Journal of Hydrology

Dr. D. Koutsoyiannis
National Technical University
Department of Water Resources
Heroon Polytechniou 5
15780 Athens
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Re.: HYDROL 2022

Amsterdam, May 28, 2001

Dear Dr. Koutsoyiannis,

We have evaluated *Hurst phenomenon and fractional Gaussian noise made easy* by Koutsoyiannis, D..

I very much regret to have to tell you that publication in our journal is not recommended. An explanation for this decision is given in the enclosed review reports, and I hope that the comments contained therein will be of use to you.

I am sorry to have to give you this news but have no other option than to return the manuscript to you. Thank you for your interest in our journal.

Yours sincerely,
For the Editor

Frans Koning
f.koning@elsevier.nl

JOURNAL OF HYDROLOGY
Manuscript: **HYDROL 2022**
Date: 17 May 2001

Roman Krzysztofowicz
Editor-in-Chief
Charlottesville, Virginia

EDITOR'S REPORT FOR THE AUTHOR(S)

The manuscript has been read by three reviewers. One reviewer (C) recommends publication, while two reviewers (A and B) do not think the manuscript merits publication on the grounds that, based on the vast research results published in the past, much more is known about the Hurst phenomenon and the properties and limitations of the fractional Gaussian noise model than the current manuscript acknowledges. I concur with the opinions of reviewers A and B.

I regret being unable to report a more positive evaluation at this time.

General instructions for the author(s)

- In a covering letter please explain how and where the reviewers' comments have been incorporated.
- Please indicate in a copy of the revised manuscript where changes have been made.
- Should you disagree with any part of the reviews, please explain why.
- Please provide 4 to 6 keywords. These should preferably be taken from the most recent American Geological Institute GeoRef Thesaurus and should be placed beneath the abstract.
- Upon submitting the revision *(in duplicate and on a disc)*, please return all material, including any manuscript pages annotated by the reviewers, to the Editorial Office, P. O. Box 1930, 1000 BX Amsterdam, The Netherlands.

(A)

Journal of Hydrology

CHECKLIST FOR THE REVIEWER

A few guidelines

* To provide the author(s) with the means to improve their paper, please comment objectively. On a separate sheet you may provide comment for the editor that you may feel necessary.
* Please document statements adequately.
* If a paper repeats previously published work please point this out to the editor.
* Please explain the reasons for your answers on separate sheets, keying your comments to the letters A-M. You may of course also provide any further comment, keying your remarks to numbers in the margin of the manuscript.
* Some of the questions that follow should be answered on a scale of 1 to 3, where 1 is the highest rank and 3 is the lowest. (Please encircle/underline your answers.)

Manuscript: HYDROL 2022
Title: *Hurst phenomenon and fractional Gaussian noise made easy*
Authors: Koutsoyiannis, D.

Do you agree to your identity being revealed to the author(s)	yes	(no)
A Is this topic		
1 suitable for the journal?	(yes)	no
2 of broad international interest?	(yes)	no
3 significant?	yes	(no)
4 novel?	yes	no ?
Please explain your answers to items A1-4 here briefly		
	high	low
B Clarity of objectives:	1 2	(3)
C Quality of methods/correctness of mathematics:	(1) 2	3
D Quality of data:	1 2	(3)
E Validity of assumptions and analyses:	1 2	(3)
F Extent to which the interpretations/conclusions are supported by the data:	1 2	(3)
G Overall significance of this work:	1 2	(3)
H Is this paper		
1 properly organized?	(yes)	no
2 to the point/concise?	(yes)	no
3 written clearly using correct grammar and syntax?	yes	no ?
I Are the approach, results and conclusions intelligible from the abstract alone?	(yes)	no
J Is the title informative and a reflection of the content?	(yes)	no
K Are the illustrations/tables		
1 useful and all necessary?	(yes)	no
2 of good quality?	(yes)	no
L Is the referencing relevant, up to date and accessible?	yes	(no)
M Are the keywords (if provided) appropriate and complete?	yes	no
N Overall quality of the work:	1 2	(3)

CHECKLIST FOR THE REVIEWER (*continued*)

Manuscript: HYDROL 2022
Title: *Hurst phenomenon and fractional Gaussian noise made easy*
Authors: Koutsoyiannis, D.

O Can you suggest any improvements to this work, or any parts which could be shortened or removed?

