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Inclusion of spatial variability in Monte Carlo simulations of pesticide leaching

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Pesticide leaching is one of the high priority issues in both the EU Thematic Strategy on the Sustainable Use of Pesticides and the registration of plant protection products. So far deterministic models have been used in the evaluation process and more recently spatially distributed modelling has also been introduced. It is however well known that, at the point scale, variability in input parameters might have a large effect on the predicted leaching concentrations. It is unknown to what extend spatially variability affects uncertainty in predicted leaching concentrations. This paper deals with an uncertainty analysis of the GeoPEARL model, with special emphasis on the inclusion of spatial distribution knowledge. GeoPEARL is a process-based, distributed pesticide leaching model (Tiktak et al., 2003), used for calculating spatial percentiles. The most important endpoint in pesticide registration is the 80^{th} percentile in space. The main objective of this study is to determine to what extent this percentile is affected by the inclusion of the spatial variability of model inputs. The Monte Carlo (MC) uncertainty analysis applied to the arable part of the Dyle river catchment (central Belgium) involves n model runs for each of the k unique plots. The analysis is performed for atrazine and bentazone.

The most sensitive input parameters are selected through literature review and discussion with model developers. The present research defines two categories of input parameters that depend on the type of uncertainty associated with them. The first category contains parameters denoted as 'plot' parameters because their spatial distribu-

tion is already known and their uncertainty is specific to each plot (e.g. organic matter content). The second type of parameters are denoted as ‘space’ parameters because the uncertainty arises from the assumed distribution of these parameters within the study area (e.g. pesticide half-live). Probability density functions are attributed to the selected input parameters, based on available data and/or expert knowledge.

Latin Hypercube Sampling (LHS) is used to sample the input distributions for the MC analysis. The total number of GeoPEARL simulations is $n * k$ (i.e. n model repetitions for k plots). An important feature of the methodology is that the sampling procedure ensures that the spatial distribution of the ‘space’ parameters is respected n times. Correlation between parameters is also accounted for in the LHS procedure if necessary.

Finally, a statistical examination of the output is made. The sampling strategy developed here allows the results to be examined in a spatial way, because the spatial distribution of input parameters was respected at the scale of the study area. This feature is very important in the context of pesticide management using distributed modelling. This step also involves the repetition of the whole methodology with different seed numbers, in order to test the robustness of the analysis.

This methodology accounts for the spatial variability and uncertainty in input parameters that were previously considered to be constant. The present study focuses on the modelling of pesticide leaching, but the methodology is applicable to any uncertainty analysis of spatially distributed hydrologic modelling.

References

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