MACRO-SE
A versatile tool for scenario-based pesticide risk assessments:

Presentation & application

a CKB/FoMa funded project

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31st August 2011

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Background

One step forward in the EU legislation (Thematic Strategy on the Sustainable use of Pesticides + Water Framework Directive)

+ Research progress in spatial estimation of pesticide fate in soils (FOOTPRINT/FOOTWAYS Tools, FROGS, GeoPEARL, MACRO-SE, …)

Is there a risk from using a given pesticide? (registration)

Which part of the landscape contributes to a diffuse pollution?
or **What mitigation measure might be efficient?**

Background

FOOTPRINT EU FP6 Project: significant progress:

(a) EU wide soil, crop, climate and land-use datasets

(b) Hydrological classification of soils (water flow path: surface water and/or groundwater?)

(c) Pedotransfer functions

(d) Post-processing tools tailored for pesticide fate assessments at the regional scale (FOOT-NES, FOOT-CRS)

Aims

- Using or creating new datasets adapted to Sweden

- A tool for answering both stakeholders questions and fulfilling research needs

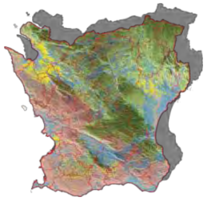
- A more flexible parameterisation and modelling environment for
  - Faster integration of new research development
  - Integration with other projects

In practice

A **command line toolbox** for scenario based pesticide fate modelling: MACRO and the FOOTPRINT methodology embedded into a package for the R software (computing environment)
+ new GIS datasets

Principle

1. Scenario list



Maps:
Soil +
Climate +
Land use

Scenario table

= all scenarios in an area

2. Parameterisation & modeling

Lookup databases (soil, climate, crop) + parameter estimation functions

Parameter sets

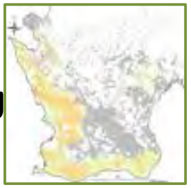
Run MACRO pesticide fate model

Results

SQLite

3. Analyse

Agglomerate Results. Spatial averaging



or export to FOOT-NES

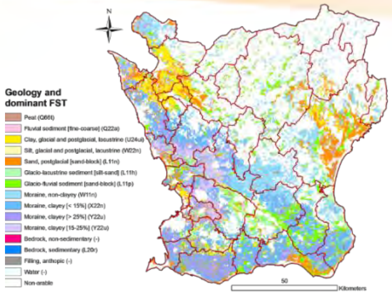
Model characteristics

•1D pesticide fate model (MACRO) on 26 years weather data series for all the combinations. Characteristics:

- Edge of the field transport (base of the soil)
- Macropore transport (non-equilibrium flow)
- Losses to groundwater (bottom of the soil)
- Losses to drains and ditches
- Losses by runoff and erosion (under development)

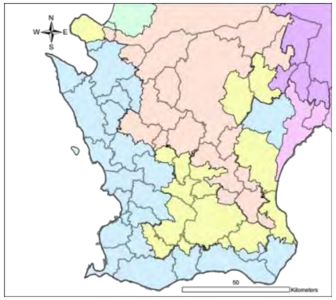
Data: Case study for Skåne (Scania)

- Soils: Soil map of Skåne (from SGU + SLU data)



- Cropping statistics (FOOTPRINT)

- Climate: 6 climate zones in Skåne (3 dominants, 3 minors), Johnsson & Mårtensson 2002

