**Hydrology and
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Discussions

# *Interactive comment on* "Hydrological recurrence as a measure for large river basin classification and process understanding" *by* R. Fernandez and T. Sayama

**Anonymous Referee #2**

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GENERAL COMMENTS:

This paper shows an attempt to introduce a new measure, "recurrence" as defined mainly by lagged autocorrelation (AC) in conjunction with other two indices, to hydrological variables (runoff, evaporation, precipitation, storage) on a global scale and particularly for major river basins of the world. The new measure can be used for the geographical classification of those world major river basins in terms of hydrological characteristics. The attempt is within the scope of HESS, and the paper is enough interesting to be published. The manuscript is readable, although sometimes redundant. I would basically suggest it to be published, but I also think those following items should

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be clarified or modified before the final publication in HESS.

TWO MAJOR COMMENTS:

FIRST:

First of all, the definition of recurrence is ambiguous. Every reviewer probably has the same comment. The recurrence defined by AC in this paper looks very similar to seasonality. What else other than seasonality is included in the current measure?

In addition, if this measure is only about seasonality, the story of this paper is rather simple. But, it is probably not true. If some other components are included in this measure, what are the included components? How much percentage do the components except for seasonality occupy? Why the authors need such a complicated measure?

If the authors want to show seasonality, the authors need to look for a measure that can only show seasonality. If the authors want to get information except seasonality (such as interannual variability), a way is to use an anomaly (anomaly from the long-term mean of each month) for the analysis.

I can basically accept an attitude such as "we found a very interesting measure, and we tried to apply it". Nevertheless, the authors need to explain what it is. The authors need to persuade reviewers and readers in general by explaining why the authors need it.

Here, I would also point out that the recurrence in this paper is dependent on the time interval of the data; in this study, the time interval of the data is monthly. In addition, the result might be much affected by the selection of 12, 24, 36, 48, 60 written in P8199, L7. Because the definition or intention of recurrence is not clear, some texts (for example, P8207, L14, "Ob shows higher fluctuation") are unclear. In this example, what does it mean by higher fluctuation? This is just an example, and there are many similar places in this paper.

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The second series of comments is about "storage".

- The definition of storage in this paper is not clear.

- While the authors argue that storage is the novel aspect, as shown in Table 1., is it fine to deal with outputs (storage) of those models in the same manner? I mean, in some models, storage consists of SM and SWE, but in some other models, storage consists of GM, SM, SS, and SWE. Because the included components are different, it is unclear whether results can be interpreted at the same standard.

- What is the definition of SS, surface storage, in Table 1?

- If SS includes river water similar to Kim et al. as introduced in the following, descriptions such as "the storage fluctuates largely because it fills in the wet season and nearly dries in the dry season"need to be reconsidered, in which the authors probably did not assume the residence time of river water in large rivers is long. The response and temporal variability of soil moisture and groundwater would not be different between small basin and large basin, but temporal characteristics of river water as a storage is very different between small river basin and global-scale large river basin. Depending on the definition of storage, similar comments may be applied to other places in the main text. If river water is taken into account, in large river basins, discussion and speculation would not only depend on precipitation, evaporation, and snow accumulation and melt. Time-lag due to river could be another major component.

- When storage has a clear seasonality in Figure 6 in a certain basin, why sometimes "S" is not shown in the same basin in Figure 4? If seasonality is a major aspect of recurrence and if a clear seasonality is seen in Figure 6, it is natural that we expect "S" in Figure 4 for such a basin. But, it is not sometimes true. Why?

- In Figure 8, what is the definition of ground moist, the value of which is very small? Also in Figure 8, it is probably ridiculous to argue which is the largest volume. If we take all the groundwater, including deep groundwater, into account, it is very sure that

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the groundwater component is the largest. But, it is also true such a component might not be treated in current global models. As such, relative change rather than absolute volume is sometimes much meaningful in outputs of current global hydrological models. As such, although the authors insist that the important aspect of this paper is the storage term, we are not sure by this paper whether the authors are dealing with orange or apple. Please make clear the above issues related to storage.

