Social vs. scientific perception of change in hydrology and climate

Reply to the Discussion by Arie Ben-Zvi on the Opinion Paper "Hydrology and Change"

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I am indebted to Arie Ben-Zvi for his Discussion (Ben-Zvi 2014) on my Opinion Paper (Koutsoyiannis 2013). He makes several points with philosophical and social importance. In this respect, the Discussion is also interesting from the perspective of the "Panta Rhei" decade (2013-2022) of the International Association of Hydrological Sciences (Montanari *et al.* 2013), which focuses on change in hydrology and society. It is difficult to disagree with the points made in the Discussion and this does not favour dialogue. However, I will try to add a few thoughts.

Ben-Zvi correctly points out that *"man's intensifying activities, since the agricultural revolution, through the industrial and the electronic ones and onwards into the future, affect the climate"* and that "*consideration of the anthropogenic effects aggravates our uncertainty about the future climate."* But why restrict change to climate? Change is everywhere and currently has accelerated, mostly due to unprecedented human achievements in technology. Many aspects of unprecedented change (including agricultural and industrial revolutions and civil infrastructures) have been intentional and planned, not by-products of other activities (in contrast to the increased CO_2 emissions which is a by-product of the intensification of energy production and use). Such environmental changes which are visible, rather than hypothetical, have remarkable effects on hydrological systems, and can be studied in a rather direct manner. Sometimes the effects are negative as exemplified by the greatly increased economic losses from floods over the past several decades. But this is principally driven by the expanding exposure of assets at risk, while it has not been possible to attribute rain-generated peak streamflow trends to anthropogenic climate change (Kundzewicz *et al.* 2013). One may also blame the uncontrolled urbanization and its expansion to flood plains (Di Baldassarre *et al.* 2010) and even the opposition to engineering solutions by the dominating 'green' ideology as well as by politico-economic agendas (Koutsoyiannis 2014).

In my view, it is bewildering that, instead of focusing on existing real changes with quantifiable effects on hydrological and societal systems, the scientific community has been encouraged, e.g. by research funding opportunities, to study hypothetical scenarios for the distant future.

On the other hand, I fully agree with Ben-Zvi that change is tightly connected with uncertainty. Accelerating change inevitably results in increased uncertainty. In turn, the increased uncertainty makes the society apprehensive about the future, insecure and credulous to a developing future-telling industry. The social demand for certainties, no matter if these are delusional, is combined by a misconception in the scientific community (cf. Taylor and Ravetz, 2013) to confuse science with removing uncertainty.

However, I believe that the hydrological community, instead of becoming part of a burgeoning system promoting unreliable predictions for the distant future, can help trace a different, more pragmatic path. Such a path need not be driven by political agendas, economic interests and the zeal for activism, but rather should pursue the truth. Hydrological experience can fight the simplistic view that complex systems can be predictable on the long run in deterministic terms, as well as that change can only have catastrophic effects; as aptly pointed out by Ben-Zvi, change usually has both detrimental and beneficial consequences, and a balanced approach is needed in studying them. While it is understandable that "*people tend to complain on negative effects more than to acknowledge positive ones*", it is also true that scientists should follow a balanced and unbiased approach.

There is overwhelming hydrological and engineering experience in studying and managing uncertainty, and in decision making under unpredictability, which can be exploited and improved in the future. An illuminating example is offered by an intense and persistent (lasting 7 years) drought that shocked Athens, starting in the late 1980s. The ingredients for the successful Athens drought management include (see also Koutsoyiannis, 2011): (a) consistent modelling and in particular stochastic hydrological model reproducing long-term persistence, also known as the Hurst-Kolmogorov (HK) behaviour; (b) advanced decision support based on an original and parsimonious stochastic methodology (termed parameterization-simulation-optimization); (c) construction of new engineering works to improve water resource availability; and (d) engagement of the society in water saving practices, which resulted in a drop of the water consumption by 1/3.

It is the HK behaviour the central focus of the discussed paper (Koutsoyiannis 2013) and its importance is also highlighted by Ben-Zvi (2014) by stating "*it is a high time to invent tools that include the HK effect within their framework for predicting future states*". In fact, the HK behaviour underlines the inevitability of uncertainty on the long run. As explained in Koutsoyiannis (2013), it is consistent with maximum entropy production at large time scales—and maximum entropy means none other than maximum uncertainty. Therefore, incorporating the HK behaviour in a framework for predicting future states is also an admission that the exact future states are unpredictable. Use of the HK dynamics in predictions may thus sound as an oxymoron, but Bev-Zvi puts it in a right way: "*As people are, in many cases, afraid of an unknown future situation more than they do of a predicted harsh one, overcoming that deficiency would be welcome.*" Indeed, while the HK behaviour emphasizes the unpredictability in deterministic terms, it can help trace the harsh cases, as well the favourable ones, quantified in probabilistic terms.

Ben-Zvi makes also a technical point with respect to reservoir capacity and yield. In that example I would propose disengaging from the length of data series, except in assessing the reliability of parameter estimates, as well as of the life span of the project, except in estimating the risk of a failure throughout this life span. In other words, instead of adhering to empirical concepts and methods, I would prefer using formal probability combined with an HK behaviour of inputs.

Overall, the comment by Ben-Zvi is timely and harmonizes with the goals of the Panta Rhei decade. In my view, the focus of the decade can help the hydrological community and the society in important tasks such as: reconciliation with change and uncertainty combined with recognition of the tight connection of change and uncertainty; recognition of the inevitability as well as the good sides of change and uncertainty; advancement of decision making under uncertainty; developing adaptability and resilience for an ever uncertain future; promotion of technology and engineering means for planned change to control the environment for the benefit of the society; and promotion of the importance of honesty in science and its communication to the society. All these could advance the Hydrology of Change and Uncertainty.

References

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