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Discussions

Interactive comment on "Technical Note: Application of artificial neural networks in groundwater table forecasting – a case study in Singapore swamp forest" *by* Y. Sun et al.

Anonymous Referee #1

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General comments

This technical note describes the application of Artificial Neural Networks (ANNs) to a groundwater modelling problem in a freshwater swamp forest. The dataset available for the study consists of rainfall, reservoir water level and groundwater table observations (at four piezometers). These data are used to set-up a Multi-Input Multi-Output (MIMO) ANN, which is trained with the Levenberg-Marquardt algorithm.

The manuscript is well written and organized; it is supported by a good set of references. The scientific approach is appropriate (yet incomplete), with the results (almost)

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sufficient to support the conclusions. While I consider the topic relevant to the aim and scope of HESS, I have some major concerns regarding the novelty of this study.

- Methods and tools. The use of ANNs for time series modelling has been a very popular research topic, and several advances have been proposed in the past decade–e.g., multi-objective calibration, modelling of the prediction uncertainty, input variable selection, improved calibration schemes, etc. (see Maier and Dandy, 2010). The methodology here adopted is an application of some well-known, existing tools, so it does not represent a methodological advancement.

- Modelling problem. According to the authors, the main novelty stands in (1) the adoption of a short prediction horizon–justified by the fast dynamics of the water table–, and (2) the use of exogenous variables (rainfall and reservoir water level data), instead of historical groundwater tables, as input to the ANN. A similar approach is adopted by Taormina et al. (2012), who modelled hourly fluctuations of the groundwater using rainfall and evapotranspiration data.

As mentioned, I think that the scientific approach is appropriate, but incomplete. First, the results obtained with ANNs are not benchmarked, so it is hard to say whether they could be improved or whether the adoption of a non-linear model is needed. How do ANNs compare with a simple linear regression, for instance? Why using a MIMO model instead of four MISO ANNs? Second, I do not fully understand why evapotranspiration has been neglected–it should be influential in such a forested area. Third, I am not too convinced by the use of the input variables. Which time lags have been considered? Why not using multiple time lags or (temporal) aggregation of the input variables to fully exploit the input-output correlation?

For the reasons outlined above, I think that the manuscript does not meet (at this stage) the standard required by this journal. I believe that the authors should (1) present either novel methods or novel data (modelling problem) and (2) further focus on the scientific approach.

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Further details and comments are outlined below.

Specific comments

- The abstract should clearly state what the novelty of the study is.

- Line 17-18, page 9318. Could you briefly elaborate on these objectives?

- Line 1, page 9319. "... as most of the system forcings are less predictable." This sentence is not very clear.

- Lines 21-24, page 9320. I would not use bullet points here; there is no need to emphasize these features of ANNs.

- Lines 15-16, page 9321. What are the main characteristics of these three categories?

- Line 9, page 9322. The activation function is used not only "for limiting the amplitude", but also for creating a mapping between input and output variables.

- Line 16-18, page 9322. This is not correct. The Universal Approximation Theorem (Hornik et al., 1989) states that "every continuous function defined on a closed and bounded set can be approximated arbitrarily closely by a Multi-Layer Perceptron provided that the number of neurons in the hidden layers is sufficiently high and that their activation function belongs to a restricted class of functions with particular properties".

- Lines 6-9, page 9324. This part should be included in Section 3.1.

- Lines 9-12, page 9324. Which time lags did you consider?

- Line 14, page 9324. It should be stated earlier that the adopted model architecture is MIMO.

- Line 19, page 9324. What is the total number of observations?

- Lines 25-26, page 9325. Is it possible to include the information about the spillway from Upper Seletar reservoir?

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- Lines 6-7, page 9326. I would not report the definition of RMSE and r–these metrics are very well known in the modelling community.

- Table 1. Which period (i.e., training, cross-validation or testing) is being considered here?

References

Hornik, K., Stinchcombe, M., and White, M.: Multilayer feedforward networks are universal approximators, Neural Networks, 2, 359–366, 1989.

Maier, H. R., and Dandy, G. C.: Methods used for the development of neural networks for the prediction of water resource variables in river systems: current status and future directions, Environmental Modelling & Software, 25, 891–909, 2010.

Taormina, R., Chau, K-W., Sethi, R.: Artificial neural network simulation of hourly groundwater levels in a coastal aquifer system of the Venice lagoon, Engineering Applications of Artificial Intelligence, 25, 1670-1676, 2012.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 9317, 2015.