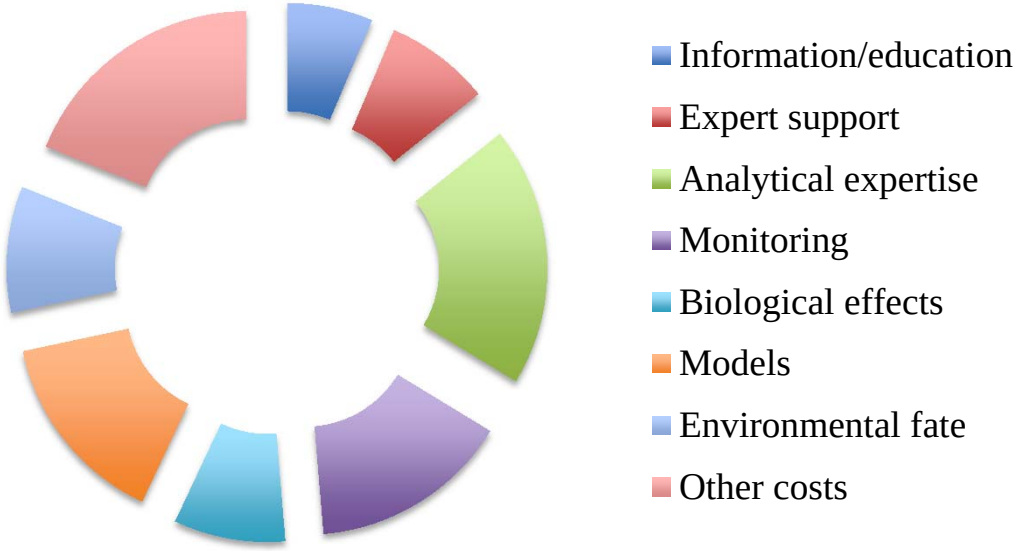
MACRO-based decision-support tools for local- and regional-scale exposure assessments in Sweden

Nick Jarvis, Mats Larsbo, Julien Moeys, Karin Steffens, Bodil Lindström, Elisabet Lewan, Mikaela Gönczi, Jenny Kreuger

CKB, the Centre for Chemical pesticides at SLU

- Funded by central Government (ca. 0.55 mill. Euros/year; Director, Jenny Kreuger)
  - a national center of expertise on the effects on the environment of chemical pesticides used in agriculture
  - a forum for collaboration between researchers at SLU and interested stakeholders outside the university

Budget 2014



For more information:
http://www.slu.se/en/collaborative-centres-and-projects/centre-for-chemical-pesticides-ckb1/

Models and risk assessment tools

……. ’to develop and maintain model-based decision-support tools for end-users, stakeholders and public authorities in Sweden with responsibility for reducing the impact of pesticide residues in the aquatic environment’

MACRO-tools

Tool	Purposes	End users/stakeholders
MACRO in FOCUS	Registration (national, zonal and EU)	National authorities (e.g. KemI), EFSA, industry
MACRO-DB	Authorisation for pesticide use in drinking water protection areas Extension and advisory work	Local authorities, landowners, consultants, advisors
MACRO-SE	Risk management Higher-tier registration Research	Water authorities, EPA, Geological survey, KemI

MACRO-DB/SE

- Predictive (blind) site-specific and regional-scale simulations
  - MACRO-SE is a regional (spatialized) version of MACRO-DB
  - Origins in the FOOTPRINT EU project
- Both account for:
  - Leaching to GW and SW via drains
  - (Planned routine for runoff/erosion losses to SW)
  - Simple dilution routines
- Only relatively simple input data required
  - A complete parameter inference system for MACRO combining class and continuous pedotransfer functions