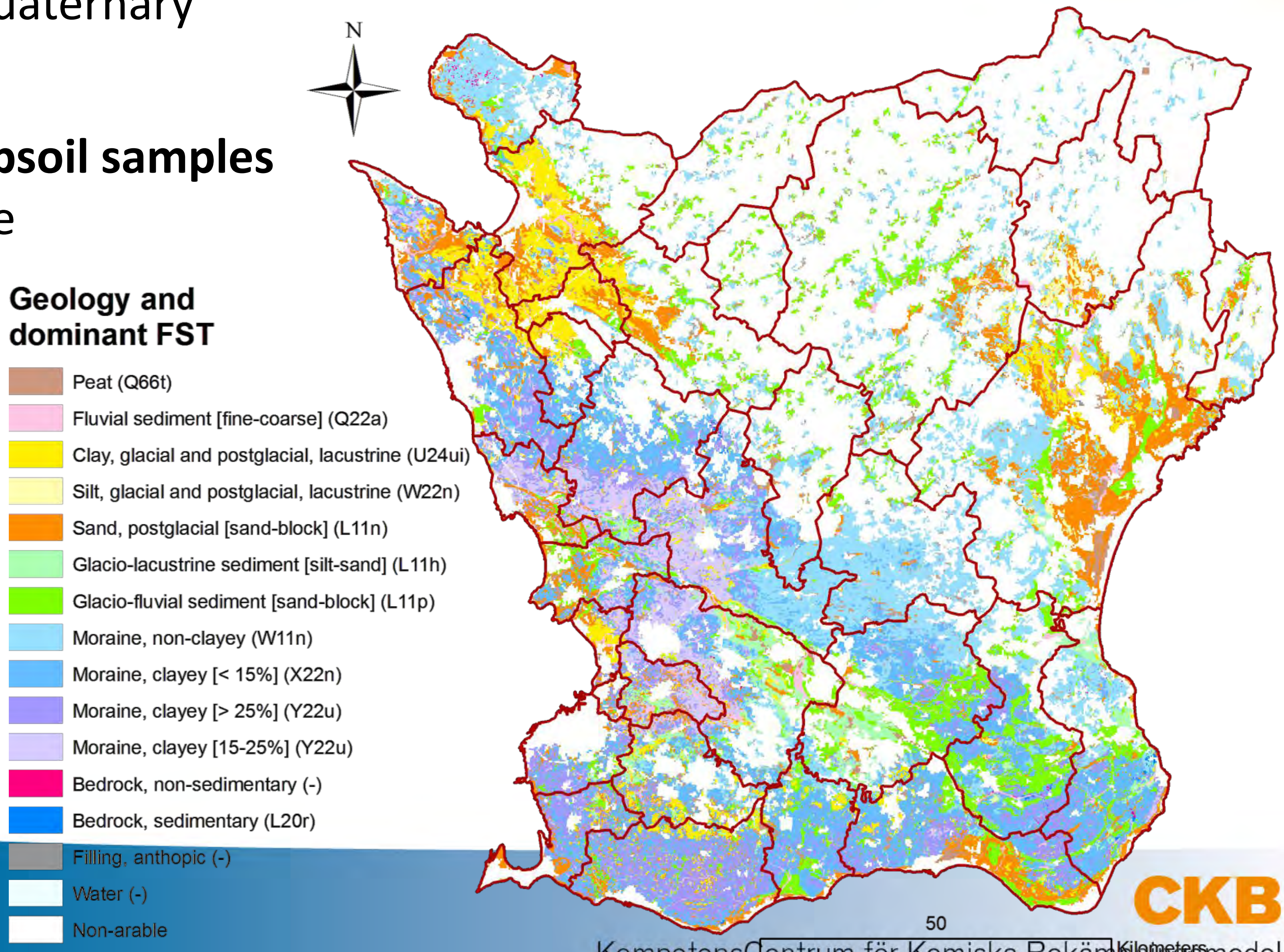


- 2 {crop x pesticides x application period} combinations
  - Isoproturon on winter cereals (wheat), autumn application;
  - Bentazone on peas, late spring application;

- Modelling: 230 simulations per crop

FST Soil Map of Skåne (south Sweden)

