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

Karin Steffens[1], Mats Larsbo[1], Julien Moeys[1], Nick Jarvis[1], Erik Kjellström[2] and Elisabet Lewan[1]

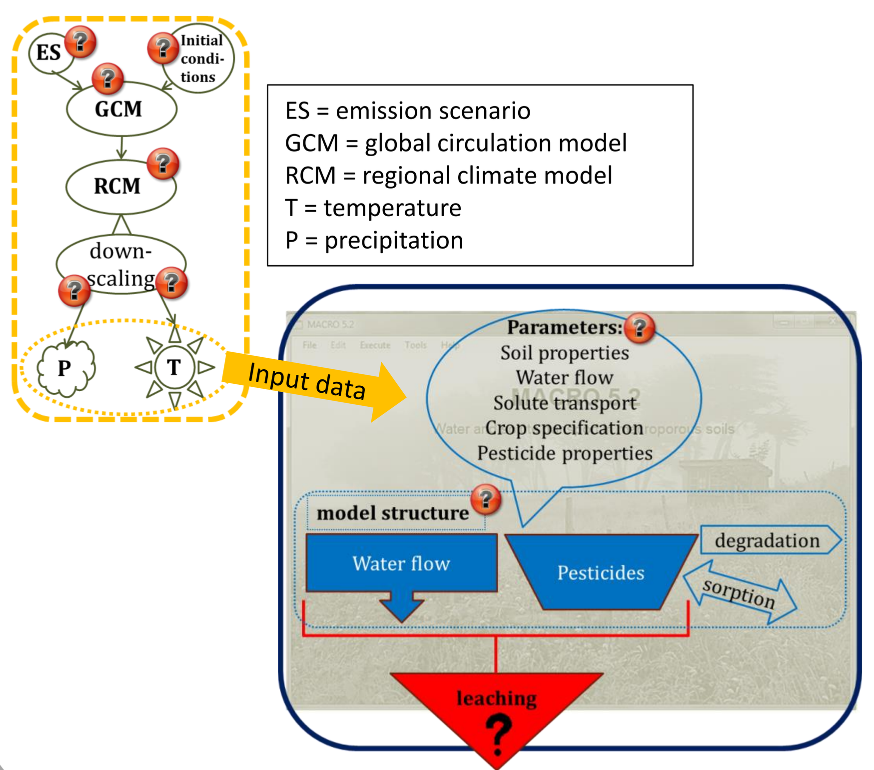
[1]Department of Soil and Environment, Swedish University of Agricultural Sciences, Uppsala, Sweden, karin.steffens@slu.se, Tel: +46 (0)18 67 3849
[2]Rossby Centre, Swedish Meteorological and Hydrological Institute, Norrköping, Sweden

SLU Swedish University of Agricultural Sciences

Aim

… to assess the role of climate input data uncertainty in predictions of pesticide leaching under climate change and its importance relative to the parameter uncertainty of the pesticide leaching model.

Sources of uncertainty



A detailed analysis of the sources of uncertainty is required for risk assessments in order to obtain a suitable base for policy and decision-making.

Methods - Step 1: Model calibration

1-year field measurements[4]: Water content, drainflow, bromide & bentazone concentration in drainflow and in soils

GLUE[1]

+ temperature dependent diffusion
+ temperature dependent sorption

8 parameters:
K_b, d, μ, K_{oc} (*): top & sub soil
Uniform prior distribution
40 000 combinations

Likelihood measure: model efficiency (EF)
Criteria for acceptance: EF>0 for all measurements

K_b: saturated hydraulic conductivity of the soil matrix
d: diffusion pathlength
μ: pesticide degradation rate coefficient
K_{oc}: sorption coefficient normalized by the organic carbon content

The procedure[5] identified 56 acceptable parameter sets that simulated the observations equally well.