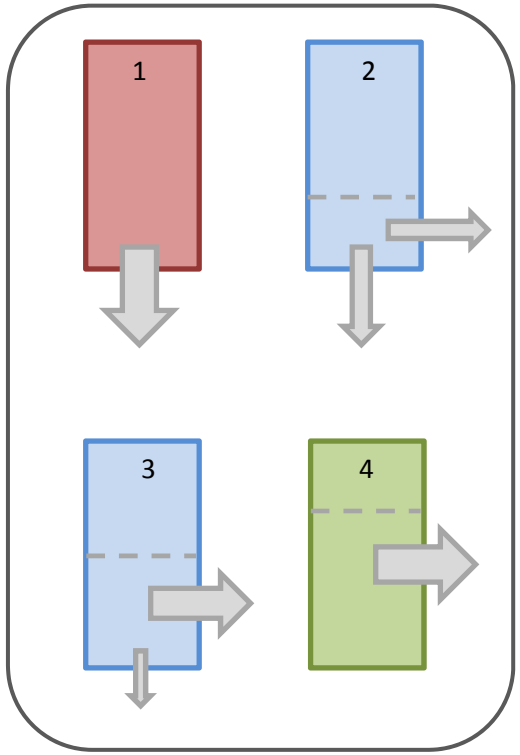
MACRO-SE: data sources

Input data	Source
Soil properties	High resolution (100 m) digital soil map
Hydrological class	Quaternary geology mapped at 0.5 m depth (1:50000)
Crop	Field-scale cropping statistics from the Board of Agriculture, aggregated for small catchments
Compound properties	PPDB database (Univ. Hertfordshire, U.K.)
Weather data	Meteorological data from SMHI (26 years for representative stations for 18 climate zones)
Applications (dose, timing, method)	User-defined

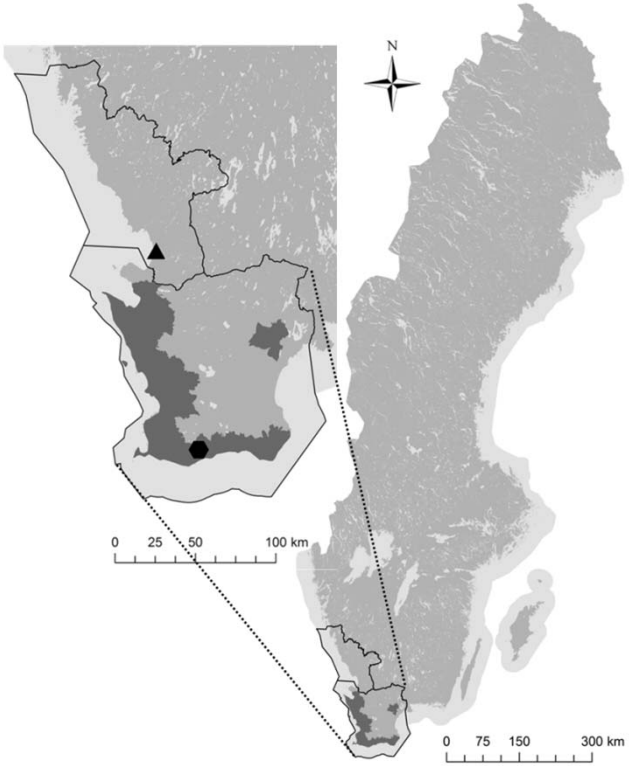
Hydrological classes

Quaternary geology	Subsoil texture	Hydrological class
Esker sediment (mainly sand/gravel)		1
Sedimentary rock		1
Moraine	Coarse	2
	medium, medium-fine, fine	3
Hard rock		3
Coarse silt/sand, gravel		4
Clay/silt sediment		4
Organic		4
Alluvial sediment		4

Red = recharge area
Green = discharge area
Blue = both recharge and discharge area



Case study: climate change effects on herbicide leaching to groundwater in Scania



Direct <u>and</u> indirect effects of climate change

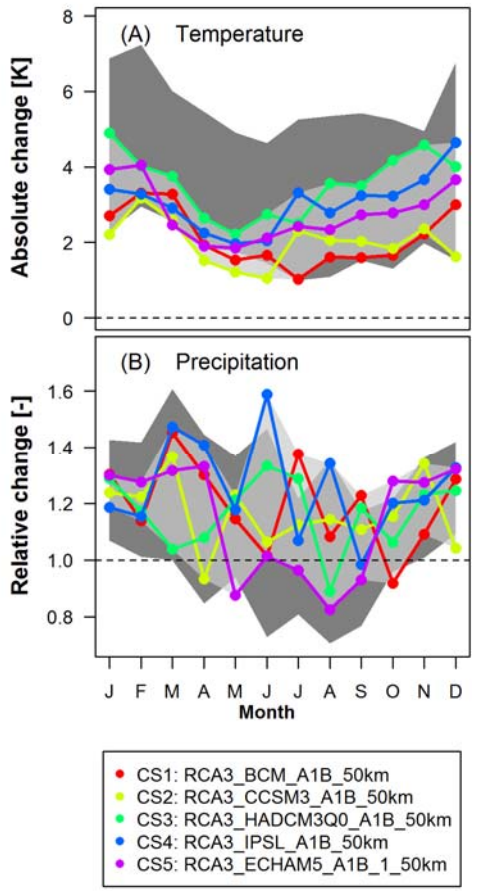
- changes and cropping patterns and herbicide usage

