We would like to thank Anonymous Referee #1 for sharing his insight on the manuscript. The constructive comments helped in clarifying various key points in the manuscript. We would like to respond as below to the comments for further revision.

1) Firstly, the authors use the word "recurrence": what is recurrence? There is no clear definition of recurrence in a hydrological sense, even if they use these statistical measures.

Recurrence was defined in the original paper as the degree to which a monthly cycle repeats year after year. However, this original definition might be unclear to deliver our idea of recurrence. In general we refer to recurrence as a variable returning to the same state after a certain period of time, but particularly, in this study we define the recurrence term as "the degree to which a monthly hydrological variable returns to the same state in subsequent years.

2) In several of the papers they cite, catchments are classified on the basis of their regime behavior, which is defined as the mean seasonal (this can be daily or monthly) water balance. How is recurrence different from these? Does it measure something different or something more than mean seasonal behavior? Why is this important to become a measure of a large river basin classification system?

The recurrence in this study measures something different from the seasonality. The seasonality pointed out by the reviewer may be defined as "the degree to which each monthly value of a regime curve deviates from the overall monthly mean" modified from Walsh and Lawler (1981) In this definition the regime curve refers to the long-term mean of a hydrological variable at each month of a year. On the other hand, with the recurrence as defined above, we try to measure how a monthly hydrological variable will return to the similar state in subsequent years. Of course the recurrence may be enhanced with stronger seasonality but randomness also influences the recurrence (see the discussion below). To measure the recurrence, we used three different indices and mainly focused on the autocorrelation.

Our reason for choosing recurrence is very practical. We believe the recurrence of runoff and other three hydrological variables are of high importance for a water management perspective. It is because typically our society has already adapted to the local hydrological cycle with or without seasonality. It is more challenging for water *managers to handle a random pattern with high fluctuations different from past experiences, such as floods and droughts happening in unexpected magnitudes and unexpected seasons. The advantage of our proposed classification is to show which variables are recurrent or non-recurrent and how different combinations of the recurrence (i.e. our proposed river basin classes) distribute in the world. The advantage of the classification is to enhance our understanding since different combinations of the recurrence indicate different dominant hydrologic regimes as discussed in Section 5. Hence, although we did not use the regime curve to directly classify the basins, the resultant groups of basins share similar characteristics in their regimes.*

3. The authors may want to include a schematic diagram to illustrate river basins with high recurrence and low recurrence, so the reader is clear on what they are talking about.

Based on the suggestion, we would like to add Figure A in the revised paper. In this figure we intend to show several possible patterns with qualitative measures of seasonality, variation and recurrence. Seasonality in the table is calculated with equation (1a) as proposed by Walsh and Lawler (1981).

$$SI = \frac{1}{\overline{R}} \sum_{n=1}^{n=12} \left| \overline{x}_n - \overline{R}/12 \right| \qquad (1a)$$

where $\overline{x}_n$ *is the mean rainfall of month n and* $\overline{R}$ *is the annual mean of a hydrological variable. The variation is quantified through the standard deviation of a variable. The recurrence is calculated with the autocorrelation (in this example, only with a lag of 12 months due to the short length of the sample time series). The left panels in Figure A show sample time series for 60 months, while the right panels show their mean values at each month (or climatology in the original manuscript).*

Case 1 represents a repeating sinusoidal pattern with small amplitude resulting in low seasonality and variation, but its repeating pattern results in high autocorrelation. Case 2, is a randomly generated series. Both cases do not exhibit seasonality as shown in the right panels, and therefore the seasonality also becomes low. The standard deviation is large for case 2; as a result, the recurrence is much smaller due to the randomness of the series.

Case 3 shows an example of high recurrence, which is adapted from the actual precipitation time series in the Yenisei River Basin. The pattern is highly repetitive with relatively small variations in different years. As a result, the recurrence is quantified as 0.84, which will be categorized as recurrent according to our threshold (AC>0.75). The Case 4 is also based on a precipitation time series from the Ob River Basin. Although the climatology in the right panel shows very similar pattern to the Case 3, the original time series show more fluctuations in different magnitudes in different years even for the same month. In this case, seasonality is the same as Case 3 (0.41) but the recurrence is small: 0.69, which is categorized as non-recurrent in this study.