Methods - Step 2: 30-year predictions

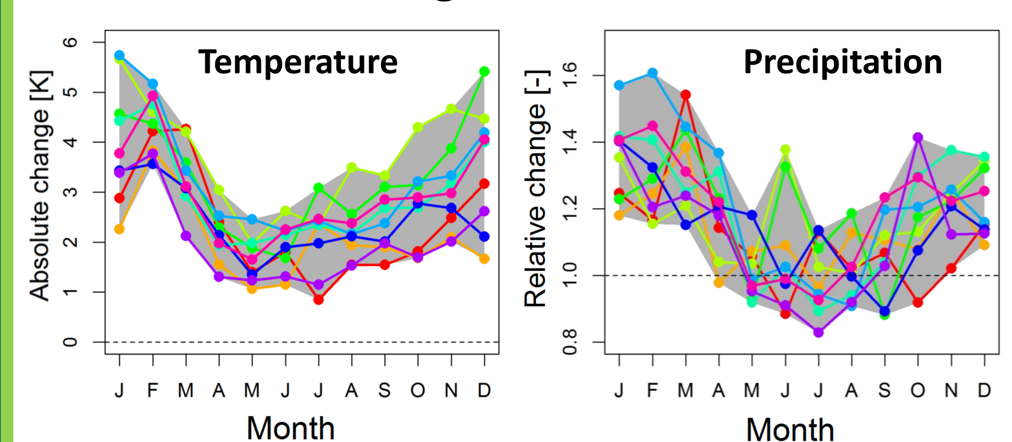
Predictions with a modified version of MACRO5.2 [3,5] were made for a heavy clay soil in South-West Sweden (Lanna) (Fig. 1) with stable macropores and high risk for pesticide leaching losses.

Fig. 1: Map of Sweden. The field site in Lanna (black circle) and the weather station (black star) representative for the agricultural region around Lanna (dark grey) are marked.

Climate input data

Daily data (1970-1999) from a weather station within the agricultural region around Lanna (Fig.1) were used to represent present climate conditions. The future time series were generated by perturbing the observed data based on monthly change factors for temperature, precipitation and solar radiation for the period 2070-2099. Wind speed and relative humidity were assumed unchanged in the future[2].

Change factors



Prediction scenarios

Hypothetical pesticides

The identified K_{oc}-values for bentazone were multiplied by a factor of 1, 10, and 50, respectively, to represent weakly, moderately and strongly sorbed pesticides.

Pesticide applications

- Two periods: Spring: 1-16 May
  Autumn: 29 Sep-15 Oct
- Application on days with <2mm rainfall
- Same application date for present & future (all climate model projections)
- Constant yearly dose: 0.45kg/ha
- Crop: winter cereals

Climate scenarios

Climate scenario		RCM	GCM	ES	Initial state
CS1	——	RCA3	BCM	A1B	
CS2	——	RCA3	CCSMS3	A1B	
CS3	——	RCA3	HADCM3Q0	A1B	
CS4	——	RCA3	IPSL	A1B	
CS5	••••••	RCA3	ECHAM5	A1B	r1
CS6	••••••	RCA3	ECHAM5	A1B	r2
CS7	••••••	RCA3	ECHAM5	A1B	r3
CS8	••••••	RCA3	ECHAM5	B1	
CS9	••••••	RCA3	ECHAM5	A2	

