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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 2:

We thank referee #2 for the constructive comments and appreciation of our work. Below we respond to each of comments separately. Comments:

1) Clarify the relation of this paper to previous work: In our research at the Hupsel Brook catchment we followed two approaches. Firstly, we tried to separate discharge into contributions of different flowroutes to better understand the catchment discharge behaviour and hence improve discharge and solute transport modelling. To this end

we measured fluxes of individual flow routes and proposed a model concept that can describe these flow routes. Secondly, we tried to lump all flowroutes into a traveltime distribution, in which each flowroute is represented through its characteristic spectrum of travel times. In this approach we use the entire traveltime distribution to predict nitrate transport at catchment-scale by relating traveltime to decomposition and sorption processes. However also for this approach a thorough understanding of the relation between flow routes, total discharge and traveltime distribution of individual flow routes is crucial. In the introduction we will include the following section: Upscaling approaches for solute transport mostly focus on travel time distributions (e.g. Botter et al., 2009 and Van der Velde et al. 2010b). Travel time distributions can be defined at all scales and implicitly account for flow routes by representing the spectrum of travel times contributing to each flow route in an overall travel time distribution. Both Botter et al. (2009) and Van der Velde et al. (2010b), however, showed that a flow simulation with accurate contributions of flow routes is paramount for representing the dynamics in travel time distributions that is needed to describe transient solute transport. In Van der Velde et al. (2010b) we used a spatially distributed groundwater model to upscale field-scale flow route contributions to catchment scales. Groundwater models, however, are notoriously inaccurate in quantifying fluxes of specific flow routes at catchment scales (Refsgaard and Hansen, 2010). Hence, in Van der Velde et al. (2009) we proposed a new upscaling approach for hydrology in lowland catchments. . ..

2) Remove Nitrate simulation from paper, because no nitrate transport model is introduced. 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 even 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 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. 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 completely 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.

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. A longer period spanning a season would already have significant changes in flow route concentrations.

3) Delete Figure 3 because information is already given in figures 8 and 9. Agree with reviewer, deleted figure and changed text accordingly.

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