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# *Interactive comment on* "Indicators of Necessary Storages for Flood and Drought Management: Towards Global Maps" *by* Kuniyoshi Takeuchi and Muhammad Masood

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RESPONSE TO THE REVIEWER #3'S COMMENTS

We are grateful to Reviewer #3 for the helpful and insightful comments. The provided comments have contributed substantially to improving the manuscript. Accordingly, we have made significant efforts to revise the manuscript with the details being explained as follows.

General comments Point #1

COMMENT: The novelty of the proposed method is not clear. The method appears to be a minor adjustment to previously published versions of this approach. The authors



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note this in page 3, lines 3-5. Although in my reading of Takeuchi (1986), it appears that the methodology presented using both the FDC and DDC may not have been previously published. Regardless, there are fairly well-established methods to determine the necessary storage in hydrologic design; some of these papers are mentioned briefly in the introduction but there is no attempt to demonstrate the utility of this approach in the context of these other well-established methods - not necessarily show this method is better but - at a minimum - that it performs as well as other methods..

RESPONSE: Thank you for your critical comments. The paper indeed uses the methodology of FDC-DDC for calculating necessary storages that was developed during 1975 to 1988. But the objective of this paper is not to reintroduce this methodology and compare with other methods but to use it for identifying spatial heterogeneity of hydrology in storage domain for which this method is best suited. The FDC-DDC method is very different from Ripple's mass curve method or the well-established simulation method. It utilizes the intensity-duration-frequency curve which has never been used for calculating necessary storage before 1975 and still not well known. This is why this paper introduces the method fairly in detail.

Point #2

COMMENT: This approach is based on the flow-duration curve, which does not consider the timing or variability of the discharge and, therefore, the accumulation or depletion of storage over time. It is then not clear how this approach can be useful, as it does not consider the storage in the previous time step, particularly for rivers where variability is large and storage is most needed to control this variability.

RESPONSE: Thanks for the comments. Yes, this approach utilizes flow-duration curves which do consider timing and variability of discharge in the way that, for instance, whatever the timing or variability is fïĄć(m) will be available as an average over m days from now with the rate of failure no more than ïĄć. The observation that it does not consider the accumulation or depletion of storage over time is incorrect. The IDF is





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a probabilistic and stationary approach and FDC-DDC can be used as a prediction of inflow before or during floods or drought. Such explanation will be added in the revised manuscript.

Point #3

COMMENT: Following from comment 2, it is repeated throughout the manuscript, "storage is the means to control discharge variation." The relation between variation in discharge and necessary storage is well established in the literature, with more storage needed as the coefficient of variation in the discharge increases; and yet, there is no consideration of this point in the demonstration of these methods. The coefficient of variation (CV) is not reported for the 3 demonstration sites so the reader has no idea of the variation of the discharge that is being "smoothed" by storage under the calibration/validation dataset.

RESPONSE: Thanks for the comments. Yes, although the CV is presented in Fig. 6 but not specific values at the demonstration sites in table 2. It will be shown and discussed in relation to necessary storages identified at three points (1.10, 0.69 and 0.90 at the outlets of the Ganges, the Brahmaputra and the Meghna). Obviously CV is the most directly connected parameter to the necessary storages to smooth out variations but we consider that the necessary storage for floods and droughts deliver much more concrete idea on the variability to hydrologists and basin managers.

Point #4a

COMMENT: The decisions made in Sections 2.2.1 and 2.2.2 seem quite arbitrary with no justification or support to suggest that these would be choices that a water manager or operator would likely choose.

RESPONSE: Thanks for the comments. Yes, it is arbitrary and does not represent real operator's choice. But we consider this represents the basic nature of reservoir operation that is to consider expected inflow, target output and available storage. In that





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sense, the assumed decision making process serves to derive a meaningful indicator.

Point #4b

COMMENT: Another example is in the assumption that the FDC and DDC curves follow a generalized extreme value distribution. There are no references provided to support this choice of distribution from previously published work and no evidence is presented to demonstrate that this is a reasonable choice.

RESPONSE: Thanks for the comments. Generalized Extreme Value (GEV) distribution Type-1, Gumbel distribution, has been used in this study to estimate extreme values. Because, in previous studies, for frequency analyses, the Gumbel distribution has been recommended for the major rivers in Bangladesh by Mirza (2002) as well as for relatively smaller data samples by Hirabayashi et al. (2013). We have revised 2.1 with these references.

Point #4c

COMMENT: Page 3, line 28 states that the FDC and DDC curve applies precipitation, yet there is no explanation of this further in the manuscript. How is precipitation used in the method?

RESPONSE: Thanks for the comments. In this manuscript, FDC and DDC method is applied on discharge time series only. The application on precipitation time series was presented in other papers such as Takeuchi, 1988.

Point #4d

COMMENT: The methodology described on p. 5, line 6 states that the “interest duration is limited to a year” but I am left to wonder how the analysis is applied to rivers where over-year storage is an important component of controlling variability?

RESPONSE: Thanks for the comments. Yes, in many large rivers with a large reservoir over-year storage is vital especially for drought management with a large target output.

But in this paper the over-year storage was omitted for simplicity since the main focus is the relation between necessary storages and catchment heterogeneity where other than topography, geology, soil and vegetation, the seasonal variation of meteorology is the major controlling factor. We consider this applies most of basins in the world except deserts or very arid regions. Besides, the procedure for calculation necessary storages is same for any m however large it is. In the item 9 of both 2.2.1 and 2.2.2, the value of m does not necessarily limited to one year. If multi-year operation is concerned, the value of m in Eq. 5 and 6 should vary all the way of available FDC and DDC extending from m=1 to multi years.

Editorial issues Point #5a

COMMENT: There are incomplete sentences: p. 8, l. 13; p. 2, l. 12-14.

RESPONSE: Thanks for the comment. They are complete sentences, but not elaborate enough and accordingly elaborated. Besides, climate change aspects were removed.

Point #5b

COMMENT: Acronyms that are not explained before being used. For example, p. 7, l. 10; Abstract, l. 18-19; p. 5, l. 1-2.

RESPONSE: Thanks for the comments. All will be spelled out when they appear at first such as Meteorological Research Institute – Atmospheric Global Circulation Model 3.2S (MRI-AGCM3.2S).

Point #5c

COMMENT: Although I do not recall that HESS has guidance on the use of “he” and “his,” I think is a lack of sensitivity to use a gendered pronoun and there are alternative ways to phrase these sentences. Page 4, line 17 is the first appearance but gendered pronouns appear in quite a few other places, such as throughout Section 2.2.2.

RESPONSE: Thanks for the comment. Indeed, only 6 places of he/she should not be

simplified by he. It was corrected.

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