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Interactive comment on "HESS Opinions "A random walk on water"" by D. Koutsoyiannis

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EMBRACING THE IDEAS ABOUT FURTHER RESEARCH

I thank Antonis Koussis for his comments (Koussis, 2010), which certainly are flattering for my paper (Koutsoyiannis, 2009) and for me personally. I found Koussis' review constructive because he tries to complement, augment and expand the ideas contained in the paper.

I was glad to read that Koussis agrees with, and emphasizes my statement for the "even higher importance in engineering" of prediction. I thank him for his extensions of the ideas outlined in the paper with formulations that make them relevant to policy, planning and management. I refer for instance in these statements from his review: "Perhaps, the hydrologic community, and particularly the competent government agen-

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cies, should rethink the ongoing dismantling of monitoring networks" and "...it is hard not to doubt the reliability of projections by climate models for time horizons from one hundred to multi-thousand years. Some of the pathologies of GCM projections, and of their post-processing (downscaling), have been highlighted in the literature, ... and make planning for water resources management under future climate scenarios seem a questionable, or even futile exercise."

Most importantly, Koussis offers two ideas for further research to extend the study. The first idea is essentially to shape a (toy?) model in continuous time whose dynamics are described by differential equations, rather than difference equations as in the present study. Again difference equations would emerge but now as approximations to the differential equations. Ideally, an analytical solution would exist and this would enable the comparison with the approximate numerical solution, as well as the study of numerical errors, as an additional source of uncertainty. This has some relevance with what Soon (2009) points out in his review, who also includes some references in recent literature.

The second idea is about a study of a more real hydrological system with more than 2 state variables and perhaps with the spatial dimension (in addition to the temporal dimension to which the present study is confined) with an additional objective perhaps to trace the emergence of Hurst-Kolmogorov behaviour in space. Such behaviour is indeed observed when analysing spatial fields of hydrometeorological variables, although this has not been given the deserved attention. The importance of spatio-temporal chaos has been also highlighted in a discussion about this paper in William M. Briggs' blog, http://wmbriggs.com/blog/?p=1269&cpage=1#comment-12955).

I am embracing both Koussis' ideas and I agree with him that conducting studies in these lines is worth pondering. On the other hand, I think that implementing these ideas is difficult and certainly needs collaboration of many experts (of course, I am open to such collaborations). For example, devising a continuous time model with analytical solution of differential equations is very difficult. While a discrete time dynamical system can be chaotic even if it is 1-D (the system in the paper is 2-D) and its calcu-

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lations are algebraic (the toy model in the paper is implemented in Excel), a model in continuous time should be at least 3-D and apparently its differential equations should be nonlinear yet with analytical solution. And apparently, a spatio-temporal chaotic model is even more difficult to construct and study, particularly if it uses differential rather than difference equations.

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