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Interactive comment on "Scale invariance of daily runoff time series in agricultural watersheds" *by* X. Zhou et al.

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Issue 1. Section 2.2: In order to make derived scaling properties for the two used methods directly comparable, please include the definition of the relationship between the scaling coefficient D and the Hurst parameter H. Namely, by transforming H=2- D, one may notice that the results of the two applied methods are substantially different.

Revision: The relationship between D and H was added as: The empirically defined Hurst exponent is related to the theoretical fractal dimension D of the graph of a corresponding time series, as: H = 2 - D.

Issue 2. Section 2.3, Page 1763, Line 11 states: " The R/S analysis is based on the fact that the difference between the maximum and minimum values of a time series yt would change for Δt, 2Δt, . . .,mΔt, where Δt is the time interval between two continuous observations." In the theoretical case where dx/dt = const where x is the analysed variable and y(t) = Pt i=1(xi - ŕx), t _ m, the previous statement would not hold. Therefore, please rewrite the previous in the context of the background of the R/S method i.e. search for the optimal reservoir volume.

Revision: The background of long-range scaling was addressed, and the R/S analysis was re-written in more detailed as suggested by Dr. Henning Rust.

Issue 3. Section 2.3, Page 1764, Line 21 states: ..."u is a dummy variable for summation"... Either drop the previous or replace the expression "dummy variable" with "time index" or similar.

Revision: We changed it to "time index" as suggested.

Issue 4. Section 3.1, Page 1764, Line 15 and Line 23 are practically almost the same: ..."the value of the negative slope represents the estimated fractal dimension of the sets"; "The negative slope of each regression line represents the fractal dimension withinthat scaling range".

Revision: The sentence in Line 23 was deleted.

Issue 5. Section 3.1, Page 1765, Line 6 states: "Since two D values were obtained from the box-counting analysis for the time series in this example over the time period under consideration, it implies that its scaling properties vary with the time scales." It is not clear what is "example" referring to.

Revision: The word "example" was replaced by "Figure 1".

Issue 6. Section 3.1, Page 1765, Line 18 states: "In Fig. 2, the break point was found to correspond to a box size of approximately 365 days." The following should be checked: if the annual cycle was removed from the time series (seasonal adjustment), would exist any break point in the scaling? Is the fractal dimension D of the investigated time series with removed seasonal cycle the same or different? (Seasonal adjustment- see for example Priestley M. B., Spectral analysis and time series, Academic Press, 1981).

Discussion: The original daily runoff time series were transformed as follows to obtain a process without seasonality (time series with zero mean and unity standard deviation): (1) logarithms of data series, (2) subtracted seasonal mean values of the time series, and (3) divided by seasonal standard deviations of the time series. After removing the seasonal component in original time series, the break point still presents at around 1 year. However, the fractal dimension increased without the periodical component. For example, at the threshold values of data mean, the fractal dimension was increased from 0.76 to 0.89 for the W-TB subwatershed of the Little River watershed in Tifton, Georgia.

Issue 7. Section 3.1, Page 1766, Line 8 states: " Estimated fractal dimensions of the runoff time series are summarized in Table 2 through 5 for each of the four watersheds." Include explicitly for which range of scales the summarized fractal dimensions are estimated.

Revision: We explicitly specified the scaling range used to fractal dimension estimation in Table 2 through 5 is scaling region 1, i.e. less than 1 year.

Issue 8. Section 3.1, Page 1768, Line 9 states: ..."the same fractal dimension (estimated using the shifted box-counting method) was obtained for the runoff series at each threshold level although these watersheds varied markedly in climate, topography, and size"

Please provide some information on the climate of the analyzed watersheds (for example mean annual precipitation) on topography (mean altitude) and on the land use type for all four analyzed watersheds.

Revision: A table was created to provide information as suggested.

Issue 9. Section 3.2, Page 1769, Line 27 states: "The lag time corresponding to the break point of the two scaling ranges was about 18 months, which is consistently greater than the value of about 1 year obtained from box-counting plots"... Similar to the recommendation given in the comment 6 for the box-counting method,

Discussion: The transformed time series used in the shifted box counting method were also used to Hurst analysis. Both original and transformed time series displayed a scaling break pattern around 18 months. For the transformed time series, the Hurst exponents increased in both scaling regions compared to the original runoff data.

Issue 10. Section 3.2, Page 1770, Line 16 states: "Because the Hurst exponent captures the long-term persistence in the data series, similar values might be interpreted as a reflection of similarities in stable sub-watershed characteristics such as topography, meteorology, and soil type." With exception of the two smallest watersheds (W-14 and W-23) the H values for other watersheds are quite similar although "these watersheds varied markedly in climate, topography, and size" as stated in the section 3.1. Therefore, the interpretation of H similarities "as a reflection of similarities in stable sub-watershed characteristics such as topography, meteorology, and soil type" is obviously here not possible.

Revision: We agree that the H values were close to each other for almost all the time series, thus the H similarities among the subwatersheds may not be simply interpreted from the topography, meteorology, and soil type. We removed it from the discussion.

Issue 11. Section 3.2, Page 1771, Line 13 states: "As previously indicated, the W-14 and W-23 sub-watersheds of the Reynolds Creek watershed have much different fractal dimension and Hurst exponent in comparison with other sub-watersheds, which might be explained by their relatively small size (0.1km2 and 0.01 km2)." Please extend the previous by indicating the H values namely, H = 0.73 (W14) and H = 0.6 (W23).

Revision: H values for two small sub-watersheds were specified.

11. Section 4, Page 1772, Lines 14-20 state: "The Hurst analysis showed that the runoff time series also displayed a rather strong long-term persistence which dissipated after 18 months. The same fractal dimensions and Hurst exponents were obtained for

the sub-watersheds within each watershed, indicating that the runoff of these subwatersheds have similar distribution of occurrence and similar long-term memory. These results indicated the existence of scale invariance in the runoff time series in agricultural watersheds over temporal and spatial scales." The "strong long-term persistence" may only be an artifact of the strong seasonal or even longer cycles. See comments 6 and 9. Further, there is not enough information given to support the conclusion regarding spatial scale invariance. Please refer to Skøien J. O., Blöschl G. (Characteristic space and timescales in hydrology, Water. Resour. Res., 9(10), 1304, 2003).

Discussion: As indicated above, we removed the seasonal component from the original time series, and applied the same methods on these transformed data. The scaling characterization still stands, although the fractal dimension and Hurst exponent values varied. We agree with the reviewer that the data and applied analysis may not be sufficient for drawing a conclusion on spatial scale invariance in this study.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 1757, 2005.