SPECIFIC COMMENTS:

- P8195, L8-L22: By highlighting the storage term as the originality of this paper also in other sections of the paper, the author argued that the storage term was not used in the geographical classification of hydrological characteristics of world major river basins. However, as far as I know, the following two papers described some geographical aspects of hydrological classification of world major basins using the storage term, although they did not take mathematical methodology shown in this study. Those previous studies did not deal with recurrence, but some aspects written in the section 4 of this paper would be comparable or common with what was written in those previous papers. Masuda et al., Geophys. Res. Lett., 28(16), 3215-3218, 2001 Kim, H., P. J.-F. Yeh, T. Oki, and S. Kanae (2009), Role of rivers in the seasonal variations of terrestrial water storage over global basins, Geophys. Res. Lett., 36, L17402, doi:10.1029/2009GL039006.

- P8196, L11-22: There is an overlap with the section "2 Data". The authors can reduce redundancy.

- P8200, L8-10: It is unclear what kind of result of FFT computation was used in the analysis later. FFT equals to an overall, general, mathematical procedure. But, the authors seemed to use a specific set of values. In addition, this sentence is not easy to understand.

- P8200: In addition to more explanation on AC, the authors are suggested to describe why Colwell's Index was necessary in this study. The mathematical definition of it is

described, but why this additional index is necessary is not explicitly described.

- P8204-8206: The authors mix facts that can be clearly observed from Figures with speculations and discussion. That is why these subsections are not easy to follow. If the authors use nearly the same structure for each of 4.1-4.4, readability will be up. How to separate into paragraphs is also a concern. For example, in the upper half of P8208, the description is firstly about drier areas, but in the same paragraph the description goes into areas except for drier areas. As such, the sections for results and discussion are sometimes not easy to follow.

- P8211-8212, "5.4 Future application...": Even if recurrence is a very good measure, it is not the only perfect measure. Recurrence only reveals a certain aspect of hydro-climate variations. In particular, we are not sure whether recurrence is the silver bullet in analyzing the impact of climate change on hydrology. Thus, although this is not what a reviewer should mention, I would argue the tone of 5.4 is very aggressive.

- P8212-, "6 Conclusions": This section for conclusions looks a redundant summary of what was already written in previous sections.

- P8226, Figure 2 and its related text: There are four characters: Q, P, E, S. It means there are 16 combinations. All is 16. Without this tree, when the authors take all the combinations, the number of all combinations is 16. Here in Figure 2, the total number is 16. Why the authors need a sequential tree?

- P8233 Figure 9 and P8234 Figure 10: At first, why characters at the vertical axis need ".00"? Secondary, because many other figures start from Jan at the left in the horizontal axis, please use the same for Figure 9. Then, I have a comment on both captions. There are words like "highly dependent", "higher", "lowest", and so on. But, the authors did not make a quantitative analysis for the arguments written in those captions and for related parts of the main text. In addition, higher or lower is very much subjective, and it is impossible to say which is higher only from these figures. In addition, differences shown in these figures are not much large, and the impact of differences shown in

these figures on the basin characteristics and classification would be determined also by other hydrological components. At least, Figure 9 and Figure 10 should be combined when the authors try to interpret those figures for the basin characteristics and classification. Independent discussion for each figure shown in each caption is thus not relevant. By the way, this comment is true for similar description in the main text. By the way, not only for these two figure captions, but also for some other captions, I do not think we usually put scientific discussion and speculation in the caption. But, there are scientific speculations and discussion in those several captions. Caption is usually limited to what this figure is and how to see it.

- P8236, Figure 12: Horizontal axis (specifically, numbers) of two figures on the left is not clearly seen.

- P8238, Figure 14 and related text: "Model uncertainty" is too general to show and explain this figure. I had the same impression when I read the main text related to this figure. Please try to use more specific set of wording. Only saying "uncertainty" is too general and ambiguous if the authors want to argue something concrete.

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