall Runoff (RR) model predictions. Event based RR models (e.g. WBNM, RORB) generally need the user to input initial loss (IL) and continuous loss (CL) as parameters. However, for SA catchments, the only available loss values for this purpose are ARR recommended values. According to the ARR, the loss values of the SA catchments are given as those for the humid zone of SA, namely: 10mm for IL and 2.5mm/h for CL in winter; and 25mm for IL and 4mm/hr for CL in summer (ARR Book 2, p. 47). These ARR recommended values are based on the median values of losses. Due to the high variability of losses in SA, the use of a representative single value (mean or median) is not appropriate. This can be seen in the Figure 1. The use of single representative loss values introduces large errors into event based RR model predictions. Considering the random nature of hydrological losses, probabilistic modelling has been suggested as a better approach to overcome the issues associated with the use of single representative values. The distributions suggested from previous studies were tested for SA catchments and it was found that these distributions were not able to describe SA catchments' loss data. Previous studies and the recommended distributions are given in Table 1. Therefore, this study aimed to identify a suitable distribution function which can adequately describe hydrological losses in SA catchments. As shown in the Table 1, the two-parameter Gamma distribution has not previously been tested for losses in SA catchments. As hydrological behaviour of South Australian catchments are generally different compared to other catchments listed in Table 1, it is required to test the distributions before applying them to SA catchments. This study provides a specific distribution, the two-parameter Gamma, which has not previously been tested for SA catchments. Also as pointed out by the third reviewer (Dr. A. Rahman), the results of this paper will provide a significant contribution to the Australian Rainfall and Runoff

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(ARR) guidelines, which are currently being updated. More importantly, this study provides new knowledge on how IL in SA based catchments are characterised and this will help fill the gap in ARR information for hydrological losses in SA catchments. In the revised paper, we have modified the Introduction stating how the work presented in this paper contributes to ongoing research in SA and why existing distributions cannot be used for catchments in the SA region. Table 1 has also been added to the Introduction.

Comment 2: "I refer to some parts of the text in this regard. On Page 4600 Lines 24-27 and Lines 28-29 it is stated that previous probabilistic methods could not be used for SA catchments. The question is do the work by authors can be generalized to other parts of Australia? The answer is no, as indicated in Page 4612 Line 21 "parameter generalization is not within the scope of this paper". As stated in Page 4601 Lines 13-14 the present work is just a case study for four catchments in SA."

Response 2: From the current content of the paper it is not clear whether or not the finding can be used for other parts of SA. Like any other hydrological variable, IL can also be directly transferred to another catchment, only if the two catchments are hydrologically similar. This study does not cover the aspect of testing "homogeneity of catchments" and hence we stated that it is beyond the scope of our study. However, in order to demonstrate applicability of the developed methodology to other parts of SA, the recommended two-parameter Gamma distribution is tested for two randomly selected catchments in the same region. The two test catchments are Rhynie (A5060500) and Splading (A5070501) which both belong to the SA wet/humid region. It was found that the IL for these two catchments followed the two-parameter Gamma distribution. Although geographical proximity does not always guarantee hydrological similarity, based on these findings, it can be stated that the two-parameter Gamma distribution is suitable for SA wet/humid catchments. Information on validation of the methodology using the two test catchments has been added to the revised paper.

Comment 3: "The authors used the terms "joint probability" which had the potential for making their work different from others. But there was not any sign of using this

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concept in their work. All the paper is based on the univariate analyses. I, as a reader, expected to see some joint probability distribution functions (jpdf) of IL and CL or any sets of two or more variables."

Response 3: This paper does not intend to determine the joint probability of IL and CL. It has been identified that incorporating the joint response of initial losses (IL) and total losses (TL) into rainfall runoff simulation can improve model accuracy (Haddad and Rahman, 2005). The first step of any joint probability approach (JPA) is to identify distributions of random variable inputs of interest (Rahman et al., 2000; Rahman et al., 2002; Nathan et al., 2003; Kuczera et al., 2006). As there is no understanding of the distribution of any of these variables (either IL or CL) for the SA catchments, a JPA approach cannot be adopted for this region. Therefore, the work presented in this paper could be the starting point towards applying or investigating JPAs to describe hydrological losses.

