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Distinguishing the effects of model structural error and parameter uncertainty on predictions of pesticide leaching under climate change

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Studying climate change impacts on pesticide leaching is laced with various sources of uncertainty, which must be assessed in as detailed way as possible in order to understand the reliability of predictions of pesticide leaching under current and future climate conditions. One dilemma in this respect is the difficulty in separating the effects of model structural error from parameter uncertainty. An example of the former is that most of the commonly-used pesticide transport models only consider temperature-dependent degradation, whereas temperature also influences transport in soils through its effect on sorption and diffusion. Especially for climate impact assessments of pesticide leaching, the processes and parameters that depend on soil temperature and moisture should be carefully considered. Two functions, one describing temperature-dependent sorption and one for temperature-dependent diffusion, were therefore introduced as options into the process-oriented 1D pesticide fate and transport model MACRO5.2, which resulted in four structurally different versions of the MACRO-model. The aims of the study were to assess (i) the uncertainty related to model structure in relation to parameter uncertainty and (ii) the importance of these sources of uncertainty in long-term predictions of leaching in the perspective of climate change.

A case study for leaching of the mobile herbicide Bentazone was performed in a two-step procedure. First, acceptable parameter sets were identified by evaluating model performance using the Nash-Sutcliff criteria against comprehensive data from a one-year field experiment on a clay soil in Lanna (Southern Sweden). Eight sensitive and uncertain parameters were sampled from uniform distributions in a Monte-Carlo approach, separately for each of the four model versions. In a second step, each model-version with its particular ensemble of different acceptable parameter combinations was used to predict leaching for a present (1970-1999) and a future (2070-2099) climate. The present climate data were taken from an observation station of the Swedish Meteorological and Hydrological Institute (SMHI, Norrköping, Sweden) near Lanna. The future climate data were derived by applying an advanced climate change factor method based on projections from the regional climate model RCA3 driven by the global circulation model ECHAM5 forced by the A2-emission scenario. The spread of the predictions for pesticide leaching produced by the ensemble of parameter sets allowed us to quantify the relative importance of model structural error and parameter uncertainty related to the MACRO-model under present and future climate conditions.