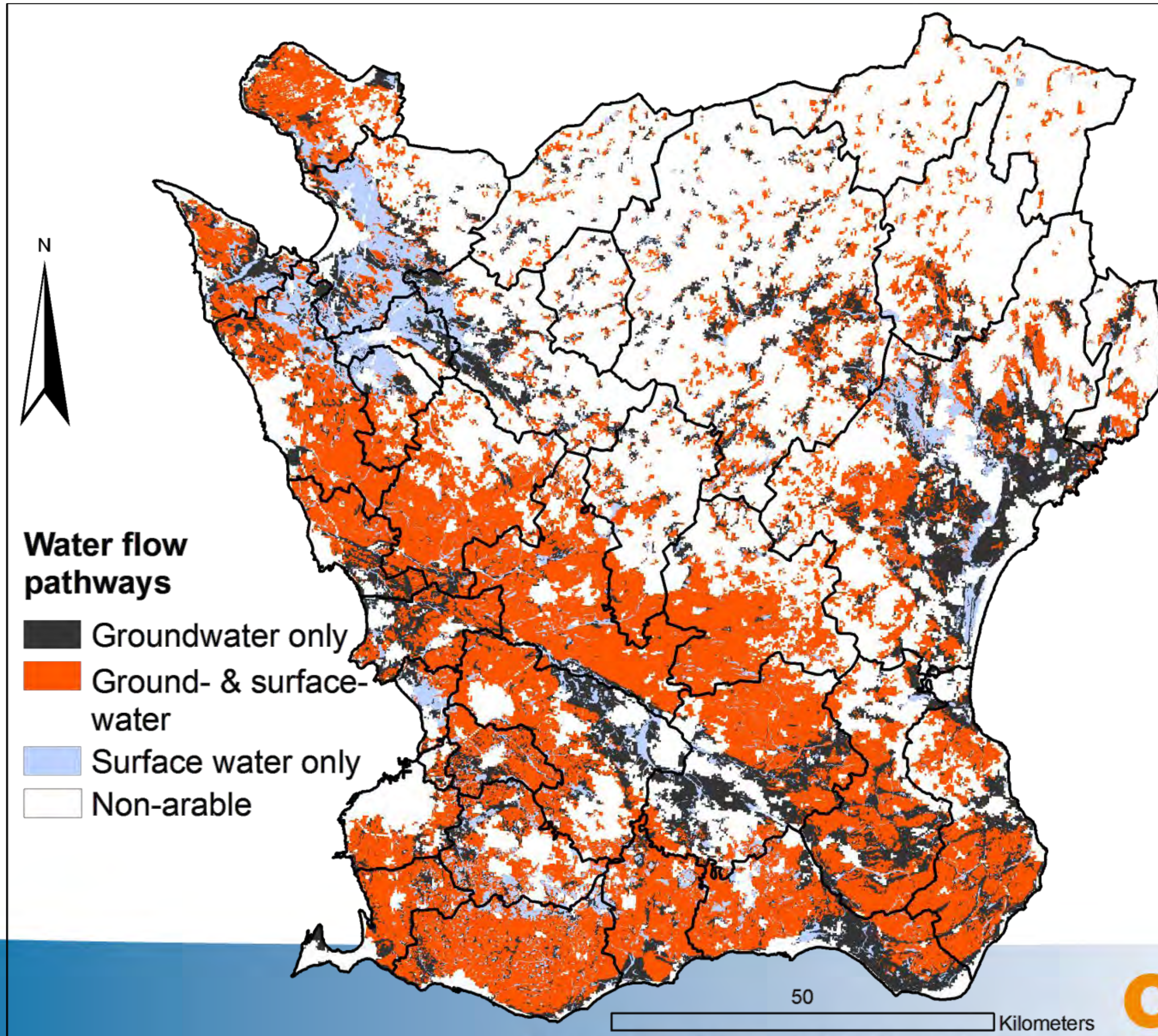
- SGU Quaternary geology
- SLU **topsoil samples** database



Contamination pathways

Where does the water go?

