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Hydrology and Earth System Sciences Discussions

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Interactive Comment

Interactive comment on "Assessing the model performance of an integrated hydrological and biogeochemical model for discharge and nitrate load predictions" *by* T. Pohlert et al.

T. Pohlert et al.

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We appreciate both the referee's and editor's comments, which improved our submitted paper to HESSD. Please find our detailed responses to the comments below. Also note our previously submitted interactive comment.

Responses to the general comments

Within the general comments, Referee 2 argued that the content of our paper does not contribute to HESS. The main reason for Referee's 2 opinion is that we submitted the conceptualisation of our model to a different journal (Ecological Modelling), and, consequently, he/she recommends to submit this paper to the same journal.

EGU

As we previously responded, the content of that paper [Pohlert et al., 2006, Integration of a detailed biogeochemical model into SWAT for improved nitrogen predictions - model development, sensitivity and uncertainty analysis. Ecol. Model., in press, doi:10.1016/j.ecolmodel.2006.11.019] deals with the conceptualisation of SWAT-N, a sensitivity, and GLUE analysis using long term records of a lysimeter experiment. A test or an application to a catchment was not performed within this former study. We have sent a manuscript version of the afore-mentioned paper to the associate editor to clarify this issue. In the meantime, the Ecol. Model. paper is accepted for publication, thus it can be accessed soon by those readers, who are interested in the details of the models theory.

Referee 2 further commented that our paper lacks novelty.

As we previously responded, the focus of our paper is on an intensive testing of the newly formulated model that does not require further calibration of N-controlling parameters. The calibration/validation included a split-sampling and a proxy-basin-test for discharge predictions, comparisons of predicted and observed nitrate loads at two gages as well as a comparison of predicted and observed longitudinal profiles of nitrate concentrations without further calibration of parameters that control N-cycle and N-transport. We included the following sentence to sharpen the scope/motivation of our paper within the Introduction part:

p. 2815, l. 11/12 (Introduction)

[...] by using eco-hydrologic models. Due to the need for spatial transferability of the models developed within the scope the SFB299 , the use of process-oriented models that require commonly available data and a minimum of calibration is required. [...]

Responses to the major comments

1) Referee 2 asked for the motivation of using a new model (SWAT-N) instead of any of the existing models.

As given in Sect. 1, a substantial number of listed N models are detailed plot models that can not be applied for a catchment (p. 2815, l. 20-29). The applicability of empirically based catchment models that compute N loads is critically discussed (p. 2816, l. 14/15), and the limitations of fully distributed models with regard to computational and data demand is also given in the manuscript (p. 2817, l. 2-6). We restated the following paragraph to further justify/clarify our model selection (see also newly introduced sentence above).

p. 2817, 2nd paragraph (Introduction)

[...] Since a process oriented model with little data demand is needed for the assessment of land-use options in meso-scale catchments on discharge and nitrate load within the research scope of the SFB299, we choose the semi-distributed SWAT-G model (Eckhardt et al. 2002), that is a modified version for mountainous catchments of the well known Soil and Water Assessment Tool (SWAT, Arnold et al., 1998). However, since the original conceptualisation of N-cycling in SWAT-G, which originates from the EPIC model (Williams et al., 1984) failed to predict N turnover accurately, we integrated algorithms of the detailed biogeochemical model Denitrification-Decompositon model (DNDC, Li et al., 1992, 2002) as well as the CropSyst model (Stöckle et al. 2003) for an improved N simulation in a previous study (Pohlert et al. 2006). The newly coupled model that is further denoted as SWAT-N is used within this study and extensively tested for applicability on the catchment scale. [...]

2a) Referee 2 asked, why we did not use log-transformed discharge data for calibration.

For river water quality modelling it is important to distinguish between loads and concentrations of a solute. In many cases, nitrate loads are strongly correlated with discharge, i.e. the highest loads can be observed during peak flow. Consequently, non-transformed discharge data are useful for calibration, to avoid mismatches of predicted load. However, as explained in Sect. 2.8, 3rd paragraph, low flows are important for the capacity of rivers to dilute constant inlets of point-source substances provided

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that relevant point-sources are present within the catchment. If relevant point-sources are present within a catchment, highest concentrations can be found during the low flow period (see also Sect. 2.5, l. 17-27). This might justify a calibration with log-transformed discharge data, if a good representation of nitrate concentration is desired. As can be concluded, the choice of an appropriate objective function for calibration of discharge leads to a trade-off between accurate load prediction on one hand, and accurate concentration prediction on the other hand. We decided to calibrate the model with non-transformed discharge data, which suggests a better match of predicted versus observed nitrate loads.

We introduced the following sentence:

p. 2825, l. 20 (Assessment of model performance)

Consequently, $E_{\log}$ is an aid for the interpretation, whether possible discrepancies between simulated and observed nitrate concentrations are due to erroneous water flow or N turnover predictions.

2b) Referee 2 asks for references for the selected parameter span and for an explanation, why the calibrated parameters fall close to the upper limits.

The parameter range used in the calibration summarizes the prior knowledge about the feasible range of parameters. We briefly discuss this issue and provide references for the selected parameter spans in the revised version. Of course, it is not very satisfactory that some parameters are close to the upper or lower limit of the feasible parameter space (although this can occasionally happen). Possible alternative reasons for this might be insensitivity of model parameters, model error compensation, or the fact that the "global optimum" is beyond the pre-selected range of parameters. Clearly, this is a topic outside the scope of this paper. Since our prior parameter range does not cover the physically plausible range of parameter values, but instead is based on reasonable parameter bounds taken from literature, we worry less about this issue.