Results – Step 1: Model calibration

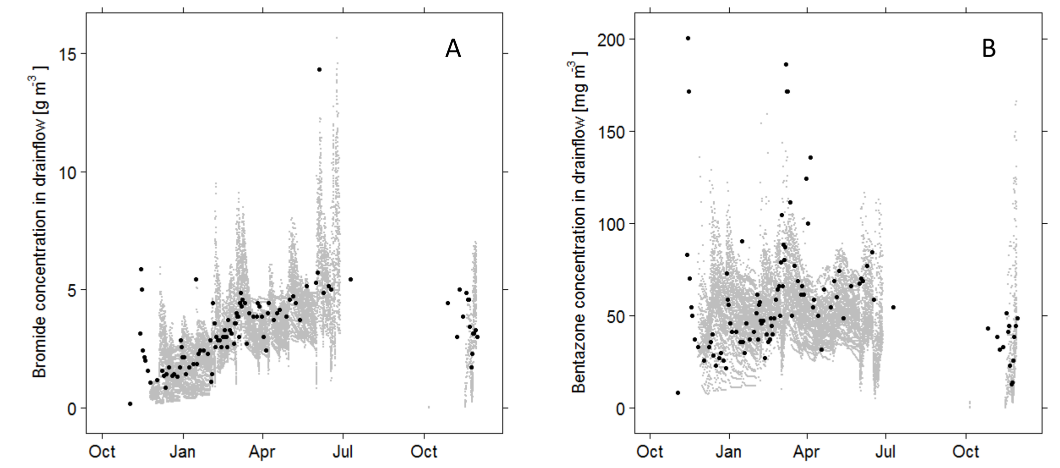
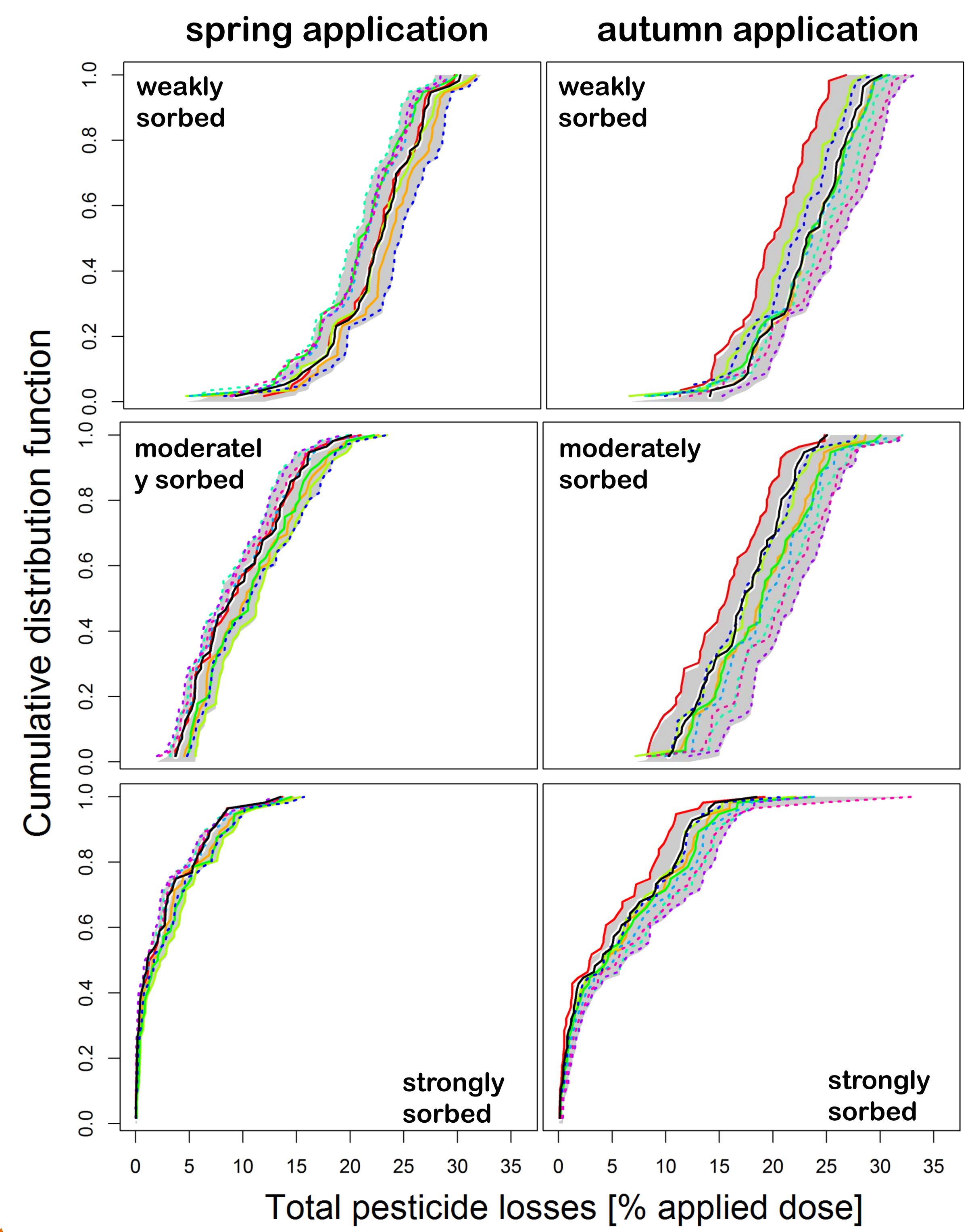


Fig.2: Comparison of measured (black) and simulated (grey) concentrations of bromide (A) and bentazone (B) in drainflow. Simulation results of all 56 acceptable parameter sets are shown.

