Hydrol. Earth Syst. Sci. Discuss., 2, S1045–S1048, 2005
www.copernicus.org/EGU/hess/hessd/2/S1045/
European Geosciences Union

Hydrology and Earth System Sciences Discussions

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

X. Zhou

xzz2@psu.edu

Received and published: 22 November 2005

Issue 1: in the first part (estimated fractal dimension) the results might be mainly due to the yearly cycle which has not been removed (as suggested e.g. in Radziejewski and Kundzewicz, 1997). To support this, Fig. 1 (left) in this comment the box counting result for a Gaussian white noise series with a yearly cycle added. The figure qualitatively resembles Fig. 1 from the manuscript, especially regarding the two distinct scaling regimes. Furthermore, it is difficult to follow the interpretation of the results. The authors report a prominent time scale of one year and "scaling properties vary with the time scale". Those findings seem to be in contradiction with the absence of a typical time scale and scale-invariance.

Discussion: We agree the deterministic components should be removed prior to drawing any conclusion about the scaling issue on hydrological time series. We are also grateful for the nice figures generated by Dr.Henning Rust. As suggested, the seasonal component was removed from the original time series and the shifted box-counting method was applied to the transformed time series. Our results showed that the break point still presented around 1 year for the transformed time seris, while the fractal dimension at the mean value (which is 0) of the transformed data was equal to 0.91, which is the same as estimated for Gaussian white noise in Figure provided by reviewer.

Issue 2: In the second part (estimated Hurst exponent), the authors do not strictly respect the definition of long-range dependence (e.g. Beran, 1994) which requires, loosely speaking, power-law scaling with $H > 0.5$ for large lags. A Hurst coefficient of H ≈ 0.5 for large lags, as reported, indicates the absence of long-range dependence, irrespectively of the behavior on small scales. A Hurst exponent of $H < 0.5$ characterizes a very unstable phenomenon (Beran, 1994, Ch. 2). In this analysis, an estimation of $H < 0.5$ might be an artefact due to the presence of the seasonal cycle (cf. Hu et al., 2001 for the influence of sinusoidal trends on DFA). A power-law in the R/S plot for small lags only indicates some memory but is not an evidence for long-range dependence neither for a power law decay of the autocorrelation function in that range (Maraun et al., 2004). Figure 2 (left) shows the R/S analysis of log-normal distributed white noise with a yearly cycle added (left) and without a yearly cycle (right). This figure demonstrates how a sinusoidal trend influences the R/S analysis. An increased Hurst exponent is suggested for lags smaller than the period of the trend and a decreased exponent (and possibly also $H < 0.5$) is suggested for larger lags. The left panel of Fig. 2 compares qualitatively well to Fig. 3 in the manuscript.

Discussion: Once again, we thank reviewer for the illustrated figures on Hurst exponent estimate. As pointed out, the trend or periodicity in time series may also display Hurst phenomenon. The transformed time series used in the shifted box counting method were also used to Hurst analysis. The results showed that both time series (original and transformed) displayed a scaling break point around 18 months. The Hurst exponents increased in both scaling regions for transformed time series compared to the original runoff data. As the reviewer pointed out, the H values ≈ 0.5 for large lags in original data is an artifact due to the presence of periodicity component.

Issue 3: Ch. 1: In the introduction the authors use the term “scaling” in different contexts: transfer from small to large catchments or from small to large temporal resolution, geometrical and dynamical scaling properties, scaling of a statistical distribution. The reader might get easily lost since the interrelationship is not sufficiently explained or referenced.

Revision: This part was reorganized as following sentences: “Different from geometric scaling in classical geometrical objects, statistical scale invariance has been found to be more general and useful in natural processes and phenomenon, which leads to relationships connecting statistical properties of the geometric feature and/or dynamic processes at different scales. Mathematically, statistical scale invariance manifests itself when the dependence of number of observations in the series greater than a specified value on the values themselves follows a power law. Statistical scale invariance is especially useful in the hydrology context since hydrological processes are often characterized by some statistical properties.”

Issue 4: Ch. 2.3: A more carefully explanation of the R/S method would facilitate the reproduction of the results presented. Especially, the notation could be improved.

Revision: The R/S method was described in more detailed as suggested.

Issue 5: P. 1763, l. 10: Typing error in the reference: Maldelbrot

Revision: “Maldelbrot” was changed to “Mandelbrot”.

Issue 6: Ch. 3.1: It should be emphasized that the fractal dimension is estimated for some binary series gained from the runoff series by use of a threshold and not from the runoff series itself.

Revision: As suggested, the following sentence was added: “It should be noted that the fractal dimensions were estimated for some binary sets derived from the runoff series based on the chosen threshold values, not the runoff series itself.”

Issue 7: Figs. 1,2: Plots would become clearer if four different symbols were used for four different data sets.

Revision: Different symbols were adopted as suggested.

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