Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

Effects of soil freezing on bromide and pesticide transport in soil columns

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Background

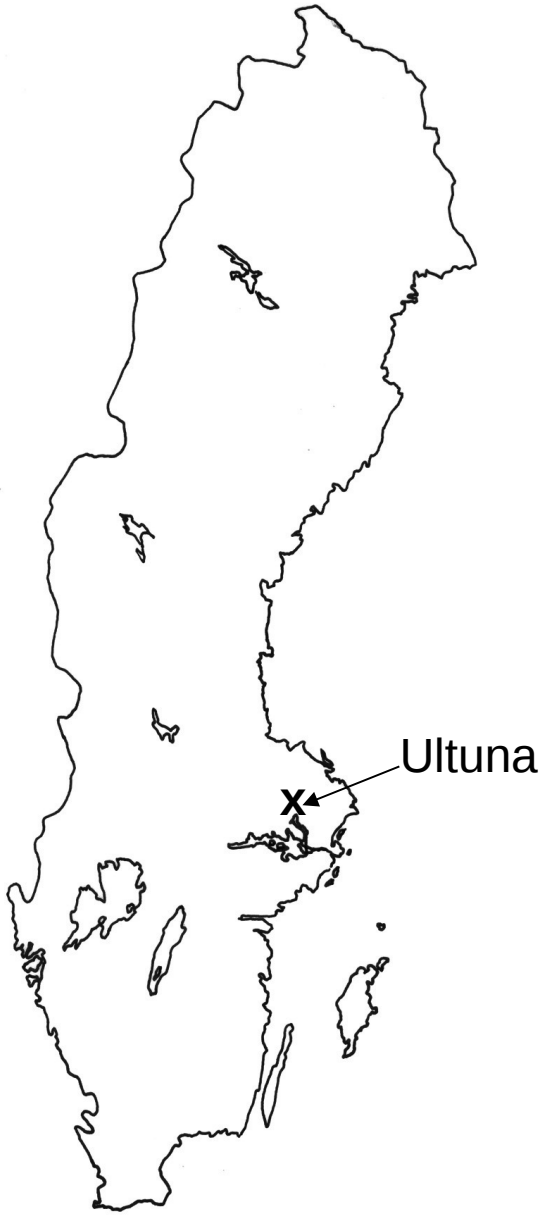
- Difference water flow frozen – not frozen soil

  → impact on solute transport

- Significant losses of pesticides to tile drainage systems during winter conditions with frozen soil
- Models used for pesticide registration
- **Objective:** Quantification of the effect of soil freezing on pesticide leaching for a Swedish clayey topsoil

Location

Ultuna (59°49′N 17° 39′E)