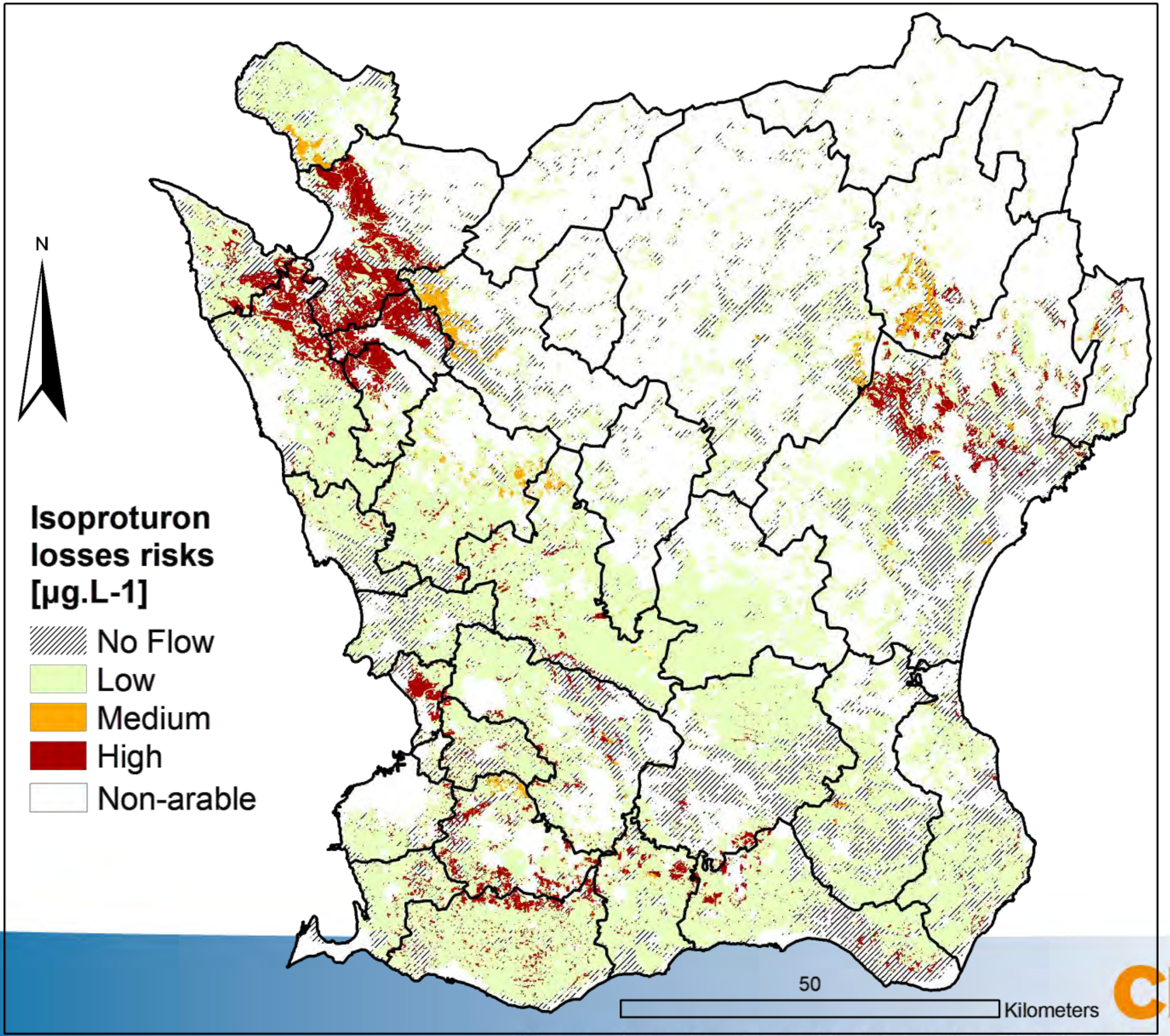
Derived from FST map (hydrological code)



Losses to drains & ditches (edge of fields)