Case 5 is a sinusoidal example repeating the exact same values every 12 months. In this case all the indices including seasonality, standard deviation and recurrence become high. Case 6 has a decreasing trend, but still it keeps higher seasonality, higher standard deviation and high autocorrelation. Note that the linear trend in this example does not decrease the recurrent measure; however in actual variables with different trend patterns (non-linear) recurrence would be reduced.

4) Without such guidance, I am unable to interpret the results in Figure 3, which claims to present the recurrence of precipitation, storage, evaporation and runoff.

We hope the above discussions will help the reader understand Figure 3.The figure presents the recurrence measured by autocorrelation in the four variables measured for the time series at each individual grid. Areas in green show high recurrence (>0.75), areas in yellow show low recurrence (0.5-0.75), and areas in red show lowest recurrence (<0.5). Section 4 explains how they are distributed in the world.

5) Also on a statistical issue, isn't it true that in the presence of strong seasonality, the autocorrelation function is strongly affected by the seasonality, and I am not sure that in these cases the regime curve is just as well sufficient to describe the time sequence of the hydrological variables.

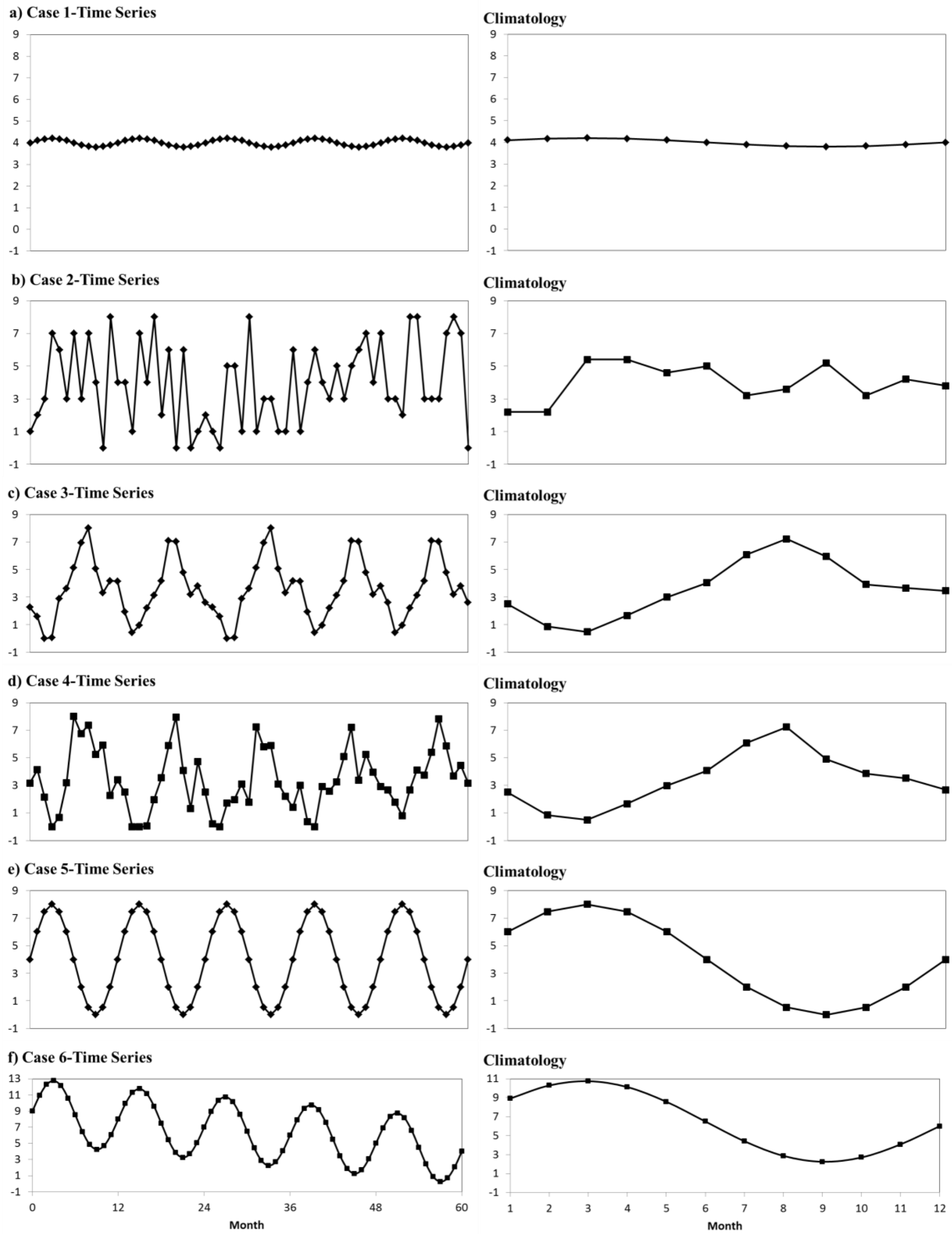
Generally high seasonality may result in high recurrence. However, as discussed above and also explained in Section 5.1, they are not measuring the same features. Figure B shows a relationship between recurrences calculated from all the time series used in *this study and their seasonality evaluated with equation (1a). Even though there is a weak positive correlation (R^2 =0.25) the plot suggests the possibility of high recurrence with low seasonality or vice versa. We will enhance Section 5.1 of the original manuscript by adding and explaining Figure B to clarify the difference between seasonality and recurrence.*