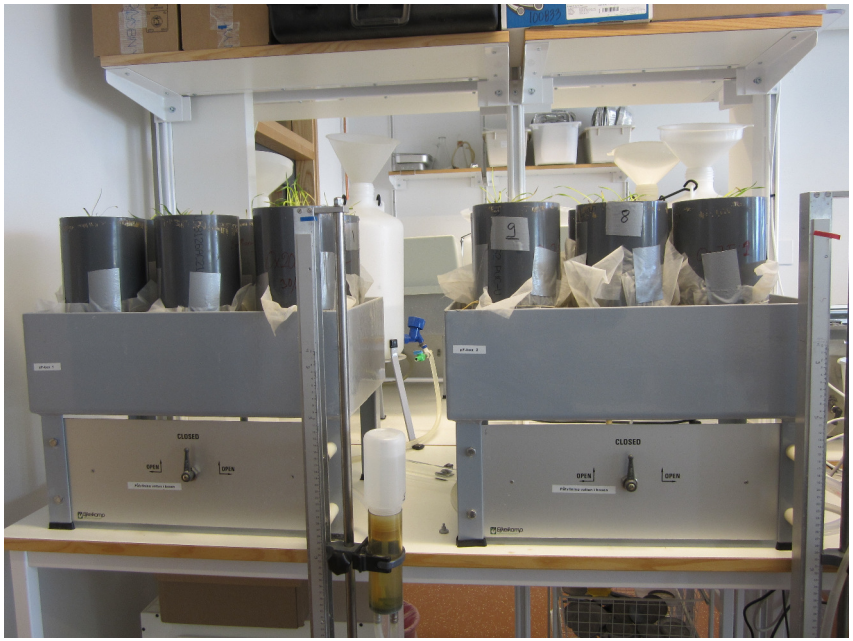


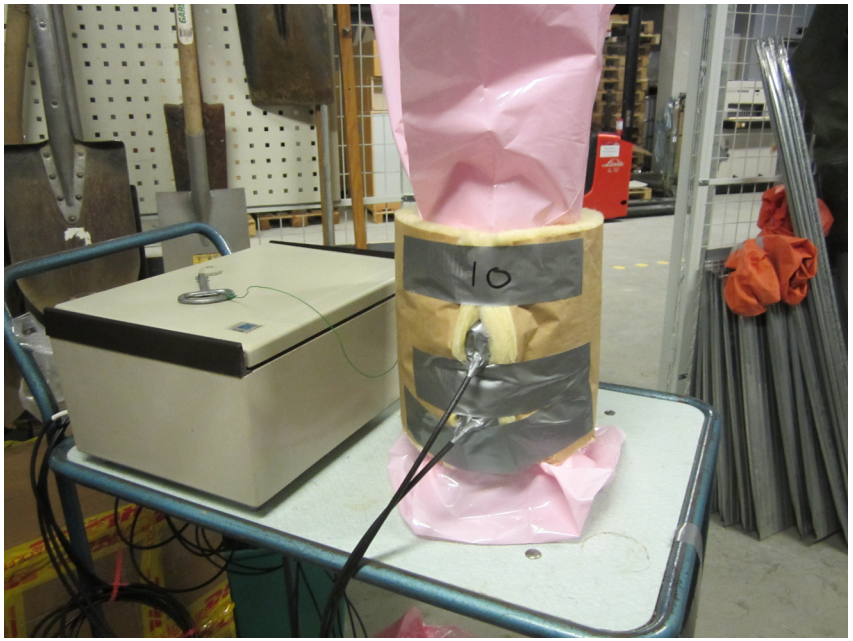
Soil

Soil texture (USDA)	Clay
Clay	55 %
Silt	33 %
Sand	12 %
Org. matter	4 %
Density	2.6 g/cm^3