Isoproturon

Drains & ditches

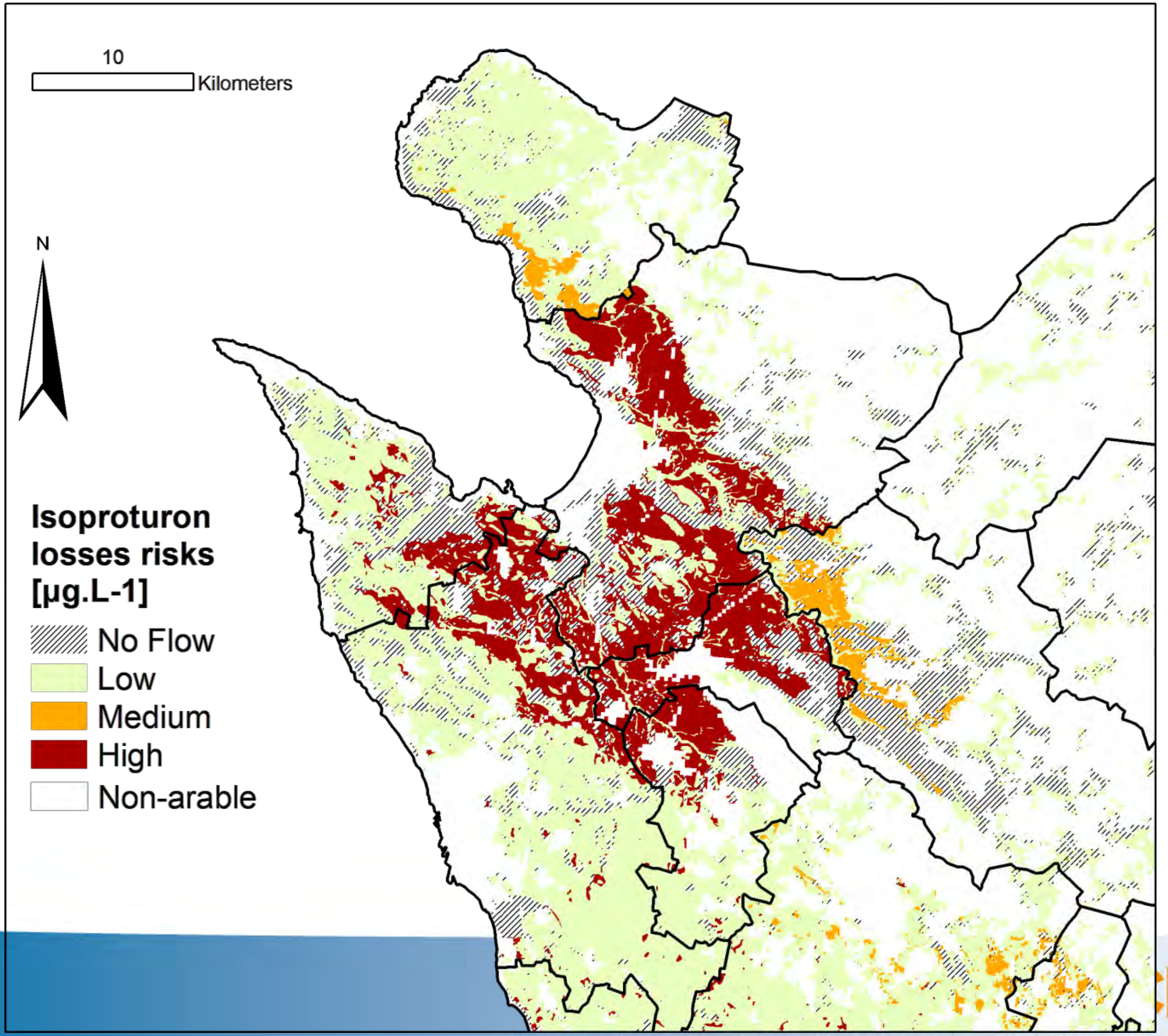


Losses to drains & ditches (edge of fields)

Isoproturon

Drains & ditches

Red = postglacial clay



Spatially variable DT_{50} and K_{OC}

- Follow up of Ghafoor et al.'s (Posters, this conference) work on pesticide degradation

- Same model structure, but fitted with only Swedish studies on bentazone (PLS regressions validated with bootstrap)

- Step 1: PTF to predict Bentazone K_D:
$K_D = 0.82 + 5.02 * fOC - 0.09 * pH$

- Step 2: PTF to predict Bentazone DT_{50}, using the predicted K_D :
$k = 10$^[- $14.79 * \log_{10}(pH) + 2.33 * \log_{10}(fOC) + 0.51 * \log_{10}(\%Clay)$ ***- 4.86 * log10(***K_D***)***] (bounded to avoid extrapolation)