Comment 4: "1- Page 4604-4605, other goodness-of-fit tests such as Anderson-Darling are preferred to graphical methods which are based on visual comparison of empirical and selected distributions."

Response 4: Anderson –Darling test results for the selected Gamma distribution have been added to the revised paper.

Comment 5: " 2- Some information missed in the paper, an important one is the size of observed IL and CL series for each catchment or better to say the number of rainfall and runoff events which are used to extract IL and CL data."

Response 5: The number of rainfall and runoff events selected for this study is presented in the Table 2, which has been included in the revised paper.

Comment 6: "3- Page 4613 Lines 5-6 which criterion was used for similarity (consistency) between distributions. The authors stated that the obtained distributions for selected catchments in SA are similar to those of other studies. How can the authors support this statement?"

Response 6: The shapes of the non-parametric distributions for the other parts of Australia can be found in the literature (Nathan and Weinmann, 2004; Ilahee, 2005; Nathan et al., 2003; Waugh, 1991). These shapes were visually tested against the non-parametric distribution that we presented for SA catchments. Unlike the parametric distributions, in non-parametric distributions, the shape of the distribution of SA catchments is similar to some other parts of Australia. The revised manuscript is modified as follows: "Shapes of the non-parametric distributions given in this study are consistent with similar studies conducted for other regions of Australia (Nathan and Weinmann, 2004; Ilahee, 2005; Nathan et al., 2003; Waugh, 1991).

Comment 7: "4- It is suggested that the authors provide a map with more details for the selected catchments. For instance, the location of rainfall and hydrometry gauges can be added to the map."

Response 7: A modified map has been included in the revised paper as shown in Figure 2.

Comment 8: "5- How can it be perceived from Table 3 that the observed and simulated IL values are within the 95% confidence interval? (Page 4611 Lines 12-14)."

Response 8: Yes, it cannot be said that observed and simulated values of the IL are within the 95% confidence interval. We revised the manuscript as follows: "In Table 3, the values of Sim (x) were calculated using a 95% confidence interval." (Please note that the Table 3 refer to the original paper)

Response to Reviewer # 2 (anonymous):

Comment 1: "The Authors presented that the two-parameter Gamma distribution was the most suited for the initial losses and a non-parametric approach, which was developed in past studies, described successfully both the initial and continuing losses." "First of all, it is not clear to me what is new in the manuscript regarding to the past

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studies on this issue. The Authors should make clear the scientific frontiers dealing in the manuscript."

Response 1: The two parameter Gamma distribution has not previously been tested for the SA region. Please refer to Response 1 for Reviewer #1 The hydrologic behaviour of SA catchments is quite different from the catchments used in previous studies that have investigated probability distributions. Therefore this paper aims to find out whether the same distributions that were used for other studies are suitable for SA catchments or not, and if not what is the best distribution. A two parameter Gamma distribution has not been tested in SA catchments before. From this study we show that the two parameter Gamma distribution can only be used to describe IL. Unlike some other studies which are based on different hydrological regions, this distribution cannot be used to describe CL in the SA region (Refer to Table 1). Table 1 has been added to the Introduction section of the revised paper.

Comment 2: "[t]he applicability and usefulness of the presented approach for major floods prediction in gauged and ungauged catchments are questionable in my point of view."... "Why is estimating hydrological losses distribution better than using directly the stream- flow distribution, which is standard in Hydrologic Statistics (e.g. Stediger, Vogel and Foufoula-Georgiou, 1992), to estimate the major flood flows?"

Response 2: The intended purpose of this study is not to replace flood frequency analyses. This study does not question the benefits of the frequency analysis of extreme floods introduced by Stedinger, Vogel and Foufoula-Georgiou (1992). The main application of the findings is to improve event based RR model predictions. RR models deal with all the events that have the potential to cause runoff and hence model predictions at a range of ARIs are expected to be improved by improving loss estimations.

Comment 3: "In order to evaluate the applicability of the presented approach, the Authors must still apply it to a set of independent catchments, adopting some regionalisation techniques. Also, the Authors must test whether the presented approach performs better than that using the streamflow distribution."

