Climate change impacts on risks of groundwater pollution by herbicides: a regional scale assessment

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Background & Aim

Groundwater contributes 50% of the Swedish drinking water supply and needs to be protected today and in the future.The aim was to assess the leaching of herbicides to groundwater under present and future climate conditions, considering direct and indirect effects of climate change. The analysis was performed for a major crop production region in Scania, a county in southern Sweden, where 60% of the total Swedish pesticide use takes place. We simulated all currently approved herbicides for 8 major crop types.

Scenarios for present & future

- Reference (present)
- Only change in climate
- Climate + land-use
- Climate + land-use + herbicide usage

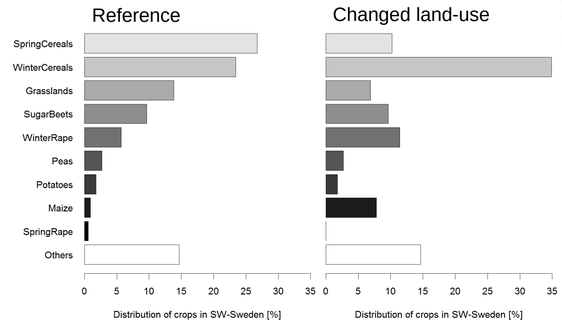
Material & Methods

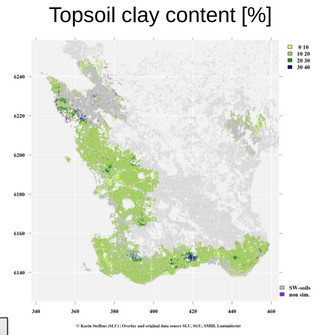
MACRO-SE, a regionalized version of MACRO 5.2, was used to simulate 59 combinations of crops and herbicides. The modelling tool provided detailed soil information, the crop growth was parameterized based on data from the Swedish statistics office (SCB), herbicide application dates, doses and frequencies were based on long-term monitoring data from two catchments in SW-Sweden, the herbicide properties were taken from the Footprint database and the climate data were derived from 5 different GCMs downscaled by RCA3 (RCM of the SMHI) using the delta-change method. Information on current and future pesticide use to support post-processing of the model output (see equation below) was based on the two monitoring catchments, information from SCB and estimates by Wivstad (2010).

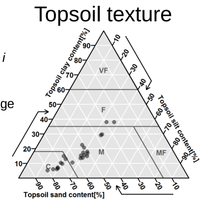
$$C_i = \frac{\sum_j^{ncrops} \sum_k^{nsubs} (f_{crop(j)}(i) f_{sub(k)}(j)\, f_{ind(j)}\, S_{ijk})}{\sum_j^{ncrops} (f_{crop(j)}(i)\, W_{ij})}$$

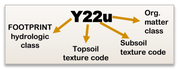
C_i = average herbicide concentration in leachate of a certain soil type i
f_{crop} = fraction of a crop j grown
f_{sub} = fraction of the area sown with crop j sprayed with herbicide k
f_{ind} = factor for changes in herbicide usage compared to reference usage
S_{ijk} = herbicide mass transported with percolating water
W_{ij} = amount of water percolating to groundwater

