Interactive comment on "Assessment of the Hype Model for Simulation of Water and Nutrients in the Upper uMngeni River Catchment in South Africa" by Jean N. Namugize et al.

Introduction

The manuscript on "Assessment of the HYPE Model for simulation of water and nutrients in the upper uMngeni River Catchment in South Africa" was submitted to the journal as a case study. The paper aimed to assess the capability of the model in simulating stream flow and transport of nutrients (nitrogen and phosphorus) in a fast-developing catchment, typical of many in developing countries, with limitations in data available. This study was motivated by inclusion of in-stream processes of transformation of nutrients in waterbodies in the HYPE model which lack in the locally-developed model in South Africa, i.e. the ACRU-NPS and this is over-simplified in SWAT model. This study also aimed to assess the capability of the model to represent the processes driving water quality in the uMngeni Catchment.

Anonymous Referee #2

Comment 2.1

This paper assesses the capability of the Hydrological Predictions for the Environment (HYPE) model in simulating streamflow, dissolved inorganic nitrogen (DIN) and total phosphorus (TP), in uMngeni Catchment in KwaZulu-Natal province, South Africa. The model was manually calibrated using stepwise approach and tested against observation and its performances were assessed based on the Nash-Sutcliffe efficiency (NSE), percent bias (PBIAS) and Pearson's correlation coefficients. Authors concluded that the HYPE model was successful in simulating streamflow, DIN and TP in the upper uMngeni catchment. The paper is a good application of the HYPE model rather than an improvement in hydrological/nutrient processes understanding and modelling approach in general and in the region. There are many shortcomings in the manuscript, most importantly the lack of uncertainty analysis. I think that a sensitivity analysis and uncertainty assessment of the HYPE model particularly to land use and soil parameterization could improve the quality of the paper. In addition, the paper misses a through discussion about the limitation of the HYPE model for discharge and nutrient simulation in the uMngeni catchment. Authors just enumerated few of them in the conclusions but these statements are not directly supported by the findings of the paper.

Response 2.1

We disagree with this comment. Our approach does provide an improvement in understanding and modelling approach, especially in the region with limited data.

Other limitations of the model are:

- *HYPE model uses static land use which is a challenge in the uMngeni Catchment, due its rapidly changing land use and modification of landscape*
- *simplification of the processes driving evapotranspiration in the model is a key challenge which affects the simulations of runoff in the catchment*
- *In the model the processes of inter-catchment transfer, water abstraction and release and atmospheric deposition of nutrients are static and over-simplified, while in reality they vary during the simulation period.*
- *Static used of daily volumes and concentrations of nutrients from the point sources of pollution, i.e. waste water treatment, industries*

Comment 2.2

Land use and soil data were desegregated from coarser scale which could be not coherent with the hydrological model scale. The Hype model is quite sensitive to the land use and soil-type information. Does the scale and the resolution of these inputs affect the model performances?

Response 2.2

The desegregation was only made for soil data, while the land use data match the model scale. The authors recognised that the HYPE model depends on the description and parameterisation of land use and soil type information.

Comment 2.3

There is a wide panoply of techniques for automatic calibration of model parameter in literature which are faster and provide an insight on parameter sensitivity and uncertainty. So, what are the reasons behind using manual calibration in this work?

Response 2.3

The choice of the manual calibration of the model regardless of being time consuming was aimed to achieve a better understanding and representation of hydrological and water quality processes and to avoid equifinality in model factors and parameters. Moreover, due to a large number of parameters to calibrate, we thought that an automatic calibration was no more plausible than the manual calibration.

For hydrological part of the model:

- *We started by calibrating the sub-catchments with the most common land use and soil, without lakes and isolation of the processes in lakes and rivers*
- *To achieve this, we first started with the general parameters that affect the water balance and flow discharge by looking to evaporation routine, i.e. the recession coefficient for surface runoff (srrcs) and the crop coefficient for PET model (Kc). Adjustments of the input data files on precipitation and temperature provided in Pobs.txt and Tobs.text, respectively and correction of the altitude.*
- *we continued with soil parameters which affect flow paths, dynamics of groundwater and discharge from headwaters i.e. water holding capacity, infiltration, percolation, recession and surface runoff (they also affect the concentration of nitrogen and phosphorus).*
- *the parameters which affect discharges in Lakes and in river reaches (rivvel and damp)*
- *At the end, we added the isolated parameters in rivers and lakes*

For water quality model, the calibration of the following parameters was carried out:

- *The general parameters that control the denitrification processes in local and main rivers (denitwrl and denitwrm) and in lakes (denitwl). The fastN and fastP pools in soil and the factors affecting sedimentation and resuspension of in rivers and in Lake (sedexp), as well as sedimentation rate of phosphorus and nitrogen in lakes (sedpp and sedon)*
- *The land use dependent parameters which guide the denitrification in all soil layers (denitrlu), the release of inorganic nitrogen from slow N via fastN. This parameter provides a steady release of IN. We also adjusted the land use dependent parameters that control the release of organic nitrogen (ON) from slow N (dissolhn, and minerfn) and the release of particulate phosphorus (PP) from slowP (dissolfn and minerfp).*

- *The soil dependent parameters adjusted are namely, freuc which controls the leaching concentrations of suspended phosphorus (SP), the resistance of soil to erosion due to overland flow (soilcoh) and the parameter affecting erosion caused by kinetic energy in rain (soilerod)*

These processes allowed better understanding of the high retention of phosphorus which is characteristic of the soil in the uMngeni Catchment. They also helped to understand that phosphorus is mainly linked to the point sources of pollution, while dissolved inorganic nitrogen (DIN) is associated to both diffuse and point sources. This provided information on the possible sources of increased levels of nutrients of the river and impoundments and catchment-based knowledge on the transport and dynamics of nutrients in a catchment having a highly modified natural vegetation, with limitations in data available.

Comment 2.4

- P6, L, 181. Why a third thick soil layer was added during the calibration of the model?

Response 2.4

We started with the calibration of the two soil layers for which soil information in the catchment was available. Due to deep groundwater in the catchment, a third layer was added and an increase of the drain-depth in geoclass file data, in order to include the hydrological activities related to the groundwater runoff.

Comment 2.5

-P7, L.213. The HYPE model has over one hundred parameters. How did you identify the most sensitive parameters for the calibration process?

Response 2.5

The most sensitive parameters for the calibration process were identified in the literature review in the other applications of HYPE model (for example, Jiang et al. (2014), Jomaa et al. (2016) and Yin et al. (2016), by manual adjustment of the input parameters and measurements of the output values and expert knowledge from previous model applications.