Response 3: The results have been validated using two test catchments (Rhynie - A5060500 and Splading - A5070501) and new section titled "Results validation" has been added to the revised paper. This validation is to prove that the two parameter Gamma distribution can be used for other parts of SA. However, as mentioned in Response 2, the intended purpose of this study is not to replace streamflow distribution based analysis.

Comment 4: "1. There is a lot of basic statistics, such as the explanation of bias and MSE, in the text. They can be summarized".

Response 4: Basics statistics are now only briefly summarized in the revised paper.

Comment 5: "2. Fig. 1 has a very poor quality."

Response 5: A modified map has been included in the revised paper as shown in Figure 2.

Comment 6: " 3. Fig. 5 shows strange values for the x-line (MSE)."

Response 6: There was a mistake with MSE values in three graphs: The values should be 0.001, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.99 The corrections have been made in the revised paper.

Comment 7: "4. Δt instead of t in Eqs (2) and (3)."

Response 7: We have now inserted Δt inserted of t in Equations (2) and (3)

Comment 8: "5. Lebanon (2010), Hill et al. (1996) and Waugh (1990) are not included in References."

Response 8: Missing references have been added to the revised paper.

Comment 9:

"6. In References, L.14 p. 4614 seems strange to me."

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Response 9: Corrected references have been added to the revised paper as follows: Lebanon, G.: Bias, Variance and MSE of Estimators: available at: http://www.cc.gatech.edu/∼lebanon/notes/estimators1.pdf (last access 1 June 2013), 2010.

Response to Reviewer #3 (Dr. Rahman):

Comment 1: “1. In Abstract, some minior rewordings are needed. Line 1, replace "multiple variables" by "various factors".”

Response 1:

Rewording has been done in the revised paper as suggested.

Comment 2: “2. Line 4, Replace first word "Using: by "Use of"”

Response 2: Rewording has been done in the revised paper as suggested.

Comment 3: “3. Line 15, Add a sentence break after "also discussed".”

Response 3: Rewording has been done in the revised paper as suggested.

Comment 4: “4. In Introduction, line 1, replace "crucial" by "an important".”

Response 4: Rewording has been done in the revised paper as suggested.

Comment 5: “5. In page 4599, line 8, what is RR?”

Response 5: RR is Rainfall-Runoff, and this has been added to the revised paper.

Comment 6: “6. Section 2, be more explicit about small to medium sized catchments, see paper by Haddad, K., Rahman, A., Weinmann, P.E., Kuczera, G. and Ball, J.E. (2010). Streamflow data preparation for regional flood frequency analysis: Lessons from south-east Australia. Australian Journal of Water Resources, 14, 1, 17-32.”

Response 6: In the revised paper, small to medium size catchments have been defined as catchments that have an upper limit of1000km2 in area. Also the recommended references have been added.

Comment 7: “7. Last line of Section 2, replace "yr" by "years".”

Response 7: Rewording has been done in the revised paper as suggested.

Comment 8: “8. Section 3.1, explain how did you select start of a runoff? Did you select a threshold runoff?”

Response 8: Yes, a threshold value equal to 0.01mm/hr was used and is now included in the revised paper

Comment 9: “9. Page 4604, Can you give some justification about the selection of candidate distributions?”

Response 9: First the distributions that were used in previous studies were included as candidate distributions. Then all the other distribution types that can be tested using SPSS were selected.

Comment 10: “10. Some text book type materials are provided in Section 3 about statistical methods, which should be reduced.”

Response 10: Details of BIAS, MSE have now only briefly been summarized in the revised paper

Comment 11: “11. For non-parametric distribution, how median/mean value of an ungauged catchment can be estimated?”

Response 11: Estimating mean/median values for ungauged catchments by using non-parametric methods is out of the scope of the research. However, methods similar to the index flood approach (Cunnane1988) can be used to estimate the mean/median of an ungauged catchment. However, this would considerably change the focus of the paper. Therefore this is not included in the revised paper.

Comment 12: “12. State, how the results of this study can contribute to the on-going

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research on losses in Australia."

Response 12: The following sentences have been added to the Introduction section of the revised paper: " The results of this paper will provide a significant contribution to the Australian Rainfall and Runoff (ARR) guidelines, which are currently being updated. More importantly, this study provides new knowledge on how IL in SA based catchments are characterised and this will help fill the gap in ARR information for hydrological losses in SA catchments."

