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Neural network hydrological modelling: all that glisters is not gold?

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The paper will begin with a critical appraisal of progress in neural network hydrological modelling and thereafter put forward a series of 'grand challenges' with regard to the potential scope and purpose of subsequent explorations in this field. The last decade has witnessed a virtual explosion in peer-reviewed publications that report successful and superior neural network hydrological modelling applications based on established hydrological topics and problems such as discharge forecasting and suspended sediment estimation. There remains, nevertheless, a pressing need for enthusiasts and proponents of neural network hydrological modelling to question the real level of scientific achievements and proven engineering accomplishments that are so often celebrated and proclaimed in pertinent publications. Neural networks have become accepted tools in the hydrological modelling toolbox and solid foundations have been established for subsequent developments in this field. Steep learning curves have been surmounted and a large corpus of scientific knowledge and supporting material has been amassed and shared. The value of such initial explorations cannot be overemphasised and the importance of such pioneering activities notwithstanding this paper will present the 'devil's advocate' case that limited progress has been achieved in terms of either neural network developments or hydrological science applications. It is suggested that neural network modellers have accommodated the demands of our existing hydrological modelling paradigm in terms of mindsets and methodologies. It is suggested that fresh approaches based on lateral thinking and different considerations are needed. The purpose of data-driven solutions is to create operational models and strategic level tools that can provide better decision making information or more accurate forecasting outputs. The development of conceptual models or distributed models based on realistic processes involves different motivations in that their mecha-

nisms are intended to extend our existing level of hydrological knowledge. It is argued that neurohydrologists should henceforth focus on developing and reporting solutions that can exploit the reported benefits of neural networks not in terms of simple curve fitting operations applied to pre-selected traditional datasets but with respect to testing their inherent computational advantages. This would include a consideration of: learning and self-organisational capabilities; fault tolerant and graceful degradation characteristics; processing flexibilities and unconstrained opportunities related to the selection of input and output variables; processing speeds and the power to undertake real time model development and model updating operations; etc. This paper will also highlight broader contentions and open issues related to the use and uptake of data-driven methodologies in the hydrological sciences. The most important matters in this respect include the need: to develop powerful tools that can handle poor quality data (noisy, with gaps, and often of lower quality than in other fields); to provide estimates of the uncertainties that are associated with model outputs; to develop mechanisms that will support the proper incorporation of smart and novel methods into our existing hydrological modelling frameworks (hybrid models); and to push for better acceptance of such methods in traditional communities that are more accustomed to process modelling. The paper will recommend that an international steering group be established and challenged to develop a set of targets and milestones and to publish a 'manifesto for change'.