I have gone through the manuscript of "Hurst phenomenon and fractional Guassian noise made easy" by D. Koutsoyiannis. I find this paper unacceptable. The author has not gone through the vast literature available on this topic. To try to bring GN models back to widespread use in hydrology would be arguing against a vast amount of empirical evidence. The author has based his conclusions on exactly one river flow series. Thus it is not an acceptable contribution.

(B)

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* Please document statements adequately.
* If a paper repeats previously published work please point this out to the editor.
* Please explain the reasons for your answers on separate sheets, keying your comments to the letters A-M. You may of course also provide any further comment, keying your remarks to numbers in the margin of the manuscript.
* Some of the questions that follow should be answered on a scale of 1 to 3, where 1 is the highest rank and 3 is the lowest. (Please encircle/underline your answers.)

Manuscript: HYDROL 2022
Title: *Hurst phenomenon and fractional Gaussian noise made easy*
Authors: Koutsoyiannis, D.

Do you agree to your identity being revealed to the author(s) yes (no)

A Is this topic
1 suitable for the journal? yes no
2 of broad international interest? yes no
3 significant? yes no
4 novel? yes no

Please explain your answers to items A1-4 here briefly

PLEASE SEE COVERING LETTER — EDITOR'S DECISION

B Clarity of objectives: 1 (2) 3

C Quality of methods/correctness of mathematics: 1 (2) 3

D Quality of data: (1) 2 3

E Validity of assumptions and analyses: 1 (2) 3

F Extent to which the interpretations/conclusions are supported by the data: 1 (2) 3

G Overall significance of this work: 1 2 (3)

H Is this paper
1 properly organized? (yes) no
2 to the point/concise? yes (no)
3 written clearly using correct grammar and syntax? (yes) no

I Are the approach, results and conclusions intelligible from the abstract alone? (yes) no

J Is the title informative and a reflection of the content? (yes) no

K Are the illustrations/tables
1 useful and all necessary? yes (no)
2 of good quality? yes (no)

L Is the referencing relevant, up to date and accessible? yes (no)

M Are the keywords (if provided) appropriate and complete? (yes) no

N Overall quality of the work: 1 2 (3)

(3)

Manuscript HYDROL 2022 "Hurst phenomenon and fractional Gaussian noise made easy" by D. Koutsoyiannis

This paper aims to provide a review of Fractional Gaussian Noise (FGN) and its properties, in a way that is accessible to hydrologists. Some motivation for studying the topic is given, as well as some simple algorithms for generating simulated FGN sequences.

In my opinion, such a review may be of interest to hydrologists, but to merit publication it really needs to be much more comprehensive and up-to-date. Greater generality would also be beneficial. The author appears to be unaware of a few key papers in the field, and of the fact that some standard software packages, such as SPlus, already provide easy-to-use methods for fitting and simulating FGN models — there really is little need for more simulation algorithms. I would, however, certainly endorse the author's views regarding the reason for 'long-memory' behaviour in hydrologic time series (superposition/mixing of processes on different scales), and his conviction that trends in such series are stochastic rather than deterministic.

In the event that the author decides to revise this paper and resubmit, I have appended some references to the end of this report. These are not exhaustive, but may provide some useful starting points. In addition, the following specific suggestions may be helpful:

- Delete equations (4) and (5) — they are not necessary. I appreciate the idea is to make clear the interpretation of (3), but realistically any reader who cannot interpret (3) correctly is not going to make much progress with the rest of the paper!

- In the interest of greater generality, equation (6) can be expanded to give both the mean and covariance structure of the aggregated process:

$$\gamma_j^{(k)} = \sum_{\ell=1}^{k} \sum_{m=jk+1}^{(j+1)k} \gamma_{m-\ell}^{(0)} \,.$$

  This result is used implicitly on page 6 in any case, where it is referred to as an 'elementary statistical property' — which I think justifies its inclusion.

- The attempt to keep things simple on pages 5 onwards, by studying an AR(1) process, is a little misguided since it becomes necessary to introduce more complex models such as ARMA(1,1) in any case. Furthermore, the specification of the AR(1) given here is unnecessarily complicated, not to mention wrong (the mean of the $\{V_i\}$ is incorrect as given). I would be inclined to introduce the general class of ARMA models, writing them in the standard form

$$X_t - \mu_X - \phi_1 (X_{t-1} - \mu_X) - \ldots - \phi_p (X_{t-p} - \mu_X) = \epsilon_t - \theta_1 \epsilon_{t-1} - \ldots - \theta_q \epsilon_{t-q} \,,$$

  and then treat the AR(1) as a special case.

