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Hydrology and Earth System Sciences Discussions

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

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I have read Demetris Koutsoyiannis's (DK) paper: "A random walk on water" several times. I find this to be a very worthy contribution to not only the science of hydrology but also to the general question on future predictability of any variable. Some readers may find DK's conclusion about the inseparable randomness or random elements from any apparent deterministic outcomes (either from highly reduced system or general mechanistic predictions) to be too negative or pessimistic.

But I remember that when I pointed out to DK about two other recent publications (i.e., Makridakis and Taleb 2009a, 2009b) from the field of forecasting science that reached a (perhaps) similar conclusion about the real-world difficulties in forecasting the future, he carefully qualified the difference between his view and those of Makridakis and

Taleb as: "In my view, uncertainty and extremes are positive qualities – without them we would not exist".

In another apparent agreement with DK's main conclusion, Liao (2009, p. 1550) independently suggested that:

"[T]he prediction uncertainty of chaos is physically unavoidable, and that even the macroscopical phenomenona might be essentially stochastic and thus could be described by probability more economically."

Let me start my discussion with a question upon seeing DK's November 29's first reaction to the comment/review posted by Steven Weijs: What does the latest "ClimateGate" incident have to do with DK's paper or Steve Weijs's review?

In investigating the details, I cannot find too many disagreements or negative things to say about DK's exploratory essay. I would only caution the less exact discussion with regards to the connection of indeterminacy and/or uncertainty of predicting the future to any definition of randomness or entropy (i.e., the links to the papers by G. J. Chaitin and A. N. Kolgomorov etc). My main concern is that the connection may not be as direct or clear as our current knowledge would permit. To illustrate a practical barrier or problem, there are serious questions even about the reliability of the computed "chaotic" solutions from discrete dynamical equations as newly discussed in Lorenz (2006), Teixeira et al. (2007) and Liao (2009).

On one specific matter though, I would like to remind DK that, according to Laskar's (1999) analysis, his specification of 100 million years for the predictability of Earth's orbit on p. 6621 may be still too optimistic. Laskar (1999) suggests that predictability of the Earth's orbital orientation lies only within 35 to 50 millions of years. A factor of two to three may be important for the integration of our solar system dynamics with essentially no unknown variables to reckon with (i.e., this is most unlike some of the thorny problems in hydrologic science) and such quantitative precision is especially relevant for the field of geology.

Also, in the transition from a simple model to the real world, "uncertainty and unpredictability" are said to be "even more pronounced". Although one can imagine the logic and explanation of this statement, it is not entirely certain that this suggestion will hold true in reality. In other words, how can we be assured that there will be no cancellation of positive and negative tendencies even given the greater degree of freedoms and nondeterministic noises in the real world?

Although I particularly like the series of questions posed on p. 6637, as I often find that penetrating questions are key to a more in-depth understanding.

But perhaps a more fruitful approach would be to ask the most direct question on how the formulation of GCMs can add to our totally inadequate handling of both the deterministic and stochastic aspect of hydrologic variations on local, regional to hemispheric scales? Should the GCMs may be deemed overly complex or too burdensome (in the sense it is being held hostage to the algorithmic complexity that its outputs are often difficult if not impossible to interpret)? What alternatives must be sought to replace GCMs?

With regard to the theme of prediction of future, Sir. James Lighthill's famous apology may be worth reviewing: (p. 38, Lighthill 1986)

"Here I have to pause, and to speak once again on behalf of the broad global fraternity of practitioners of mechanics. We are all deeply conscious today that the enthusiasm of our forebears for the marvelous achievement of Newtonian mechanics led them to make generalizations in this area of predictability which, indeed, we may have generally tended to believe before 1960, but which we now recognize were false. We collectively wish to apologize for having misled the general educated public by spreading ideas about determinism of systems satisfying Newton's laws of motion that, after 1960, were to be proved incorrect."

Perhaps DK would proffer that apology may not be necessary after all because the real world, in most cases, simply contains both too many variables and too many un-

bounded interactions among the variables to offer any reliable or meaningful projections into the future. For example, sometimes ago, my enthusiasm for the claim that there exists a finite bound to the dimension of the global attractor of atmospheric circulation (i.e., as deduced from the primitive equations; see Lions et al. 1997) quickly died off when I learned that that dimension, with additional assumptions, is about 10^{19}. So all pretension of a deterministic prediction of future climatic states must be abandoned. One can certainly agree that although we may understand and explain all the changes for a hydrologic variable but this does not guarantee that we can now predict the future evolution of the variable with any confidence.

Seriously though, who are we trying to kid? How to achieve an accurate predictions of climatic variables? It has been nearly impossible to accurately predict temperature and rainfall for more than a season ahead.

Overall, DK's paper is a superb addition to the science of why and how a hydrologic variable varies and insight into its potential unpredictability, given a long-enough time horizon (i.e., in the sense of Liao 2009). HESS and all DK's colleagues should be congratulated for rewarding DK's deep and sharp intellectual mind with the EGU Henry Darcy Medal for 2009. Of course, congratulations to DK himself for this fine distinction as a hydrologic scientist.

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