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Hydrology and Earth System Sciences Discussions
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Interactive comment on "Prediction of dissolved reactive phosphorus losses from small agricultural catchments: calibration and validation of a parsimonious model" *by* C. Hahn et al.

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Thank you for your comments.

1) In the paper we evaluated the performance of the P model by comparing the measured DRP loads and the simulated 10 % and 90 % quantile bands plotted in the same graph. As Table SD1 (see supplement) shows, which was not included in the paper, also the NSC values show fair agreement between measured and simulated DRP data. We now included the table in the supplement (Table S1) and refer to it in the manuscript (page 1482, L.25; revised manuscript L. 383/384).

2) Given that the objective of the RRP model was to simulate DRP losses, we believe that it makes sense to compare simulated and observed fluxes. As the simulated water fluxes match the observed water fluxes most of the time quite well, a good match of the observed DRP losses implies that also the DRP concentrations are matched well. We will emphasize this point by adding a sentence in the manuscript (page 1483, L.4; revised manuscript L. 388-390). We also compared simulated and measured DRP concentrations. Results are shown in Figure SD1 for the Stägbach catchment. Due to the model structure, we can only calculate the DRP concentrations by dividing simulated DRP loads through simulated runoff. This gives an average concentration of fast and slow runoff. As the contribution of the two types of runoff vary in time, the results only make limited sense. A direct comparison with measured DRP concentrations as shown in Fig. SD1 is not very meaningful, because small timing errors of the dynamics of one flow component may cause short but large deviations in the predicted DRP concentrations. Thus, the extreme values of the simulated concentrations in the graph are probably due to this problem. Still, the majority of the simulated DRP concentrations are in the range of the measured concentrations.

3) For all model runs we performed an analysis of the residuals (see also Fig. SD4, SD5). We did not include it in the paper in order to restrict the length of the manuscript. We also discussed the limitations of the model and the resulting bias in model results in the discussion section (p 1488, L 5-25; revised manuscript L. 506-532). In response to the comment of the reviewer, we extended this discussion and refer more clearly to the problems mentioned in the results section (p 1481, L 10-13). With respect to the underestimation of some high runoff peaks, we in particular state that they may be explained by (a) local thunderstorms for which "the real rainfall amount may not be properly measured" (Lazzarotto, 2005, Chapter 3), and/or (b) by occasional infiltration excess runoff not adequately accounted for by the model. In addition we discuss possible reasons for the prediction of rather rapid baseflow decline as compared to observations (page 1488, L.5-26, revised manuscript: L.506-532).

Linearity was chosen to keep the model as simple as possible. We were interested in P losses and thus we focused on a good representation of high flow events and the dry periods were less relevant except to the degree they affect the spatial DRP loss patterns. Nevertheless, the argument is valid. Thus, we implemented a quadratic reservoir instead of a linear one (Eq.3: qslow = S2 c) to test the influence of that model-modification (name of new model version: version 2sq). The calibration resulted in 60 accepted parameter sets (from 5 million Monte Carlo Simulations, with a NSC threshold of 0.6, model version 2sq) instead of 724 (model version 2). According to the NSC calculations, the performance of model version 2sq was slightly better than that of model version 2. This was valid for the validation periods of the Lippenrütibach catchment and the Stägbach catchment (compared to Tab. 4): NSC quantiles for LIP: 25%: 0.45, 50%:0.54, 75%: 0.54; NSC quantiles for Stäg: 25%: 0.65, 50%: 0.7, 75%: 0.72. Nevertheless, accelerated baseflow decline (LIP, Fig. SD2B) as well as a slight overestimation of baseflow (Stäg, Fig. SD3) during dry periods still occurred. Given the fact that the improvement of model performance was rather small (see residual analyses for the Stägbach catchment for model version 2 (Fig. SD4) and 2sq (Fig. SD5), and the spatial model predictions (Fig. SD6) were similar to the results already presented in the manuscript, we prefer to stick to the linear approach, but will elaborate on this point in the discussion part (revised manuscript L.507, 517-523).

Data on nitrate dilution during runoff events were only used to estimate the proportion of fast flow that is new water. For that purpose, we actually relied on the fact that nitrate and DRP behave very differently. It is important to realize that eta relates to fast flow and not directly to total flow. The amount of fast flow and the area on which fast flow is generated both vary in time. Thus, the model does account for the fact that saturated zones are getting larger and that DRP can get lost from larger areas when soil water levels rise.