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We rearraged/added the following paragraphs to clarify this issue:

p. 2820, l. 9 (Sect. 2.2 Spatial input data)

The soil-profile-data comprises of both textural and bulk density classes according to the German soil classification. The relevant soil physical parameters were derived from these information using the tables of AG Boden (1994).

p. 2824, l. 19-28 (Sect. 2.7 Calibration)

We choose the upper and lower limits for moist bulk density and saturated hydraulic conductivity as given by AG Boden (1994). The spans for the anisotropy factor that denotes the ratio between lateral and vertical saturated hydraulic conductivity, the baseflow recession constant as well as the groundwater delay time were similarly set as given by Eckhardt and Arnold (2001) and Huisman et al. (2004).

p. 2826, l. 18 (Sect. 3.1 Discharge)

The calibrated values of the parameters bulk density moist as well as saturated hydraulic conductivity for both selected soil units and layers are close to the upper limit of the given parameter span (Table 1). The phenomena that several “optimised” parameters are close to one bound of the selected parameter span using automated single or multi-objective calibration routines has been frequently reported in literature (e. g. van Griensven et al. 2002, Vrugt et al. 2003, Yapo et al. 1998, Eckhardt et al., 2005). Possible reasons for that may be: (i) an insensitivity of the specific parameter (i.e. values of the parameter within a broad range leads to similar results, though the calibration algorithm further searches and stops when the termination criteria is reached), (ii) the global optimum of the parameterisation is beyond the predefined parameter span, or (iii) an effect of model and data error compensation.

3a) Referee 2 recommended to move Sect. 2.6 (The SWAT-N model) at the beginning of Sect. 2. (Materials and Methods).

We have done so according to her/his reccomendation.

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3b) In contrast to the Referee's 2 opinion that the focus is on the new model, the focus of our paper is on the assessment of SWAT-N for river discharge and nitrate load predictions (see our title). Hence, a detailed description of the conceptualisation of SWAT-N is not essential for the conclusion of this paper. The relevant differences between the old and the new model are described in Sect. 2.6 (The SWAT-N model). However, we included two new Figs. that illustrate the conceptualisation of the old SWAT version (i.e. EPIC based) and the new SWAT-N version (i.e. DNDC and CroSyst based). Furthermore we added the following sentence in the revised manuscript:

Sect. 2.6 (The SWAT-N model), at the very end of last paragraph

[...] Figures X and Y illustrate the old and new conceptualisation of N-cycle within SWAT, respectively. A detailed description of the conceptualisation of the [...]

Responses to Referee's 2 minor comments

1. p. 2818, l. 12 (changes)

... m. a. s. l. -> ... m above sea level.

2. p. 2824, l. 1 21 (response)

Referee 2 asked for the meaning of the calibrated parameters. The meaning of the parameters were already listed in Table 1 within the old manuscript. The revised version additionally lists them within the text (see afore-mentioned response to the major comment 2b).

3. p. 2824, l. 25-28

Referee 2 asked for a clarification of our calibration strategy with regard to distributed parameters. We added the following sentence to clarify this issue.

[...] according to predefined ratios. This is similar to a percent-change-calibration, where a single distributed parameter is varied for each run by multiplying each value of that parameter with one factor. Consequently, the factor only needs to be calibrated.

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4. p. 2824, l. 3-7

Referee 2 asked for a discussion between surface watershed divide and groundwater divide.

As given in Sect. 2.6 (The SWAT-N model), the watershed delineation is done using a DEM and standard GIS functions for watershed delineation implemented within AVSWAT. Groundwater divides are neglected within this step of data pre-processing. The extend of the delineated watersheds based on a DEM largely depends on both the spatial resolution and the accuracy (vertical resolution) of a DEM. However, Borman (2005, this journal), who worked on the same catchment and tested the impact of various DEM resolutions on the output of the fully distributed model TOPLATS, did not find strong effects on simulated discharge for commonly available DEM resolutions, although the extend of watersheds were substantially different. Furthermore, the findings of Kaviany (1978), who studied the hydrogeology of the Dill catchment within his dotoral thesis, do not indicate that groundwater devide and surface water devide is different in the Dill watershed.

5. Fig. 4

We changed Fig. 4 in that we removed the log-transformed graphs. The new Fig. 4 is included within the revised manuscript.

6. New figures and re-numbering of figures.

We introduce two new figures that aim to clarify the differences between SWAT and SWAT-N as requested by Referee 2. They are denoted Fig. 1 and Fig. 2. Consequently, the numbering of the old figures changed accordingly.

Own minor modifications

p. 2814, l. 4 (insertion of a new word)

... Dill catchment for a 5-year period. -> ... Dill catchment (Germany) for a 5-year

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period.

p. 2816, l. 23/24 (insertion of a new and more recent citation for SWIM)

[...] the SWIM model (Krysanova and Haberlandt, 2002; Hattermann et al., 2006)

p. 2825, l. 22

... in regard to ... -> ... with regard to ...

p. 2827, l. 24-27

We removed the references "(Fig 4a)", "(Fig 4b)", "(Fig 4c)", and "(Fig 4d)", since Fig. 4 only comprises of two graphs within the revised manuscript as it was suggested by Referee 2.

p. 2831, l.17

... in regard to ... -> ... with regard to ...

Sources (only newly cited sources within this response and the revised MS)

AG Boden.: Bodenkundliche Kartieranleitung, 4 edn., Schweizbart'sche Verlagsbuchhandlung, Hannover, 1994.

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Vrugt, J. A., Gupta, H. V., Bastidas, L. A., Bouten, W., and S. Sorooshian, S.: Effective and efficient algorithm for multiobjective optimization of hydrologic models, Water Resour. Res., 39(8), 1214, 2003.

Yapo, P. O., Gupta, H. V., and Sorooshian, S.: Multi-objective global optimization for hydrologic models, J. Hydrol., 204, 83-97, 1998.

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