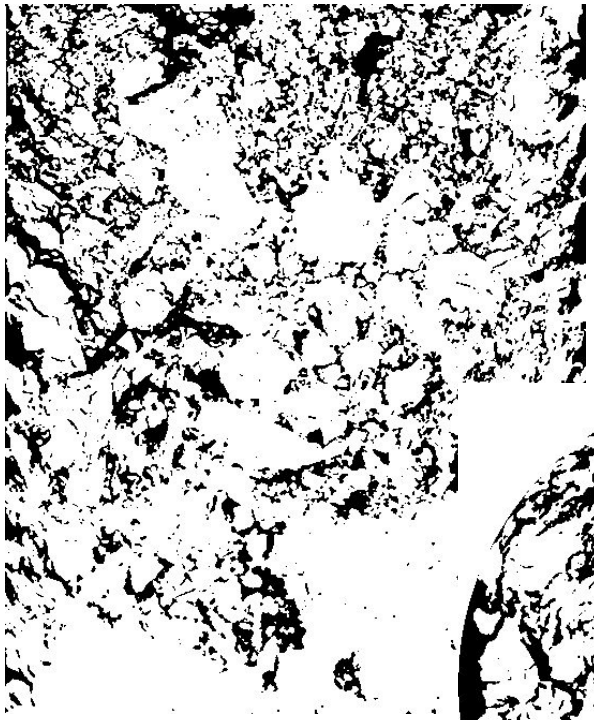
Sampling

Sample preparation

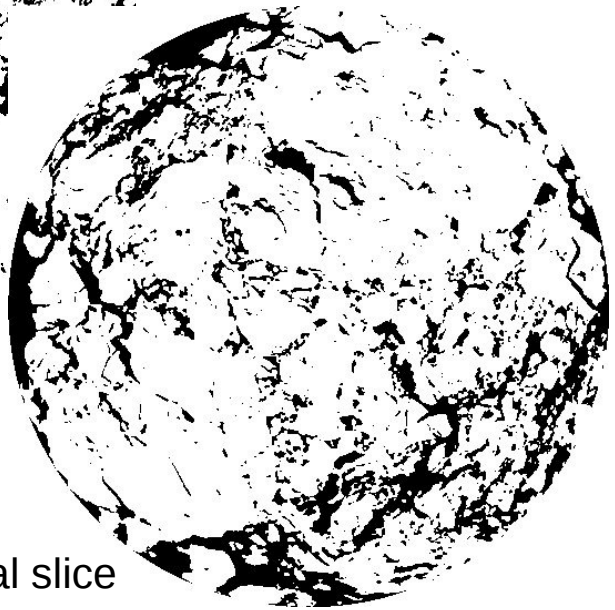




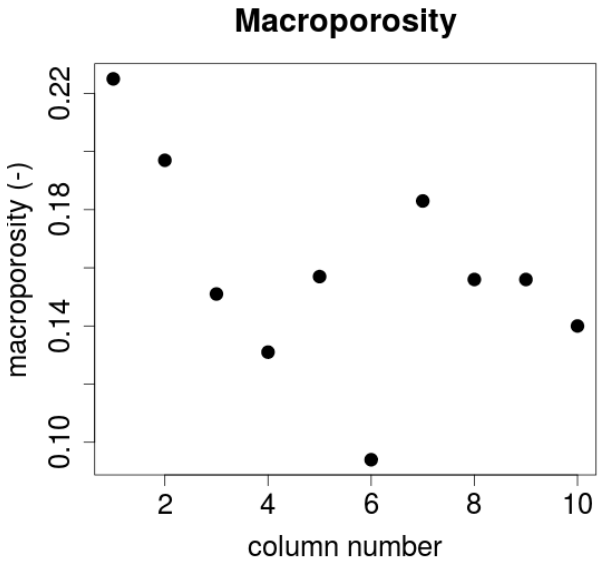
X-ray

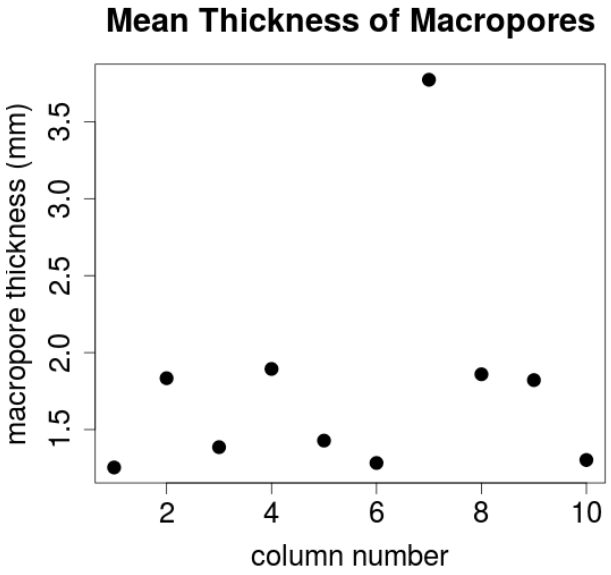


Vertical slice



Horizontal slice





Chemicals

Substance	Dose (kg/ha)	Solubility in water (mg/L)[a]	Koc[*] (cm^3/g)[a]	DT_{50} lab[**] (days)[a]
clomazone	0.12	1102	287[***]	89
propyzamide	0.5	9	840	47
diflufenican	0.15	0.05	1996[***]	142
bromide	50	–	–	–

* Organic carbon sorption distribution coefficient.
** Degradation half-life at 20°C.
*** Freundlich adsorption coefficients (Kfoc).

