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Hydrology and Earth System Sciences Discussions

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

Anonymous Referee #1

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General Comment

The manuscript is well structured and addresses an interesting topic - the scaling properties of daily runoff time series in agricultural watersheds. There are no technical errors in the analysis, but some important information is missing, wherefore the results do not provide enough support for the conclusions.

Due to the chosen scientific methods the overall impression is, that the authors overlooked the recent developments of the Hurst parameter detection and interpretation of the estimates. The recommendation is to introduce a review of the recent scientific literature on the topic as well as a detailed analysis of the structure of the used time series (trends, periodicities) and information about the physical watersheds properties (topography, climate, land use type) as the scaling behaviour in nature is more a rule than an exception (Koutsoyiannis D., Hydr. Sc. J., 50(3), 405-426, 2005). Studies which illustrate the need for an analysis of the time series structure prior to draw a conclusion on the time series scaling properties are the study of Klemeš (Water Resour. Res., 10(4), 675-688, 1974) who introduced a concept of the nonstationarity of the mean as an explanation of the Hurst phenomenon, the study of Bhattacharya et al. (J. Appl. Probab., 20, 649-662, 1983) who proved that weakly dependent processes perturbed by small monotonic trends also manifest the Hurst phenomenon, while the studies of Montanari et al. (Math. and Comp. Mod., 29, 217-228, 1999) and Markovic et al. (Geophys. Res. Lett., 32, 17, 2005) showed that the Hurst parameter estimates of various methods are sensitive to the presence of periodicities in time series. Further, an extensive review on the Hurst phenomenon detection and modeling is provided by Montanari (in "Theory and applications of long-range dependence", P. Doukhan, G. Oppenheim, M.S. Taqqu (Eds.), 461-472, Birkhauser, 2003). The basic method choice guidelines are given by many authors (Beran J., Statistics for Long-Memory Processes, Chapman & Hall, 1994; Coeurjolly J.-F., J. Stat. Soft. 5(7), 2000).

Specific comments:

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.

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 y_t would change for $\triangle t, 2\triangle t, ..., m\triangle t$, where $\triangle t$ is the time interval between two continuous

observations."

In the theoretical case where $dx/dt = const$ where x is the analysed variable and $y(t) = \sum_{i=1}^{t}(x_i - \bar{x}),\ t \leq m$, 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.

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.

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 within that scaling range".

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.

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).

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.

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 analysed watersheds (for example mean annual precipitation) on topography (mean altitude) and on the land use type for all four analysed watersheds.

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, it would be interesting to see if there are a break points in the scaling behavior of deseasonalised time series.

9. 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.

10. 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).

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 artefact 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., 39(10), 1304, 2003).

Review summary

1) Does the paper address relevant scientific questions within the scope of HESS? YES

2) Does the paper present novel concepts, ideas, tools, or data? ALMOST

3) Are substantial conclusions reached? ALMOST

4) Are the scientific methods and assumptions valid and clearly outlined? ALMOST

5) Are the results sufficient to support the interpretations and conclusions? NO

6) Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? YES

7) Do the authors give proper credit to related work and clearly indicate their own new/original contribution? YES.

8) Does the title clearly reflect the contents of the paper? YES

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9) Does the abstract provide a concise and complete summary? YES

10) Is the overall presentation well structured and clear? YES

11) Is the language fluent and precise? YES

12) Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? YES

13) Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? YES

14) Are the number and quality of references appropriate? NO

15) Is the amount and quality of supplementary material appropriate? YES

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