Crop distribution

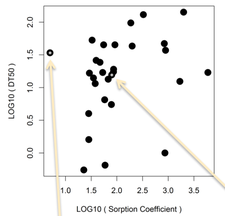


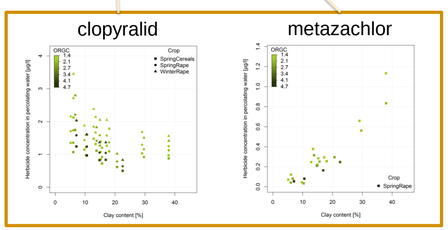




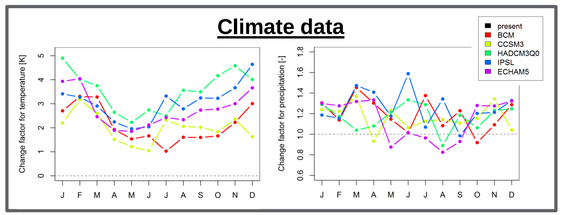


Simulated herbicides

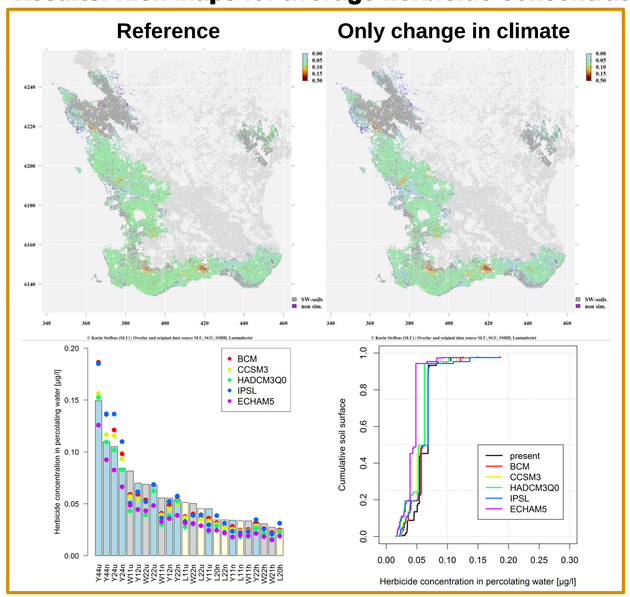


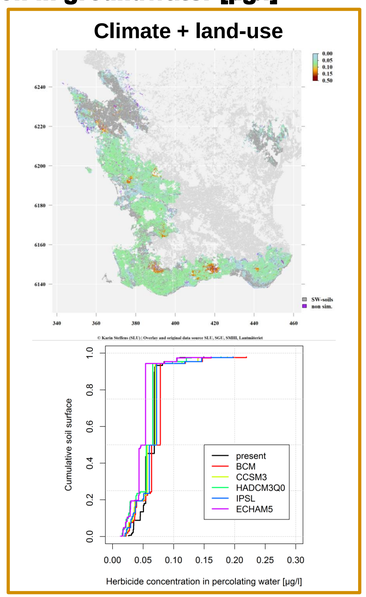


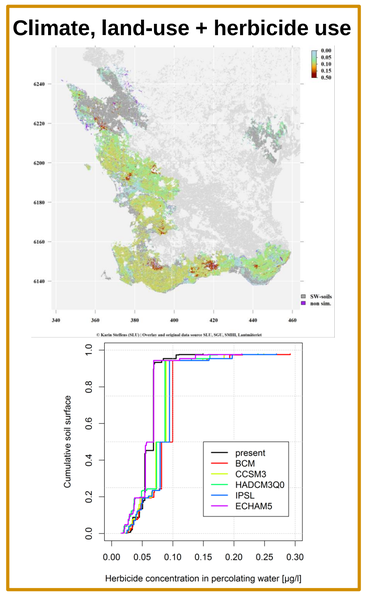
Climate data



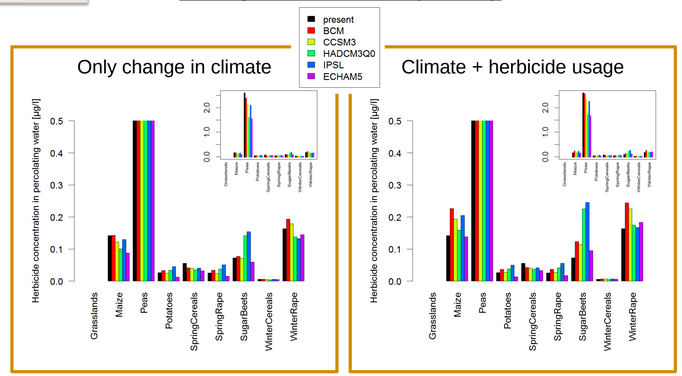
Results: Risk maps for average herbicide concentration in groundwater [µg/l]







Average concentration per crop



Conclusions

Leachate concentrations from different soils vary substantially between herbicides due to their inherent properties. Although simulated herbicide concentrations exceed allowable limits for some combinations of compound, crop and soil type, their relative impact on average concentrations at regional scale is small due to dilution effects.

When **only** direct **climate change** effects were considered, **concentrations decreased** (median by **-4%**), except for soils with high clay contents. When **changes in land use** (more autumn-sown crops and maize) were also considered, **concentrations only changed slightly** (**-0.8%**) from present to future. Accounting for **more herbicide use** due to increased weed pressure **increased** the median **concentrations considerably** (**28%**), although the average concentration never exceeds the drinking water limit of 0.5 µg/l. Nevertheless, the safety margin for error and uncertainty is small: the simulations suggest that for ca. 80-90% of the land surface, leachate concentrations are within a factor 10 of the allowed limit. The results could also be affected by additional factors not considered here (e.g. shifts in vegetation periods, frequency/intensity of rainfall events).

Acknowledgement

The study was financed by the Swedish Farmers' Association for Agricultural Research (SLF) and by strategic funding from SLU within the Soil-Water-Landscape research program. The collection of the monitoring data was financed by the Swedish EPA. We thank Erik Kjellström and Barry Broman from the Swedish Meteorological and Hydrological Institute for providing the climate model projections.

References

Wivstad, M. (2010): Klimatförändringarna – en utmaning för jordbruket och Giftfri miljö

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