[a] Pesticide Properties Database (PPDB)

Experimantal workflow

I. frozen: freezing to -2°C (5 columns)

not frozen: storge at +2°C (5 columns)

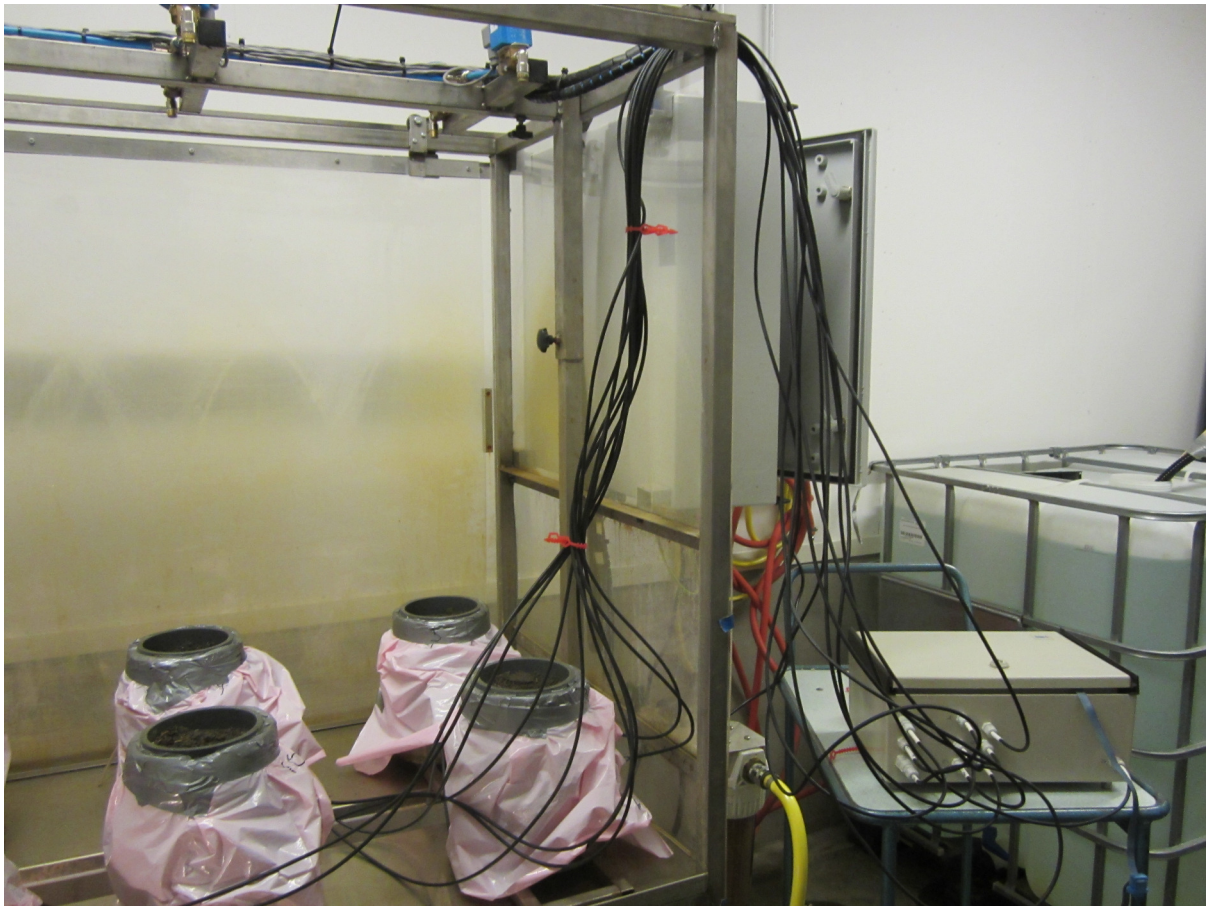
II. irrigation with 20 mm (rate 5 mm/h for 4 hours)

4-10 samples for bromide analyses per column

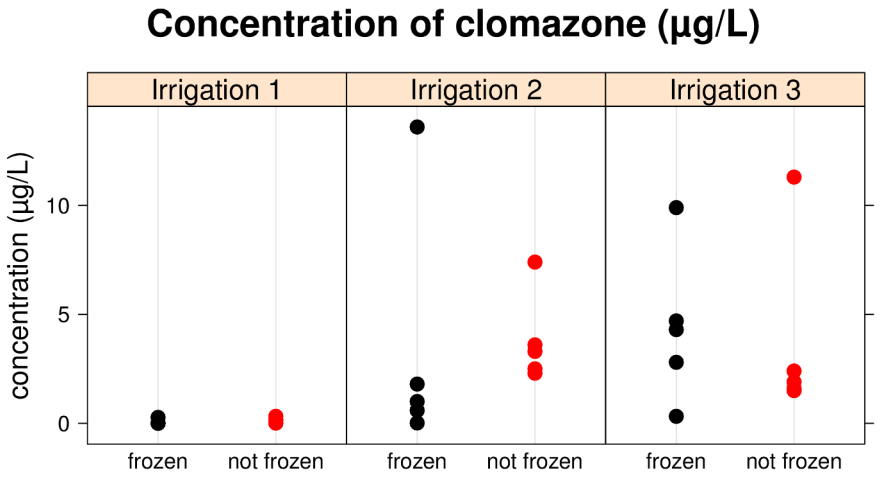
1 grab sample for pesticide analyses per column