Scania has:

- 20% of the agricultural land of Sweden (0.5 mill. hectares)
  - GSS production region in Scania is ca. 60% agricultural land
- 50% of the total agricultural production of Sweden
- 60% of the total pesticide usage

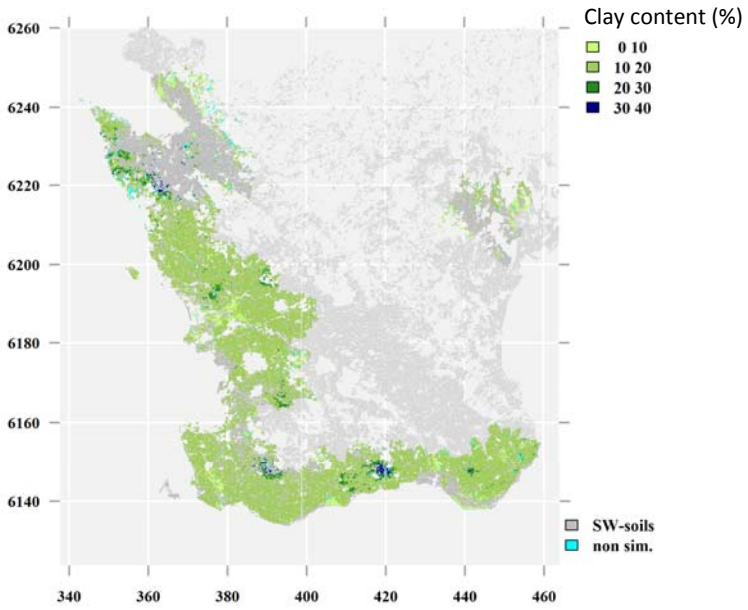
Climate change and driving data

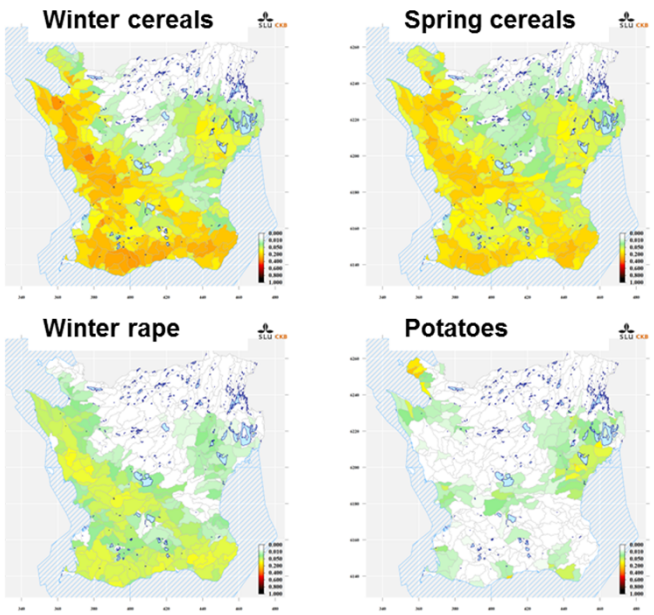
- Present climate (1970-1999):
  - 30 years of daily weather data from a representative station
  - Daily rainfall disaggregated to hourly data
- Future climate (2070-2099):
  - 5 different GCM's downscaled with the SMHI Rossby Centre RCM (RCA3)
  - A1B greenhouse gas emission scenario
  - Bias correction by the delta change method