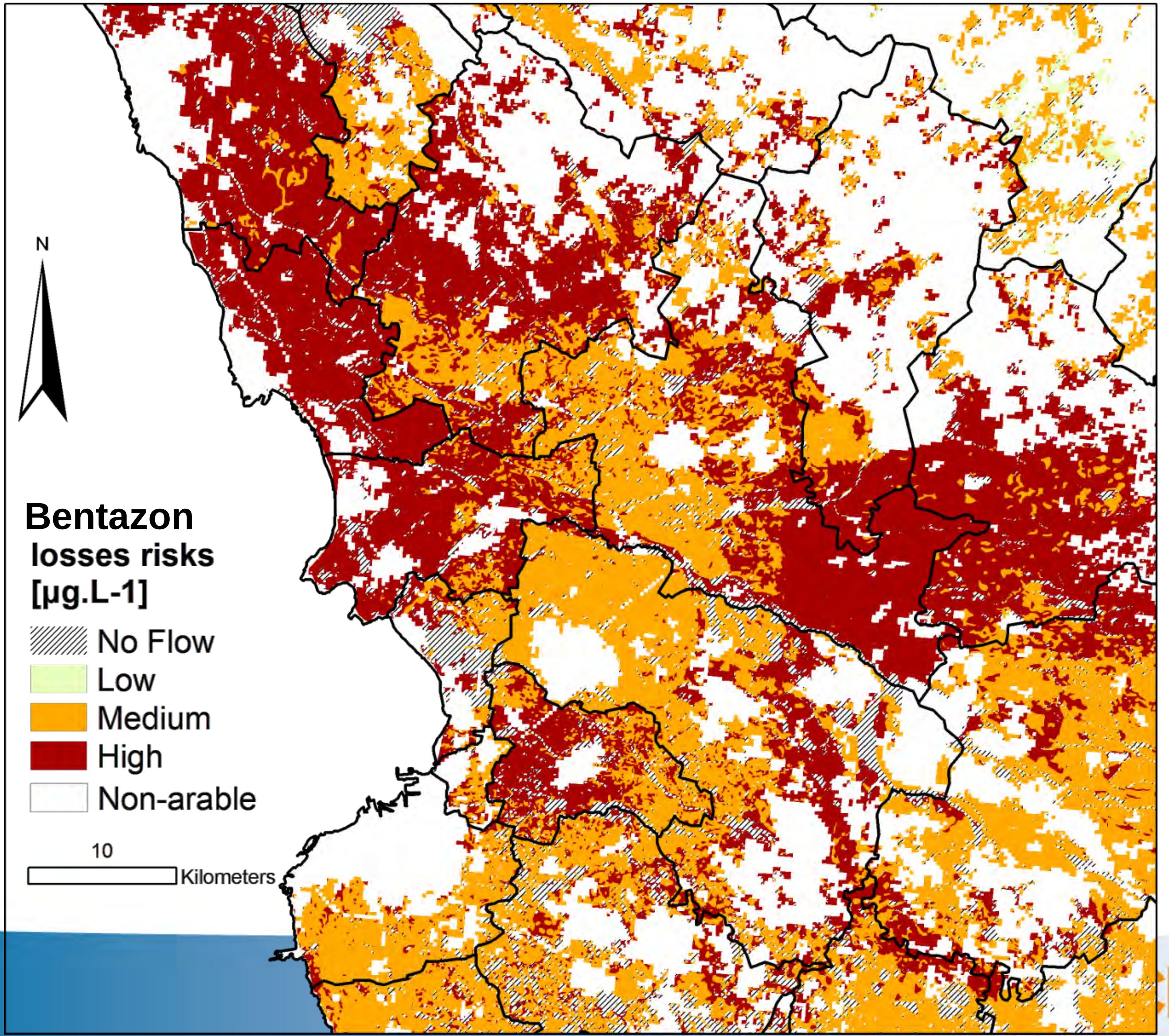
- Checked: Average prediction errors lower than when using a k value from a pesticide properties database (PTF = improvement).