- At the bottom of page 6, the last sentence ('For a large aggregated timescale, ρ^k becomes small ...) is not a correct argument. The point is that the numerator of (14) is dominated by the first term.

- Pages 4–7 essentially deal with the topic of 'timescale dependence for short memory processes'. All of this material is very standard. Some references to indicate this would be in order. In fact, if it becomes necessary to shorten the paper I would suggest that a lot of this material can be cut out completely and replaced with a concise discussion, backed up with a few well-chosen pointers to the literature.

- Section 3 ('Some real world examples') can only be really convincing if the ARMA models fitted to the datasets are realistic. Nobody in their right mind would seriously contemplate fitting an AR(1) to either of these datasets! For example, the Nile river data clearly shows a slowly-decaying autocorrelation function, which is consistent (in a standard Box-Jenkins approach) either with a nonstationary model or a high-order autoregression. My immediate reaction to this data (again, within the Box-Jenkins framework) would be to difference it. If you do this, you see immediately that the picture is actually rather complicated — there are periods of high and low variance in the differenced data. The ACF and PACF of the differenced series suggest a MA(2) model — i.e. an ARIMA(0,1,2) model for the original data. Indeed, the diagnostics from an ARIMA(0,1,2) suggest that it fits rather well, except for the changing variance. Now there is no way that any environmental time series genuinely follow an ARIMA(0,1,2) model, whose sample paths are unbounded; however, it makes far more sense to compare FGN with this than with AR(1). The unbounded sample paths of ARIMA models are, for me, the most compelling reason for considering fractional differencing; however, in this particular case I would be very keen to try and work out what is going on in the variance of the process before doing anything else.

  I have not examined the other dataset in detail; however, similar comments apply. This affects quite a lot of the discussion in the paper, where FGN is compared with AR(1).

- On pages 12 and 13, the definitions of the underlying continuous-time Markov processes are incomplete — in particular, we need to know where the values $m_{(1)}, m_{(2)} \ldots$ come from. I actually thought this entire section made very heavy weather of an extremely simple point, which is that long-memory processes can be regarded as having irregular changes on all time scales (hence the power law spectral behaviour).

- Another suggestion for reducing length: remove all material relating to range. It has been included for completeness, but is not really necessary (particularly since it is hardly used in modern practice).

I had a number of other, minor, comments but at this stage these are probably not appropriate. Some suggested reading is as follows:

Haslett, J. and Raftery, A. (1989): Space-time modelling with long-memory dependence: assessing Ireland's wind power resource. *Applied Statistics*, **38**, pp.1–50.

This paper is a bit mathematical, but provides the algorithms which are used today in packages such as Splus to deal with long-memory models.

Hosking, J.R.M. (1981): Fractional differencing. *Biometrika*, **68**, pp. 165–76.

This paper really lays the foundations for the use of long-memory models in modern time series analysis. It is very readable and well-written, and should be a mandatory item in any reference list on this subject.

Stephenson, D.B., Pavan, V. and Bojariu, R. (2000): Is the North Atlantic Oscillation a random walk? *Int. J. Climatology*, **20**, pp.1–18.

A recent example of the application of long-memory models in climatology. Contains some nice discussion of the pros and cons of different classes of model, focusing upon the application rather than the mathematics.

(1)

(C)

Because of the long delay, I have spent less time on the paper than it deserves, but a quick reading suggests that the paper should be published in its present form, although editing will be required to correct some minor points of linguistics. The author is obviously aware of the extensive hydrological literature on the Hurst phenomenon, including the monograph on the "Statistics for Long-Memory Processes" by Jan Beran, and the interesting explanation of Hurst-like behaviour presented in Section 5 of the paper seems very similar to some of the examples given in Section 1.3 of Beran´s book: in particular the example in Section 1.3.4 on hierarchical variation ("Cox (1984) proposed a physical explanation for these correlations by constructing a model with hierarchical variation ....each time this process is applied, the current one-dimensional scale is stretched ..... In addition, new short-term variation ('noise') is introduced....."). The author might wish to consult the paper by Cox (1984) referred to by Beran and given in full in the book´s bibliography, if he can get a copy (not too easy, I believe).