4) The value of the parameter h was optimized by fitting simulated to observed data in the work of Lazzarotto (2005, Chapter 5). The period between manure application until

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30 to 40 days after manure application was the most sensitive time span (Lazzarotto, 2005). Lazzarotto (2005) also examined the influence of manure in comparison to that of soil-P. We included more information about h in the manuscript (P 1474, L. 22, revised manuscript L. 201-202). Furthermore, we ran the model with three different h values: 0.003, 0.007 and 0.011. The results are given in Figures SD7, SD8 and SD9. These figures show that for one event the maximum contribution (90 % quantiles) of DRP from manure on the total DRP loss varies between 50 to 70 % depending on h. Varying h within the above range of values, thus can result in a 20 to 30 % difference. We added a statement to highlight this aspect in the manuscript (page 1489, L.14, revised manuscript: 546 - 550). Nevertheless, DRP losses from manure are mostly the smaller fraction. In the model we are using Gaussian error propagation to account for the uncertainty of the h parameter value (h=0.007 +/-0.004).

5) We refer to our answer to a comment from Russell Adams: "We neglected runoff from forested areas because Lazzarotto et al. (2006) found that runoff from forests did not play an important role for P export. Furthermore, Bosch and Hewlett (1982) found that changes in forest cover by less than 20 % of a catchment area did not have a significant effect on stream flow. In our case, forest covers less than 20 % of the catchment areas. Moreover, we think that it is safe to assume that runoff from forests generally responds much slower to rainfall events (due to interception) than runoff from agricultural and urban areas. Thus, given a lack of adequate data for calibration and validation, we felt that the errors resulting from an untested runoff model for the forested area would have been larger than those resulting from neglecting runoff from forests altogether." In addition, forests are not fertilized with P, thus soils are not enriched with P, and forests in a highly agricultural area as the Swiss Plateau are often mainly situated along rather steep slopes. Thus they generally have low topo indices. Thus we expect the contribution of P losses from forested areas to be rather small.

6) The objective of this paper is to present the RRP model and its validation. Regarding the calibration results we focus on the Lippenrütibach catchment, because this is the

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only calibration catchment for which respective P data were available. Furthermore, the calibration results for the four calibration catchments were already discussed in Lazzarotto et al. (2006) and Lazzarotto (2005), and we want to restrict the length of the manuscript.

Validation.

Model Version 2 improves the simulation results of LIP as well as Stäg, compared to model Version 1. Applying model Version 3 deteriorated the model performance for LIP and improved the performance for the Stägbach catchments, compared to model Version 2, for the reasons given in the paper (page 1482, L.7-21). It appears that better results are obtained when the HRUs (poor and well drained soils) are similar. This is however not the case if we are looking at the calibration period and the four calibration catchments. As can be seen in Table 2 the catchments RTB, GRB and MEI have more evenly distributed HRUs if model Version 3 is applied, while the opposite applies for LIP. However, better results when changing from model Version 2 to model Version 3 are only obtained for RTB. The model results deteriorated for GRB and MEI. It shows that model results need to be interpreted for every catchment and model version separately, as we have done in Section 3.1.1.

Field measurements.

While the assumptions underlying the model might have been discussed already, they have not been spatially tested. We prefer to keep section 3 because spatial data for model validation is scarce and because it adds information about the internal dynamics of soil moisture that would be lacking otherwise. In order to shorten this section we have merged 3.3.3 with 3.3.4 and moved Fig. 9 to the supplement.

Technical corrections.

1) We included the units.

2) We have assumed (truncated) uniform parameter distributions for all parameters.

This assumption is not critical to our results because we did not interpret the results in a probabilistic manner. Accordingly, we did not derive for example posterior distributions for the model parameters that could be influenced by the prior distributions. We just ensured that the range of the distributions were wide enough such that the data did not indicate better parameter values outside the pre-defined range.

3) We tried different methods to display the confidence limits. Using two red lines was the best option. In addition, the other participants and referee did not mind. Thus, we suggest to keep Figures 2 to 5 as they are.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C3151/2013/hessd-10-C3151-2013-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 1465, 2013.

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