Reply to the anonymous referee #1

We really appreciate the reviewer for thoughtful and constructive comments. Changes have been made in the revised manuscript according to some technical comments. In the following, we focus on providing some clarifications for some comments.

1. P7008 ln4, why did not select more catchments? Data quality issue or time series are too short?

Regarding the selection of the catchments, two criteria are considered. One is the length of continuous streamflow records should be as long as possible to provide more information. The other one is the records of all the catchments should within same period for consistency. As a result, 197 catchments with 51 years continuous data from 1948 to 2001 are chosen from more than 400 catchments in the MOPEX dataset.

2. P7010. Use of R2 and Ens may not be appropriate for the purpose of evaluating the FDC model. The authors should consider a chi-squared test or a sensible statistical test for comparing two distributions.

Even though the mixed gamma distribution was used to fit the FDC, we used it as a fitting model rather than as a probability distribution. The objective of fitting a function to the FDC is to capture their shape in a concise way, through few parameters, and then analyse the spatial and temporal variability of these parameters across the US and across years. We are interested in a good curve fitting and therefore measures such as R^2 and Ens are appropriate. We are not interested in determining whether the FDC is drawn from a given probability distribution and therefore statistical goodness of fit tests are not appropriate.

3. P2012 ln5-10. The authors calibrated equation (3) against normalized time series to optimize the three model parameters. As I understand, Figure 3 simply showed results of the model calibration. These results are not independent validation of equation (3).

Yes, quantitatively, plots shown in Figure 3 cannot be considered as an independent validation of equation (3), or as an independent validation using the mixed gamma distribution to approaching the flow duration curves. Our analysis is a characterisation of the spatial and temporal variability of FDC across the US. At this stage we are not interested in the regionalisation of the FDC, for which a validation on independent sites would be

necessary. Figure 3 is visual evidence to present spatial variability of the shape of FDCs across a wide range of climatic and geologic conditions and is a comparison between fitted FDCs using the mixed gamma distribution and observed FDCs. The Nash-Sutcliffe coefficient and goodness of fit are used to measure how good equation (3) can approach observed duration curves at different catchments.

4. P7012 ln24-28. The authors should consider a chi-squared test or a sensible statistical test for comparing two distributions.

Please refer to our response for comments #1.

5. P7013 ln3-8. Do these results indicate that the simple mixed gamma distribution is not accurate in these catchments or years? Do we know why?

Yes, box plots of Ens and R^2 in Figure 4 suggested that the shapes of duration curves of some catchments were difficult to be accurately approached by the mixed gamma distribution. Maybe, the shape of FDCs in these catchments is very flat or not decreasing smoothly. Several factors are potentially responsible for that, including climatic and physiographical factors, impacts of vegetation and human, and so on. How different factors influence on the shape and how the shape varies spatially are not analysed in this study, but provided in companion papers part 2 and 3, respectively.

6. P7013 ln26-27. I assume what you are saying is that larger alpha values for the TFDCs and SFDCs are also found in the arid regions. Please reword.

Thanks, we will reword these lines in the revised manuscript.

7. P7014 ln1-5. Please explain what you mean by "share similar region patterns"? Do you mean the PDCs and FFDCs have similar shapes? Or you mean the alpha values show similar region patterns?

In these lines, "share similar region patterns" means that alpha values show similar region patterns. In the revised manuscript, we will refine this sentence to "the spatial distribution of the alpha values of PDCs and FFDCs shares similar regional patterns and that of TFDCs and SFDCs also shares similar regional patterns."

8. P7014 ln10. Replace "comparatively" "relatively".

Thanks. We will revise it in new manuscript.

9. P7014 ln10-26. Here, the authors discussed the nature of the parameter k and possible reasons for the observed spatial patterns. In my view, this belongs to Discussion.

Thanks. We will move this short discussion to section 5.1.

10. P7015 ln9-11. The shape parameter of the PDC showed some correlation with that of the FFDC, but they are not closely correlated.

It is unreasonable for us to assert that the parameters are "closely" or "strong" correlated without any statistic correlation test. In the revised manuscript, Spearman rank correlation coefficient (i.e., Spearman's rho) is used to quantify how closely the physical parameters and shape parameters are correlated.

11. P7015 ln15-16. Is this shown somewhere in the paper?

We should give the evidence of this conclusion sentence. From Figure 3, higher degree of similarity can be found in the upper tail of the PDC and FFDC than in the lower tail. We will revise this sentence in the revised manuscript.

12. P7015 ln16 – 26. The discussion on precipitation and the parameter alpha of the FFDC makes sense in principle. Is it possible to quantify the relationship using some statistical measures? Is the correlation good enough for practical applications? In other words, can you infer the parameter alpha of the FFDC from the PDC?

Spearman's rho is adopted in the revised manuscript to quantify the statistical dependence of the correlations. Whether the correlation can be used in the practical application or not is dependent on how strong the casual relationship is inferred from the statistic correlations. In this study, the variability of duration curves between catchments and between years are related to physical explanatory variables, through which we try to identify climatic and landscape controls on both fast flow and slow flow duration curves. These empirical correlations may not be good enough for practical application but can help advance the research on developing more process-based understanding of the physical basis of the FDCs for use in regionalization studies.

13. P7016 ln11-14. Shown in Figure 8?

The relationship between parameter κ and physical characteristics are shown in Figure 8 and Figure 9. In the revised manuscript, this conclusive sentence will be moved to the end of that paragraph, and statistical measures will be carried out to quantify the dependence of parameter κ on the physical characteristics.

14. P7016 ln27-28. Examination of Fig.8a and c reveals a stronger correlation between parameter k and the baseflow index for TFDCs. I would have expected a stronger correlation for SFDCs. The authors should elaborate on this.

With respect to statistical dependence test, the Spearman's rho was 0.73 and 0.55 for the correlations in Figure 8(a) and (c), respectively. The correlation of baseflow index with κ of TFDCs is stronger than that with SFDCs. Intuitively, SFDCs should have a stronger correlation with baseflow index than TFDCs since SFDCs is slow component of the total flow. However, stronger correlations between TFDCs and baseflow index were obtained from both long-term duration curves of 197 catchments and annual duration curves in 8 catchments. With respect to the Nash-Sutcliffe coefficient and R^2, fitting results for SFDC is better than that for TFDC. Therefore, stronger correlation of baseflow index with TFDC may be true and there is some casual relationship behind, or it may be confounded by failure to fit accurately in higher values by the mixed gamma distribution. However, it is beyond the scope of this study.

15. P7017 ln5. The baseflow index (BI) was estimated from daily streamflow and you can estimate the k-value directly from the daily streamflow.

Actually, the κ-value in this study is estimate from daily streamflow time series directly using moment method. For this sentence, we tried to argue that the strong correlation between baseflow index and κ-values of TFDC and SFDC suggests that baseflow index, which was primarily considered as a surrogate of landscape controls, can be used to estimate the κ-values in practical applications.

References:

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Vogel, R. M., and N. M. Fennessey (1994), Flow-duration curves. I: New interpretation and confidence intervals, J. Water Resour. Plann. Manage., 120(4), 485-504, doi:10.1061/(ASCE)0733-9496(1994)120:4(485).