Simulating current conditions and practices

- Leaching to groundwater was simulated for:
  - 9 major crop types (ca. 80% of the agricultural land) and 37 herbicides
    - All substances approved for use on these crops in Sweden (except glyphosate and two others)
  - 24 major soil types (ca. 97% of the soils with recharge to groundwater)
- Application doses, timings and % crop area sprayed based on data from two monitoring catchments in the region





Reality check against monitoring data

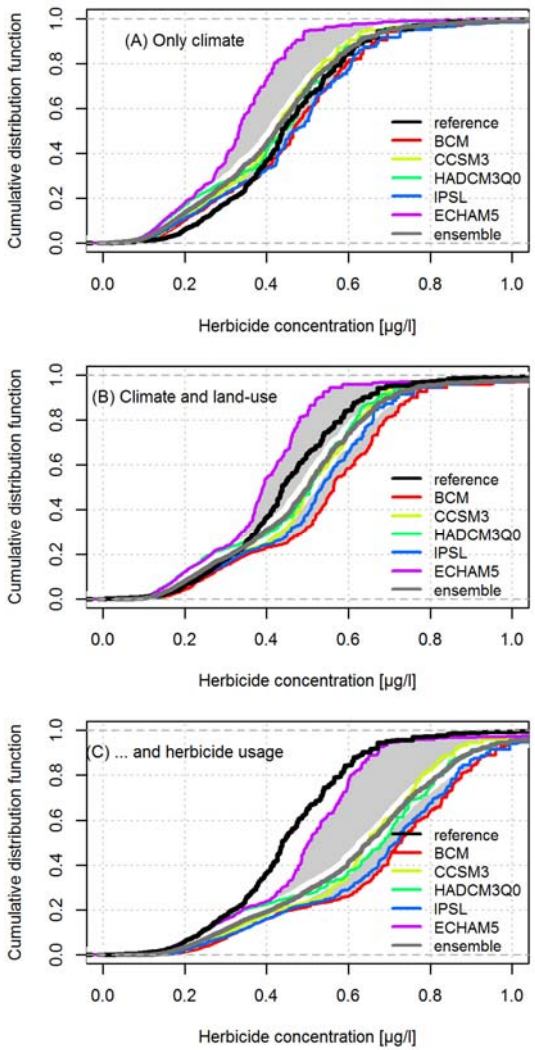
- Groundwater surveys carried out by the county councils (Scania, n=141 and Halland, n=64)
- Survey of private wells in Halland (n=19)
- Two wells in each of the two monitoring catchments

		Simulations		Sum
		Leached	Not leached	
Monitoring	Detected	10	2	12
	Not detected	2	19	21
Sum		12	21	33

88% correct classification of compound leachability …….
…. although concentrations are generally overestimated

Three future scenarios

- Scenario A: only direct effects of climate change (temperature and precipitation)
- Scenario B: as A, but including expected changes in cropping patterns:
  - 50% of grassland area replaced by maize
  - Areas cropped with spring cereals and spring rape reduced by 60% and 100% and replaced by winter cereals and winter rape in the proportion of 3:2
- Scenario C: as B, but also including increases in herbicide use, due to increased weed pressure
  - Sprayed area and number of doses increased, on a crop-by-crop basis
  - Total herbicide use increases by 45% in this scenario
- Projected indirect effects (scenarios B and C) were based on interviews with extension advisors
- 'Worst-case' analysis ('business as usual')



Results

- 4 of 5 climate scenarios suggest only minor direct effects of climate change
  - increased leaching in a wetter climate is balanced by higher temperatures which increase degradation
- Differences between climate model projections increase when indirect effects are included
  - But indirect effects overshadow the direct effects
  - The area at risk (concentrations > EU limit of 0.5 µg/L) is projected to double by the end of the century

Concluding remarks

- There are many sources of prediction uncertainties: many of them are unquantifiable, others surely unknowable:
  - *"as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns - the ones we don't know we don't know"* (Donald Rumsfeld, 2008)

- We simulated a worst-case 'business-as-usual' scenario
  - Adoption of mitigation policies and management strategies will be necessary to ensure groundwater protection in the future (and compliance with current legislation)
    - Organic farming, IPM
    - Technological advances, for example …
      - New herbicide chemistries (lower doses and/or better fate properties)
      - Precision application technologies