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Hydrology and Earth System Sciences Discussions

Interactive comment on "Low-frequency variability of European runoff" *by* L. Gudmundsson et al.

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We thank for the insightful contributions of the editor D. Koutsoyiannis and his commitment to contribute as an editor to the scientific discussion; although his contributions go beyond his responsibility as an editor. We take the opportunity of this "interactive discussion" to directly react to some of his suggestions, criticisms and comments.

1 Hurst - phenomenon

We are well aware of the "Hurst phenomenon" and its coverage in the hydrological literature. Like the measure Φ_Q (Eq. 2) used in the paper, the Hurst statistic can be interpreted as a parametrization of the variance distribution of a power-spectrum.

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However, our impression is that most empirical (data based) investigations that analyze runoff time series with respect to the Hurst phenomenon, share several common features which distinguish them from our study:

1. In many cases the temporal resolution of the considered data is limited to annual values (e.g Tallaksen et al., 1997; Vogel et al., 1998; Koutsoyiannis, 2002, 2003, 2010). Thus the statistics applied parametrize the variance distributions on frequencies $>$ one year. This would be equivalent to parameterizing the spectral properties of Q_{Long}, and would be an interesting task itself, but is not the objective of our study.

2. Most studies analyze only a limited number of time series, making it difficult to draw robust quantitative conclusions. The only study we are aware of that covers a large number of time series is Vogel et al. (1998), which also operates on annual values and is therefore not directly related to the framework of our study.

3. We are only aware of a few "Hurst" studies that consider daily or monthly time series (e.g. Montanari et al., 1997; Mudelsee, 2007). Our impression is that one crucial feature in the technical procedure of these studies is to deseasonalize the time series prior to any further analysis. Thus they parametrize the variance distribution of the power-spectrum of the series $R = Q - Q_{Seas}$, and thus are not directly comparable to Φ_Q (which parameterizes the spectrum of Q).

Bases on these considerations we decided not to mention the Hurst phenomenon in the discussion paper (following our attempt to keep the paper short and concise). However, we agree that it might be helpful for the reader to highlight the differences of this body of literature to our study. Therefore, we suggest to point out the novelty of our approach by contrasting it to the literature focusing on persistence of hydrological time series, including the Hurst-phenomenon.

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2 “Arbitrariness” of decomposition in Eq. 3

The editor pointed out that the decomposition in Eq. 3 is somewhat arbitrary. It is true that time series can in principle be decomposed into a large number of sub-series, each defined by its own frequency band (basically Eq 1). Nevertheless, we believe that the separation into “sub-annual”, “seasonal” and “low-frequency” variability can be justified by reference to the different types of phenomena associated with each time scale, such as runoff response to rainfall vs. slow variations in the water budget. In fact, this type of conceptualization is underlying many other studies that investigate either annual values (ignoring “sub-annual” and “seasonal” variability) or so called monthly anomalies (which by subtracting the long-term mean of each month ignore “sub-annual” variability).

Discussing these issues in detail would make the paper less focused and we therefore prefer not to include an in-depth discussion, but suggest to mention that a further analysis of the spectral properties of Q_{Long} may be fruitful. A discussion of the limitations of the chosen approach will be included.

3 Low frequency variance of temperature (Fig 4)

The editor mentioned doubts about the low values of the fraction of low-frequency variance of temperature (Fig. 4, Φ_T) and presented a “counter example” (Koutsoyiannis, 2011). However, the time series that was analyzed in this example had a annual resolution and thus the results cannot be compared directly to our findings. The overall low values of Φ_T can be easily explained be the large amplitude of the annual cycle of temperature. Low-frequency variations of temperature are of a much lower order of magnitude and thus Φ_T is small.

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4 Section 3.3

Section 3.3 covers the description of two methods, (1) ISOMAP that is used to extract spatial patterns or simultaneous variations and (2) Procrustes analysis that is used quantify the similarity of patterns identified with ISOMAP.

In our response to the comments of Reviewer #1 we reflected on the choice of the level of details when introducing complex methods and regard the Editors comments as an demand for clarification.

We therefore suggest to expand the method description, or alternatively provide the additional details in a methodological appendix.

5 "Hypothesis"

The editor mentioned some doubts regarding our conclusions to accept the "Hypothesis" on p. 20 l. 23 ff, especially focusing on the relation between low frequency variance of runoff and the atmospheric variables.

