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Assessing pesticide leaching under climate change: The role of climate input uncertainty

Karin Steffens (1), Mats Larsbo (1), Julien Moeys (1), Nicholas J. Jarvis (1), Erik Kjellström (2), and Elisabet Lewan (1)

(1) Swedish University of Agricultural Sciences, Soil and Environment, Uppsala, Sweden (karin.steffens@slu.se), (2) Swedish Meteorological and Hydrological Institute, Rossby Centre, Norrköping, Sweden

Pesticide leaching from arable land constitutes a potential risk for contamination of ground and surface waters. Degradation and transport of pesticides in arable soils are influenced by both soil type, compound properties and application timings and are also strongly linked to weather and climate such as temperature and rainfall patterns. The assessment of pesticide leaching under climate change can give early indications of possible changes in pesticide leaching risks of importance for water pollution and serve as a basis for decision-making regarding the use of pesticides. Such an assessment requires detailed analyses of different sources of uncertainty that influence the results. The aim of this study was to assess the uncertainty related to climate scenario input data and to compare this to the parameter uncertainty of the pesticide leaching model. Furthermore, the influence of the choice of application timing on the leaching results was investigated. We used a modified version of the pesticide leaching model MACRO5.2 that included both temperature dependent sorption and diffusion. The calibration of the model to a one-year field data set for a clay soil in South-West Sweden led to 56 equally acceptable parameter sets representing the parameter uncertainty for that soil. Nine different climate model projections of the regional climate model RCA3 (Swedish Meteorological and Hydrological Institute) were available as driven by different combinations of global circulation model (GCM), greenhouse gas emission scenarios, and initial states of the GCM. The future time series used to drive the MACRO-model were generated by perturbing a reference climate data set (1970-1999) for an important agricultural production area in South-West Sweden based on monthly change factors for 2070-2099. Scenario predictions for different pesticide properties and application seasons were performed. Our analysis showed that pesticide leaching was sensitive to changes in both rainfall amounts and temperatures in periods that are critical for pesticide losses from drained clay soils in Sweden (spring and autumn) and to the choice of the pesticide application date. The choice of a specific climate model projection could not only change the magnitude of the predicted future losses but also the direction of change independent from pesticide properties and application season and thus, strongly influence our estimations of future changes in pesticide leaching risks and thereby linked threats to surface water quality. Although the parameter uncertainty was relatively large, 50 to 80% of the different parameter sets predicted a similar change in pesticide leaching losses from present to future, which underlined the impact of climate input uncertainty on the results.