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Hydrology and Earth System Sciences Discussions

Interactive comment on "Nested-scale discharge and groundwater level monitoring to improve predictions of flow route discharges and nitrate loads" *by* Y. van der Velde et al.

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Reply to comments of referee 1:

We thank referee #1 for the constructive comments and appreciation of our work. Below we respond to each of comments raised by the referee.

Comments:

1) My major concern relates to the "prediction of nitrate loads". The model applied is indeed a flow model, no transport phenomena are included. As such, the model can

not be used to predict nitrate loads. The assumption of constant concentrations in the different flow components done in section 3.5 can hardly be supported.

We agree with both referees and the editor that our simplistic approach to nitrate transport does not reflect the complexity of processes that affect nitrate transport, and therefore should not be presented as a nitrate transport model. We have even demonstrated this point ourselves in previous work [WRR, van der Velde et al., 2010] as was pointed out by referee #2. The point we wanted to make was that correct contributions of flow routes, with each flowroute connected to specific biochemical processes and travel times and consequently specific solute concentrations, are paramount for correct solute (nitrate) load estimates. Correct flow route fluxes are far more important for load simulations than for correct discharge simulations. Unrealistic contributions of flow routes might very well lead to realistic predictions of total discharge, but when each flow route is related to unique nitrate concentrations as measured in the field (albeit probably not constant with time) this will give unrealistic nitrate load estimates. This is demonstrated by showing that the spread in possible outcomes for the total nitrate load is much larger for a model calibrated on catchment discharge only, compared to a model that is calibrated on a nested-scale experimental setup with explicit measurements of flowroutes at a field scale, although both models describe discharge equally well. For this reason we agree with the referees to remove nitrate transport from the title and as explicit objective of this paper and clearly refrain from presenting a solute transport model. However we would like to keep the nitrate comparison in the paper as a demonstration of the crucial role of flowroutes in solute transport modelling. To this end we have rewritten the part about nitrate transport and the corresponding results. We think it helps to connect this paper to our previous and future work and puts the paper inline with the overall goal of our work: To improve our understanding of hydrological pathways in lowland catchments and through that improve nutrient transport modelling in lowland catchments. If however, the reviewers and editor object to this line of reasoning, we will remove the nitrate load demonstration completely as suggested.

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A reaction to the constant flow route concentrations: In Rozemeijer et al, (2010c) we observed that the contributions of flowroutes to discharge change much faster (in reaction on rainfall events) than the concentrations of flowroutes. Rozemeijer et al (2010c) showed that nitrate concentrations of tube drain flow (the major source of nitrate) do not show much temporal variation over the month simulation period used in this paper (which is at the end of the flushing season and wet conditions during the entire month). In Van der Velde et al (2010a) and Rozemeijer et al. (2010c), we also showed that the spatial variability of nitrate concentrations in groundwater and among tube drains is huge, compared to the temporal variability of single tube drains. For the one month nitrate comparison in our paper, we think the constant flow route concentrations are not very unrealistic assumptions. However, we agree this cannot be called a nitrate transport model as it has no predicting capability outside this one month period.

2) Including references to other nested-scale experiments in introduction

We agree, we included a section on nested scale solute transport experiments and the relation between flow routes and travel time distributions in the introduction (in reaction to a remark of referee #2).

3) To many subsections in sections 2 and 3

We removed and rewritten some of the subsection to improve focus of paper.

4) Are the GW depths assumed to be spatially correlated or random? Any correlation with the soil depth or with the elevation? Why did you use a normal distribution? Is the shape of the distribution constant with the spatial scale?

The normal distribution is and effect of the central limit theorem: There are many fields within the catchment, all with similar but slightly different shaped water tables depending on soil type, surface elevation and distance between ditches and tube drains. The overall distribution will approach a normal distribution. Only when the features that strongly affect the shape of the water table are large compared to the model area

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(such as for example glacial ice-pushed ridges in the Netherlands) the central limit theorem will not hold and deviating distributions may be expected (recent experience). To clarify, the origin of the normal distribution will now be discussed in more detail in this paper No spatial correlation in groundwater depths is assumed. Note that the spatial pattern in topography (ditches, elevation and soil type) created the overall distribution of groundwater depth. Our first step is to remove the spatial location of a certain groundwater depth and to state that a certain volume of water within a catchment is always stored in a unique distribution of groundwater depths. We demonstrated this concept in a previous paper with a spatially distributed groundwatermodel. Groundwater depth is calculated as the difference between soil elevation and groundwater level. Hence, correlation with elevation is implicitly accounted for in the distributions. Overall no correlation is assumed between the groundwater depth and model parameters such as porosity, van Genuchten parameters and drainage resistance. Of course this can be disputed, but this is the assumption needed to create a relatively simple model.

5) Section 3.5: 2 Figures and 1 Table are described very quickly here p. 8446, l.11-18: I suspect this is due to the fact that the flow volumes are better captured by the BPS-N (see above). The differences in the C prediction are indeed small.

We elaborated on the discussion of both figures especially with respect to de nitrate load demonstration (see remark 1). The table is discussed in previous section.

6) please rephrase this sentence.. a model approach can not change the contribution of tube-drain discharge, which is a physical process.

We agree, we rephrased: Our combined nested-scales observation and modeling approach could narrow down our estimates of the contribution of tube drain discharge to the discharge of a sub-catchment of 0.4 km2 to 34-61% of the total discharge.

7) figure 12: Mention what the grey and dark areas represent.

Legend is in Figure A. We will add text in the legend to clarify: The light grey band

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gives the results of the model calibrated on all nested-scale measurements,.

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