Results – Step 2: 30-year predictions

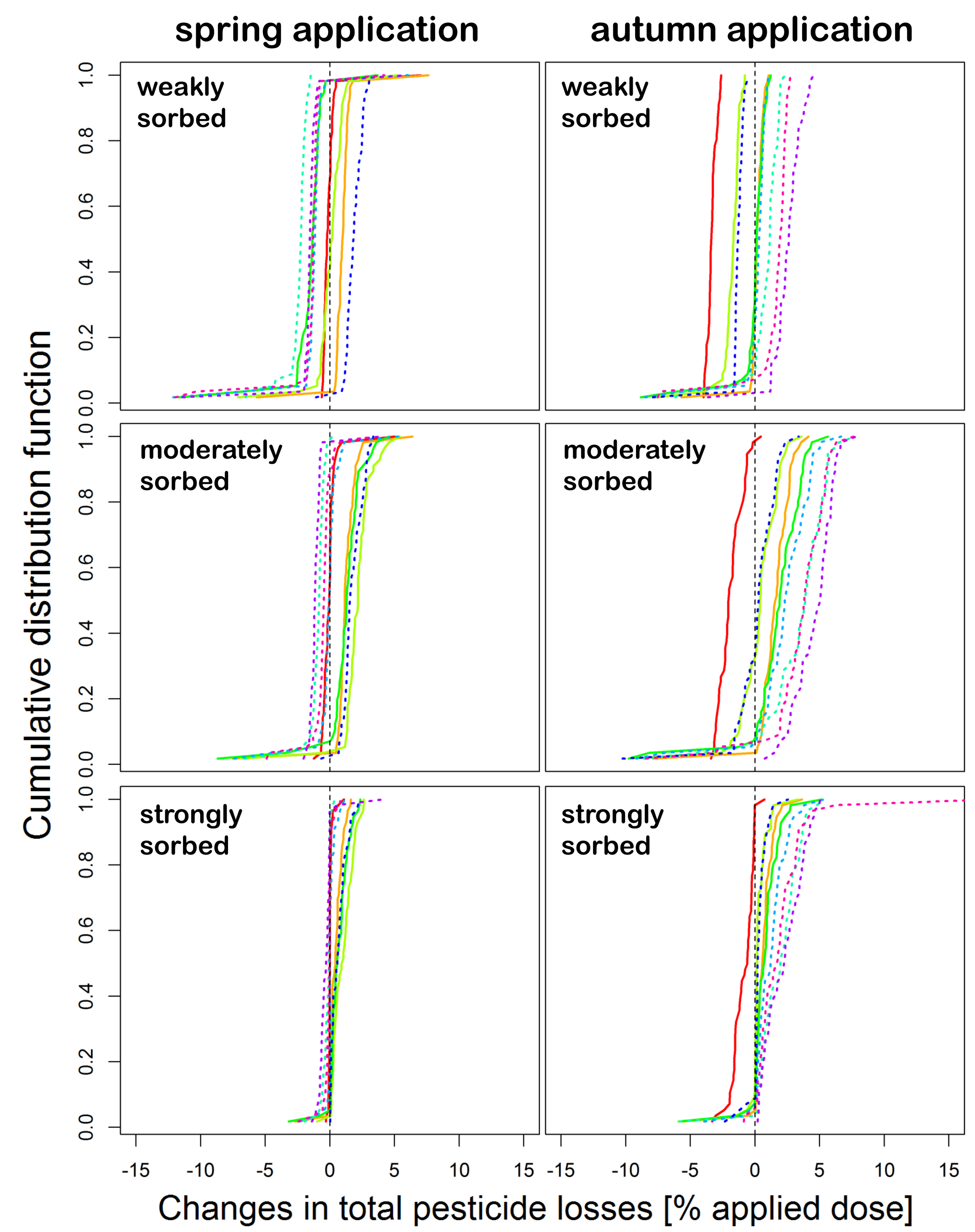
Simulated pesticide leaching losses

… generated from 56 acceptable parameter sets, for present climate (black) and future conditions based on 9 different climate scenarios (colored lines).



Changes in pesticide leaching losses

… from present to future as predicted by the different parameter sets, demonstrating the relative importance of climate input uncertainty.



Summary & Conclusions

- Climate model projections of seasonal changes in temperature and especially precipitation strongly affect both the magnitude and direction of change in future pesticide leaching.
- The predicted changes between present and future were very similar for different parameter sets given a specific climate scenario.
- For predictions of changes in pesticide losses, the impact of climate input uncertainty was larger than the impact of parameter uncertainty, whereas the opposite was the case for predictions of actual leaching losses.
- Our results demonstrate the importance of using an ensemble of different climate scenarios when assessing possible changes in future pesticide leaching.

References

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