1. Φ_Q is a parametrization of the variance distribution of the power-spectrum of Q. In hydrology it is often assumed that catchments act as spectral filters that reduce the high-frequency variance of precipitation. Commonly the "filtering" is assumed to depend on catchment properties, which implies that the variance distributions of the power-spectra of Q and P will be different. The results of the correlation analysis (Table 1 in the discussion paper) support this. However, this does not imply that the variance of Q_{Long} and P_{Long} are independent.

2. The strong empirical relationship among the space-time patterns of Q, T and P suggest that they are directly related. We regard this empirical finding as suffi-

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cient to “proof” that low-frequency runoff follows closely the atmospheric drivers (which in fact is not surprising). The interpretation of the patterns of P_{Long} and T_{Long} falls in the domain of atmospheric science and its detailed discussion would go beyond the scope of this study. Instead several references are included as a guide to the relevant literature.

6 Data reliability

The editor expressed some doubts regarding the credibility of re-analysis data (here the WFD was used) and suggested to include some comparisons to observed precipitation and temperature records. Data quality is an important aspect of any environmental science and the use of a certain data product is often a trade-off between data availability and data reliability. However, assessing the quality of reanalysis data products is a huge task and thus would go beyond the scope of this study. Further, we believe that comparing the values of one grid-cell to station values would not do justice to the nature of re-analysis products, that are build to provide reliable estimates of large-scale patterns. Some of our results actually support the ability of the WFD to capture large-scale features of atmospheric variability as demonstrated by similarity in the spatial patterns of simultaneous variations of Q_{Long} and P_{Long} (Fig 5). For these reasons we consider an a detailed comparison of the WFD against a few station data to be less relevant for the scope of this study.

7 Data availability

The availability and the access of runoff data is in detail described in Stahl et al. (2010). We suggest to state this clearly in the data section.

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The Watch Forcing Data (WFD) is a newly developed data product and to date only available for participants of the WATCH project. The WFD will be made publicly available Aug 1st 2011

References

Koutsoyiannis, D.: The Hurst phenomenon and fractional Gaussian noise made easy, Hydrological Sciences Journal, 47, 573 – 595, doi:10.1080/02626660209492961, 2002.

Koutsoyiannis, D.: Climate change, the Hurst phenomenon, and hydrological statistics, Hydrological Sciences Journal, 48, 3 – 24, doi:10.1623/hysj.48.1.3.43481, 2003.

Koutsoyiannis, D.: HESS Opinions "A random walk on water", Hydrology and Earth System Sciences, 14, 585–601, doi:10.5194/hess-14-585-2010, 2010.

Koutsoyiannis, D.: Hurst-Kolmogorov dynamics as a result of extremal entropy production, Physica A: Statistical Mechanics and its Applications, 390, 1424 – 1432, doi:10.1016/j.physa.2010.12.035, 2011.

Lins, H. F.: Regional streamflow regimes and hydroclimatology of the United States, Water Resources Research, 33, 1655–1667, doi:10.1029/97WR00615, 1997.

Montanari, A., Rosso, R., and Taqqu, M. S.: Fractionally Differenced ARIMA Models Applied to Hydrologic Time Series: Identification, Estimation, and Simulation, Water Resour. Res., 33, 1035–1044, doi:10.1029/97WR00043, 1997.

Mudelsee, M.: Long memory of rivers from spatial aggregation, Water Resour. Res., 43, W01 202, doi:10.1029/2006WR005721, 2007.

Stahl, K., Hisdal, H., Hannaford, J., Tallaksen, L. M., van Lanen, H. A. J., Sauquet, E., Demuth, S., Fendekova, M., and Jódar, J.: Streamflow trends in Europe: evidence from a dataset of near-natural catchments, Hydrology and Earth System Sciences, 14, 2367–2382, doi:10.5194/hess-14-2367-2010, 2010.

Tallaksen, L. M., Madsen, H., and Clausen, B.: On the definition and modelling of streamflow drought duration and deficit volume, Hydrological Sciences Journal-Journal Des Sciences Hydrologiques, 42, 15–33, 1997.

Vogel, R. M., Tsai, Y., and Limbrunner, J. F.: The Regional Persistence and Variability of Annual Streamflow in the United States, Water Resour. Res., 34, 3445 – 3459, doi: 10.1029/98WR02523, 1998.

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8, C439–C445, 2011

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