6) I hope the authors are aware of a classical (in Europe especially) approach to characterizing seasonal water balances (including storage, however estimated). It is called the Wundt Diagram – this is presented in the seasonal prediction chapter of the PUB Synthesis Book (Bloeschl et al., 2013), and results from some of the large river basins this paper is also studying – they may want to refer to this if they find it appropriate.

We find the reference relevant to our study and we will include it in the revised manuscript.

7) Likewise there has been a recent paper in WRR on the classification of the MOPEX basins in the USA on the basis of the Wundt Diagram: Berghuijs et al., 2014: Patterns of similarity of seasonal water balance: A window into streamflow variability over a range of timescales. Water Resources Research, 50, doi:10.1002/2014WR015692.

We find the reference relevant to our study and we will include it in the revised manuscript.



Case	Seasonality	Standard Deviation	Recurrence (AC)
Case 1	0.031	0.14	1.000
Case 2	0.242	2.53	0.093
Case 3	0.410	2.15	0.843
Case 4	0.410	2.22	0.690
Case 5	0.622	2.82	1.000
Case 6	0.789	3.38	1.000

Figure A. Schematic time series representing different levels of recurrence, variability and seasonality.

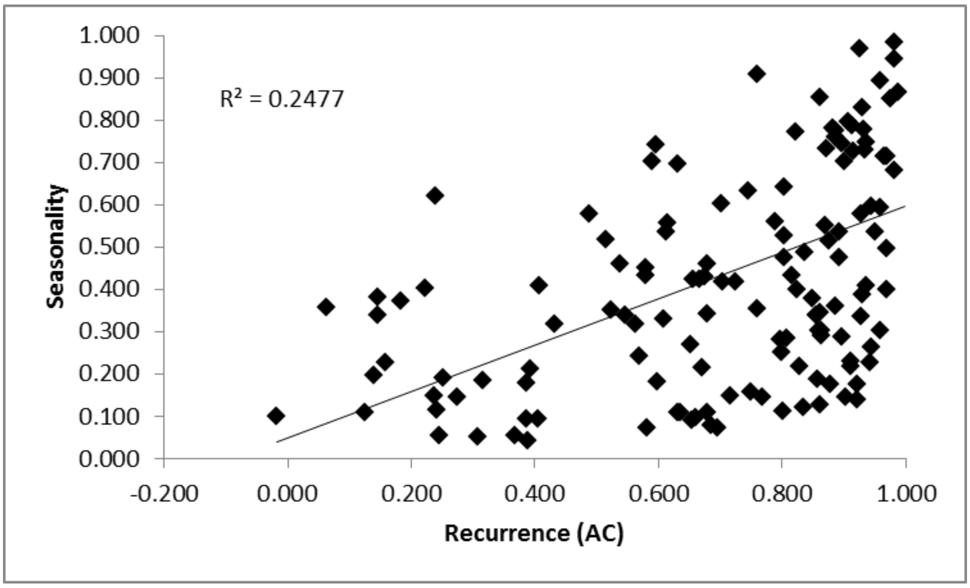


Figure B. Relationship between recurrence and seasonality from all of the time series used in this study.

References

Walsh, R., and Lawler, D.: Rainfall seasonality: description, spatial patterns and change through time, Weather, 36, 201-208, 1981.