Comment 13: "13. Please refer few recent papers e.g. Hill, P., Graszkiewicz, Z., Sih, K., Nathan, R., Loveridge, M., Rahman, A. (2012). Outcomes from a pilot study on modelling losses for design flood estimation, Hydrology and Water Resources Symposium, Engineers Australia, 19-22 Nov 2012, Sydney, Australia. Loveridge, M, Rahman, A. (2012). Probabilistic Losses for Design Flood Estimation: A Case Study in New South Wales, Hydrology and Water Resources Symposium, Engineers Australia, 19-22 Nov 2012, Sydney, Australia."

Response 13: These references have been added to the revised paper.

Reference

Cunnane, C. :Methods and merits of regional flood frequency analysis, J. Hydrol., 100(1), 269-290, 1988.

Haddad, K. and Rahman, A.: Regionalisation of rainfall duration in Victoria for design flood estimation using Monte Carlo simulation, in: Proceedings of MODSIM05 – International Congress on Modelling and Simulation: Advances and Applications for Management and De- cision Making, MODSIM05, 12–15 December 2005, Melbourne, VIC, Australia, 1827–1833, 2005.

Ilahee, M.: Modelling Losses in Flood Estimation, Ph.D. thesis, School of Urban Development Queensland University of Technology, Queensland University of Technology, Queensland, 2005.

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Kuczera, G., Kavetski, D., Franks, S., and Thyer, M.: Towards a Bayesian total error analy- sis of conceptual rainfall-runoff models: characterising model error using storm-dependent parameters, J. Hydrol., 331, 161–177, 2006.

Nathan, R. and Weinmann, P.: An improved framework for the characterisation of extreme floods and for the assessment of dam safety, in: Proceedings of the British Hydrological Society International Conference, Imperial College, London, July, 186–193, 2004.

Nathan, R., Weinmann, E., and Hill, P.: Use of Monte Carlo Simulation to Estimate the Expected Probability of Large to Extreme Floods, in: Proceedings of the 28th International Hydrology and Water Resources Symposium: About Water, 10–13 November, Novotel North beach, Wollongong, NSW, Australia, 1.105–1.112, 2003.

Rahman, A., Weinmann, P. E., and Mein, R. G.: The probabilistic nature of initial losses and its impact on design flood estimation, Hydrology and Water Resources Symposium, Perth, Australia, 20–23 November, Sheraton Perth Hotel, Perth, Western Australia, 71–75, 2000.

Rahman, A., Weinmann, P., Hoang, T., and Laurenson, E.: Monte Carlo simulation of flood frequency curves from rainfall, J. Hydrol., 256, 196–210, 2002.

Stedinger, J.R., R.M. Vogel and E. Foufoula-Georgiou: Frequency Analysis of Extreme Events, Chapter 18, Handbook of Hydrology, McGraw-Hill Book Company, David R. Maidment, Editor-in-Chief, 1993.

Waugh, A.: Design losses in flood estimation, International Hydrology and Water Resources Symposium, Perth, October 1991, 629–630, 1991.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C2196/2013/hessd-10-C2196-2013-supplement.pdf

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Tables:

Table 1: Distributions tested for Australian catchments

Distribution	Catchments tested	Recommended for IL	Recommended for CL
four–parameter Beta distribution	10 Victorian catchments (Rahman et al., 2002a)	Yes	No
	15 Queensland catchments (Tularam and Ilahee, 2007)	Yes	No
	4 Victorian catchments (Ishak and Rahman, 2006)	Yes	Yes
Exponential,	four Victorian catchments (Ishak and Rahman, 2006)	No	Yes
two–parameter Gamma	4 Victorian catchments (Ishak and Rahman, 2006)	No	Yes
	5 NSW catchments (El-Kafagee and Rahman, 2011)	Yes	Yes

Table 2: Selected rainfall events

Catchments	Rainfall period considered	No of events selected
Scott Bottom (A5030502)	1991 - 2010	200
Mt Pleasant (A5040512)	1989 – 2011	227
Yaldara (A5050502)	1985 - 2011	200
Penrice (A5050517)	1986 - 2011	185
Rhynie (A5060500)	1985 - 2011	208
Splading (A5070501)	1992 - 2011	142