3 repetitions of the freezing – irrigation cycle

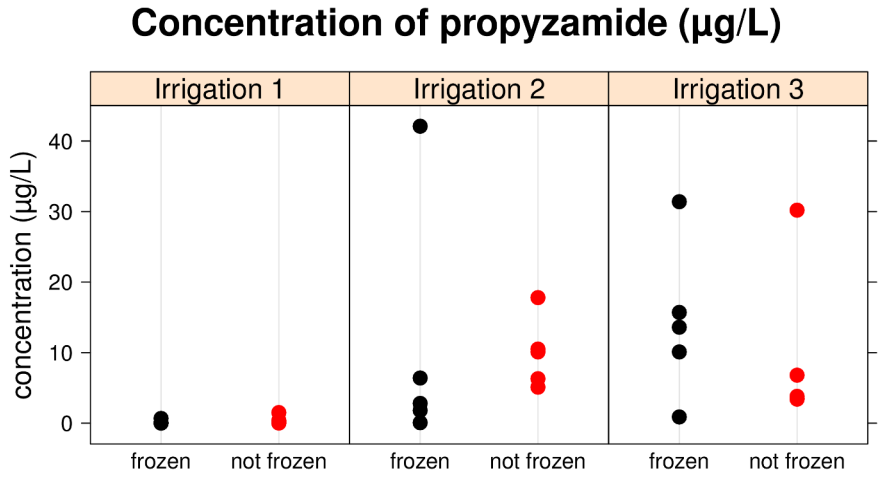
Irrigation

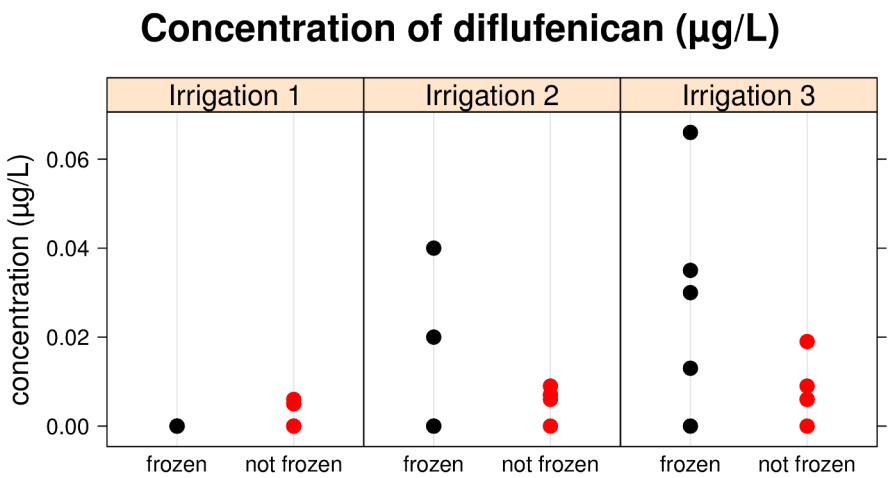


Pesticide Concentrations

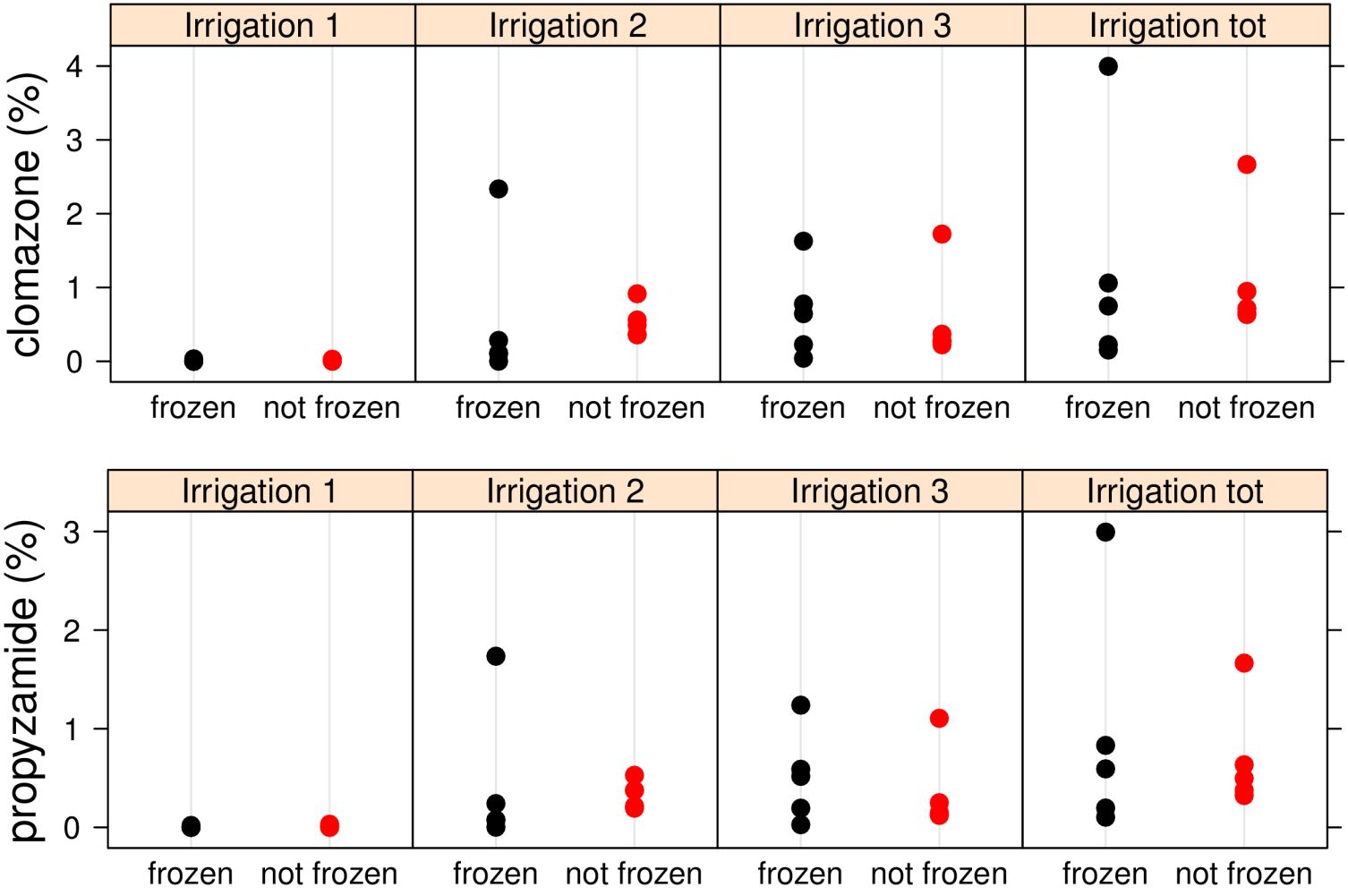


frozen
not frozen

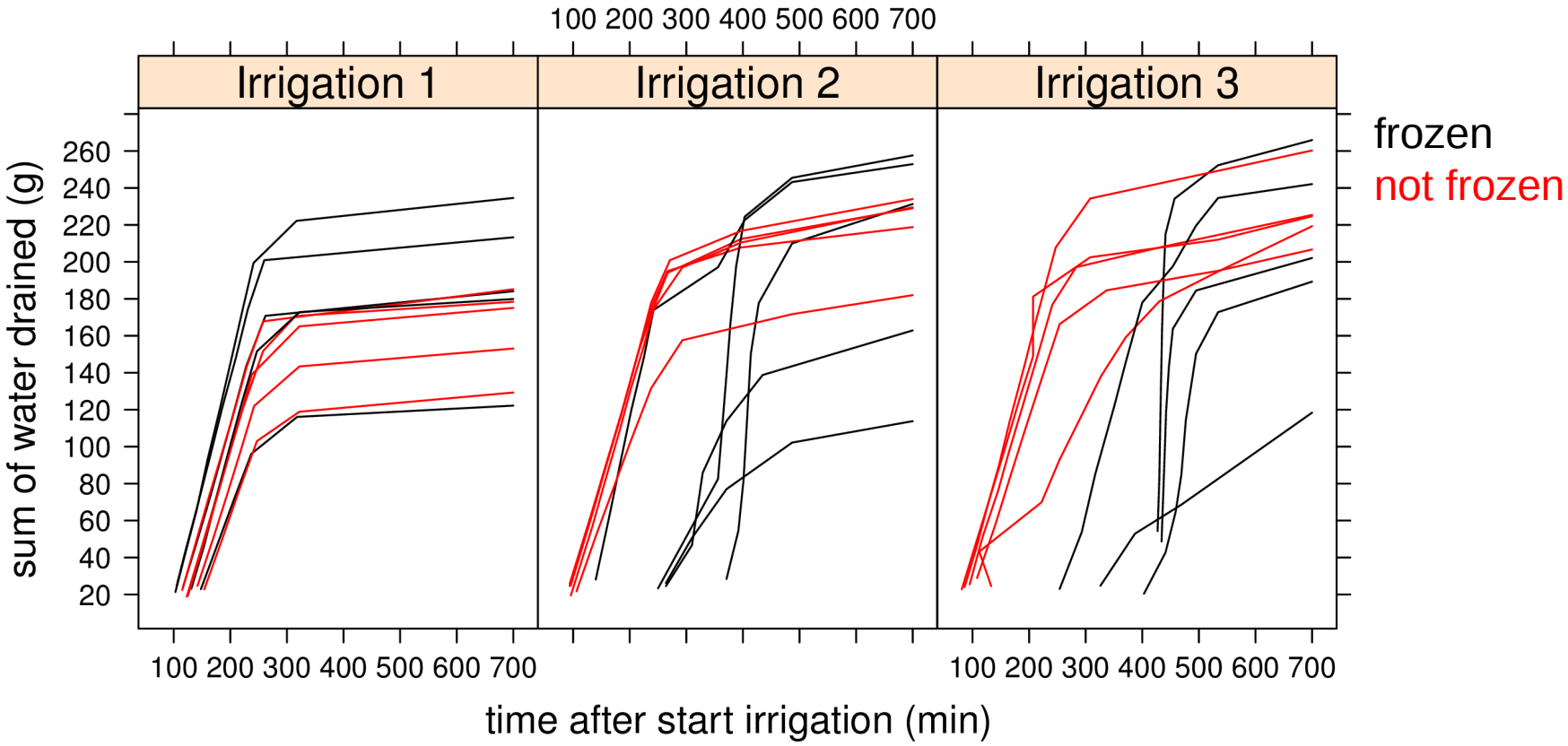




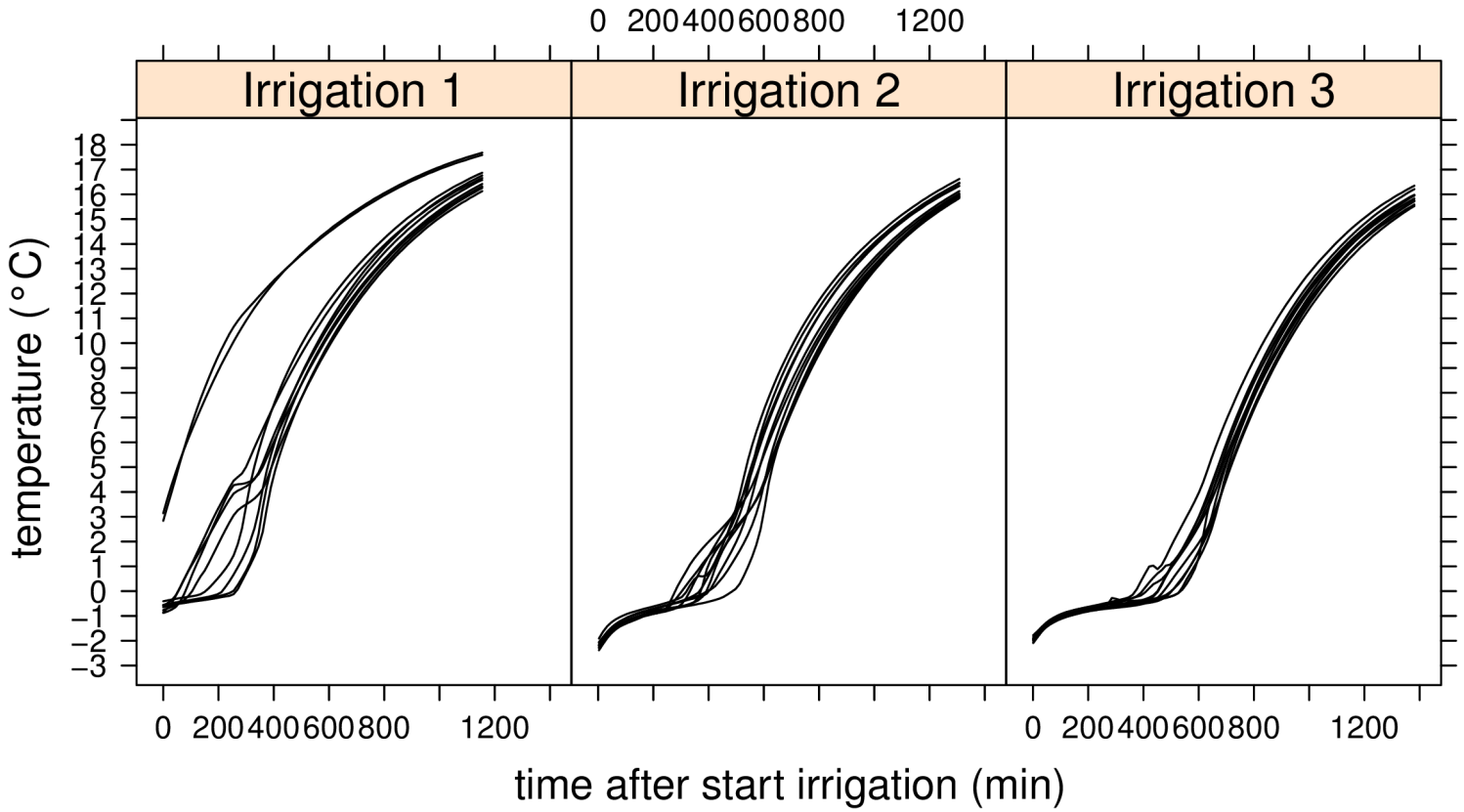
Pesticide leached in % of applied amount



Water flow


Irrigation 1
Irrigation 2
Irrigation 3
sum of water drained (g)