Without spatially variable DT_{50} and K_{OC}

Bentazone
Groundwater

Differences:
Coarse / clayey soils

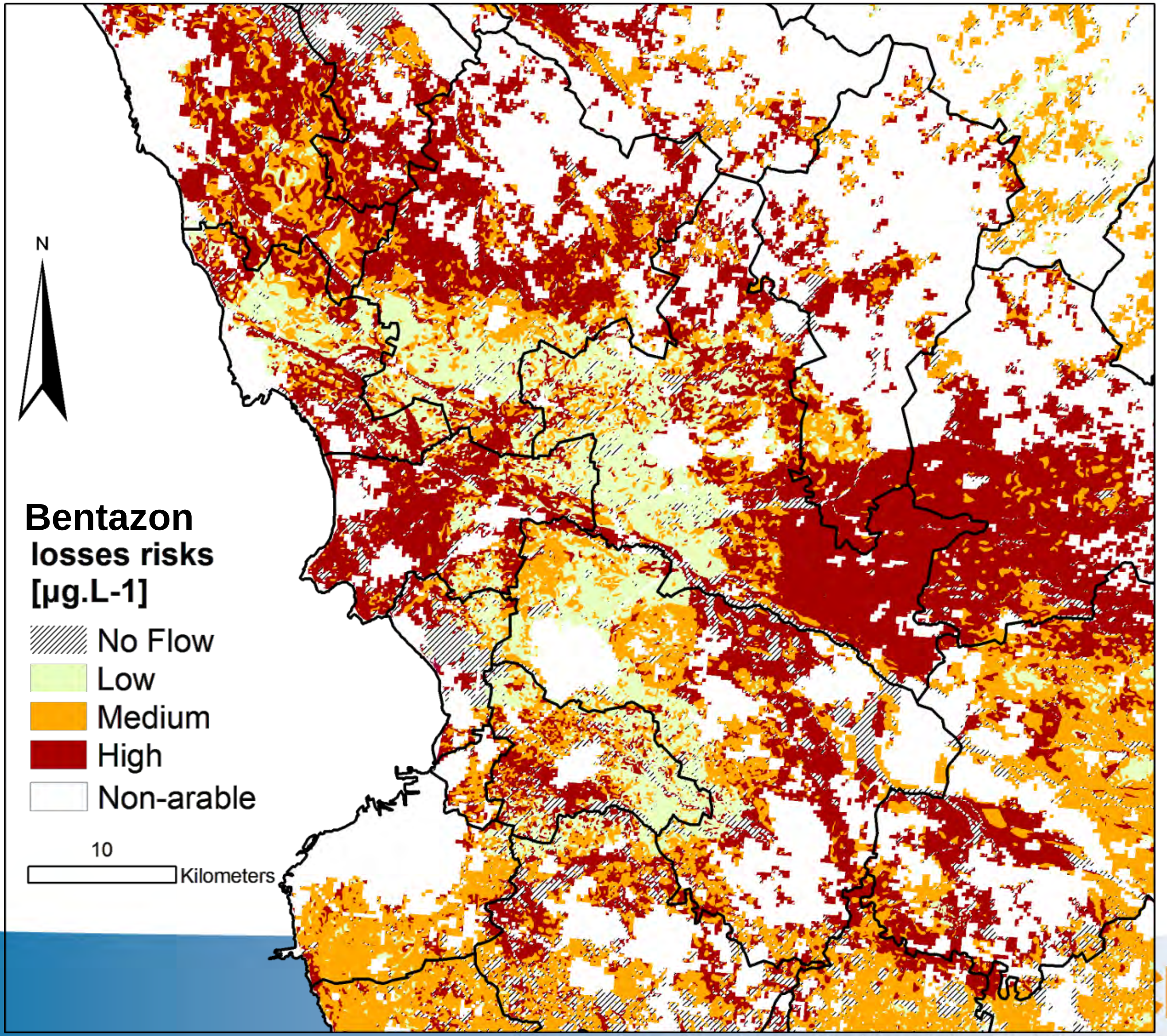
But also cropping statistics (municipality level)



With spatially variable DT_{50} and K_{OC}

Bentazone
Groundwater

NB: Lower concentration in some area, higher in other area



Ongoing work

• Climate change impact on pesticide losses? (Steffens et al.'s poster);

• Digital Soil Map of Sweden (Grant Tranter);

• Simple dilution routines for surface water;

• Improved handling of GIS data;

• **Validation against pesticide monitoring data (CKB)**. Problems to solve:

  - Historical contamination of groundwater;
  - Poor geo-referencing of the monitoring sites (municipality)
  - Not designed for extensive monitoring (vary in time & depth)

Conclusion

Regional modelling of pesticide fate is a powerful tool, but:

- Need to be tested against monitoring data. Not so simple;

- Spatially variable DT_{50} and K_{OC} is promising, but more literature meta-analysis needed;

- Quality of input survey data is critical;

- Usage by stakeholders & researchers to be defined;

- More technical improvement expected;

Thank you for
you attention

Any questions?

Additional information

The FOOTPRINT Soil Type (FST) classification

Recharge or discharge area?	Classes	MACRO bottom boundary condition	Description
Recharge to groundwater	L, M, N	Unit hydraulic gradient	Permeable substrate, groundwater > 2m depth
Discharge to surface water	O, P, Q	Zero flow	Low-lying topography, groundwater depth (O, P > Q)
	R, S, T, U, V		Impermeable substrate
Both recharge and discharge	W, X, Y	Percolation as function of water table height	Slowly permeable substrate Recharge: W>X>Y