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Hydrology and Earth System Sciences Discussions

Interactive comment on "Development of IDF-curves for tropical india by random cascade modeling" *by* A. Rana et al.

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Dear F. Ahammed

Firstly we would like to extend our appreciation towards your efforts in understanding the importance of our research. We would also like to thank you for the very constructive feedback on this submission; it has provided us with very handy support in tackling the important issues ahead of researchers in the field.

Please find below the answers for all your queries.

A. Rana et.al.

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Interactive Discussion

Discussion Paper

F. Ahammed: Abstract: Rainfall Intensity-Frequency-Duration (IFD) relationships are widely used for water resources planning and management. Preparations of IFD relationships using traditional approaches are difficult tasks due to lack of short duration (< 24 hours) rainfall data in many developing countries including Bangladesh. Hence, several alternative approaches have been applied to determine sub-daily rainfall intensities from daily rainfall data. Rana et at. (2013) applied random cascade modelling to develop IFD relationships for Mumbai, a tropical Indian City. These results were compared with the corresponding values of Dhaka, another tropical city of Bangladesh. Comparison results validated the findings of Rana et al. (2013). 1. Introduction: One of the major objectives of IFD relationships is to determine the maximum rainfall intensity for any particular duration and return period. Such information is required to design several hydraulic structures including flood protection and drainage infrastructures. Traditional approaches are based on Pearson Type III or Log Pearson Type III, where short duration rainfall data are required, which are not available in many developing countries including Bangladesh. Researchers developed several alternative approaches to prepare these IFD relationships using daily rainfall data. Ahammed and Hewa (2012) applied scaling theory to 57 years (1953 to 2009) daily rainfall data to prepare IFD relationships for Dhaka, a tropical city in Bangladesh. Validation of this work was done by comparing with the corresponding values of Darwin, capital city of Northern Territory of Australia (Ahammed et al. 2013). Rana et al. (2013) nicely applied random cascade modelling for the development of IFD relationships for Mumbai, another tropical city of India. However, the presentation of the IFD curves belongs to several significant limitations. It is also questioned whether the findings have been validated accurately. In this discussion paper, an attempt has been performed to validate the IFD relationships of Mumbai City developed by Rana et al. (2013). 2. Presentation of IFD curves: The presentation of IFD curves by Rana et al. (2013) could be improved by incorporating the following recommendations: The X-direction of the curves shows time up-to 6 hours. It is recommended to use atleast 24 hours. For designing hydraulic structures of a catchment, the peak stormwater runoff volume is estimated based on

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rainfall intensity whose duration equals to time of concentration (tc) of the catchment (Chen and Wong 1993). Argue (2006) presented a discussion whether site time of concentration (tc) or critical storm duration (Tc) would be utilised during design process. The dominant flooding considerations - site, local or total catchment may determine which alternative tc or Tc will be used in the design process. Hence, it is recommended that the duration in X-direction of IFD curves by Rana et al. (2013) should be modified to show longer time period; these will give better opportunities to practitioners to design hydraulic structures for Mumbai City. It is recommended to show an IFD curve for 100 years return period. The question of 'what Average Recurrence Interval (ARI) of storm should be employed for designing hydraulic structures' is challenging to answer. It is recommended to consider an awful situation of 100 years ARI design storm for a catchment, where flood control is the prime aim of stormwater management. However, installations of hydraulic structures considering this situation could be expensive and hence, idealized ARI values (5 or 10 years) could be adopted. Presentations of IFD curves for Dhaka City by Ahammed and Hewa (2012) show duration up to 24 hours and return periods up to 100 years. Figure 1 shows the IFD relationships of Dhaka City developed by Ahammed and Hewa (2012). 3. Comparisons of IFD relationships: The IFD relationships for Mumbai City developed by Rana et al. (2013) were compared with the corresponding values of Dhaka City developed by Ahammed and Hewa (2012). The comparison results validated the IFD relationships of Mumbai City, as, for a particular duration, the differences of rainfall intensities for different return periods are almost similar. Figure 2 shows the comparison results of IFD relationships between-Mumbai and Dhaka City. 4. IFD equation: Ahammed and Hewa (2012) developed an equation (see Equation 1) to determine rainfall intensity for a particular return period of Dhaka City. However, similar equation is not available in the paper developed by Rana et al. (2013). I=(52.423+22.293(-ln(-ln(1-1/T))))/(dËĘ0.681).....(1) Where, I = rainfall intensity (mm/hr), T = return period (yr), d = duration (hr).

Conclusions: A review was carried out for the IFD relationships of Mumbai City developed by Rana et al. (2013). The presentations of the IFD curves require significant

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improvement. An equation to determine rainfall intensity for any particular period could be presented. The comparison results of IFD relationships of Mumbai City against the corresponding values of Dhaka City validated the findings of Rana et al. (2013).

References Ahammed, F. and Hewa, G. A.: Development of hydrological tools using extreme rainfall events for Dhaka, Bangladesh, Water International, 37(1), 43-52, 2012. Ahammed, F., Hewa, G. A. and Argue, J, R.: Introducing leaky-well concept for stormwater quantity control in Dhaka, Bangladesh, Applied Water Science, 3(1), 115-123, 2013. Argue, J. R.: Discussion of watershed scale evaluation of a system of storm water detention basins by Clay H. Emerson, Claire Welty, and Robert G. Traver, Journal of Hydrologic Engineering, 11(6), 636, 2006. Chen, C. N. and Wong, T.: Critical rainfall duration for maximum discharge from overland plane, Journal of Hydraulic Engineering, 119(9), 1040-1045, 1993. Rana, A., Bengtsson, L., Olsson, J. and Jothiprakash, V.: Development of IDF-curves for tropical india by random cascade modeling, Hydrology and Earth System Sciences Discussion, 10, 4709 – 4738, 2013.

Response: Thank you for your effort in analyzing the work in close details and giving your valuable feedback. The comparison of results from both the cities is highly appreciated and strengthens our results. IDF curves have been developed for the tropical climate, like India, for city of Mumbai using a random cascade model for obtaining the high-resolution temporal data, which is often lacking in the developing countries. The results have been presented in form of IDF curves with return period of 2, 5 10, 20, 40 and 80 years for time up to 6 hrs on X axis and Intensity (mm/hr) on Y axis. As per knowledge in the field, it is difficult to estimate T= 100 years even with observed data, as a result, we have not tried to estimate the same with the disaggregated values due to increase in uncertainties. As for the storm duration, the 24 h values are the observed ones and were therefore not represented in the IDF curves and also the design storms are likely to be shorter than the daily storm. Moreover, short temporal scale precise intensity values are often used/required in practical applications in hydraulics and hydrology. The graph would be less clear if the horizontal axis is extended

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to 24 hours. As per the Equation for intensity calculation is concerned Gumbel extreme value distribution was considered, which by authors view is well established, and could not be presented in the paper due to space limitations. To perform frequency analysis, each of the durations is taken with annual maximum values representing a population with a probability of Gumbel distribution. The procedure doesn't require formulation of intensity equation as the annual maximum values are fitted to Gumbel distribution and desired IDF can easily be plotted with different return periods.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 4709, 2013.