Fig. 1. Tables

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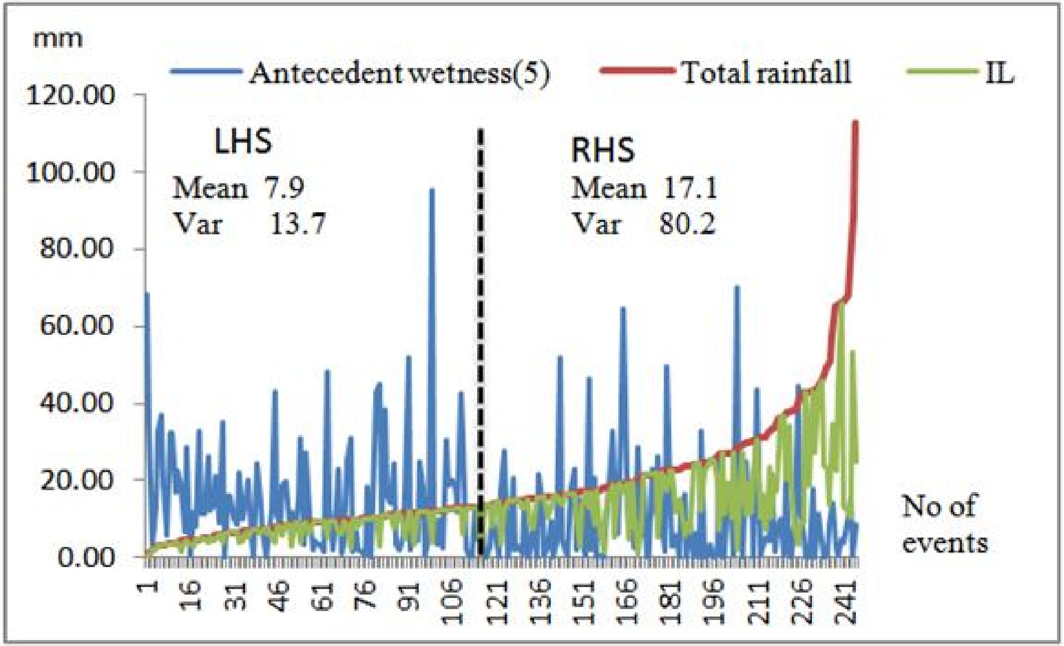

Fig. 2. Figure 1

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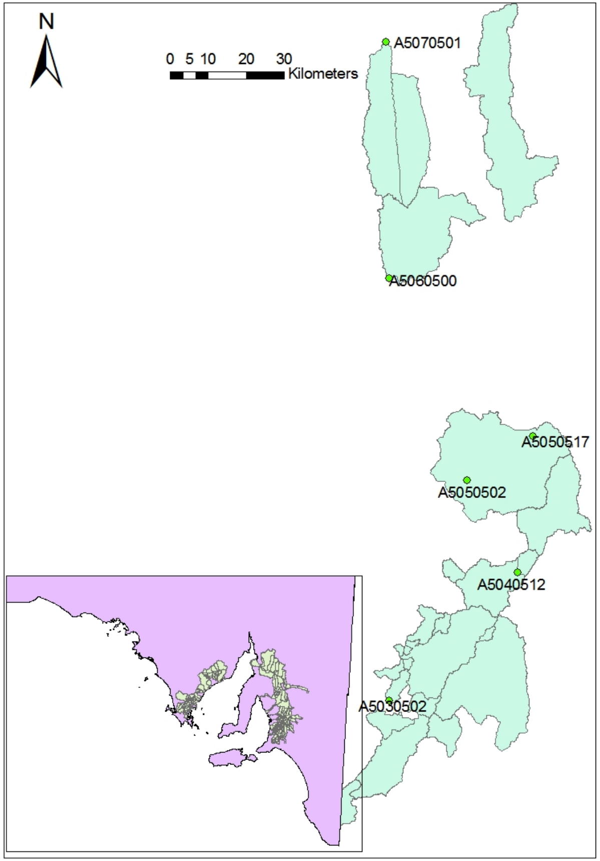

Fig. 3. Figure 2