time after start irrigation (min)
frozen
not frozen

Temperature of frozen columns



Summary

- No significant difference in the amounts of pesticides leached
- Differences in water flow
- Fast thawing during irrigation events

MACROPORE FLOW AND SOLUTE TRANSPORT THROUGH PARTIALLY FROZEN SOIL – COLUMN EXPERIMENT

- Roger Holten, PhD student
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  Supervisors: O. M. Eklo (NIBIO/NMBU), M. Stenrød (NIBIO), N. Jarvis (SLU), M. Larsbo (SLU), J. Kværner (NIBIO)

- Frederik Norheim Bøe, M.Sc. student
  Norwegian University of Life Sciences (NMBU, Ås)

  Supervisors: O. M. Eklo (NIBIO/NMBU), Hans Christian Teien (NMBU)

OBJECTIVES

Include a new algorithm for freezing and thawing in the model MACRO (SLU) to make the model a better tool for describing fast transport of pesticides to groundwater by preferential flow in macropores in frozen soil.

- Experiments where pesticides are applied to undisturbed soil coloumns which undergo cycles of freezing and thawing and analysis of leachate and soil structure, will hopefully give information about how freezing and thawing influence pesticide transport in the soil.

- The new data together with existing data from field and laboratory studies under Norwegian/Swedish soil and climate conditions will be used to parameterise, calibrate and validate an improved MACRO model.

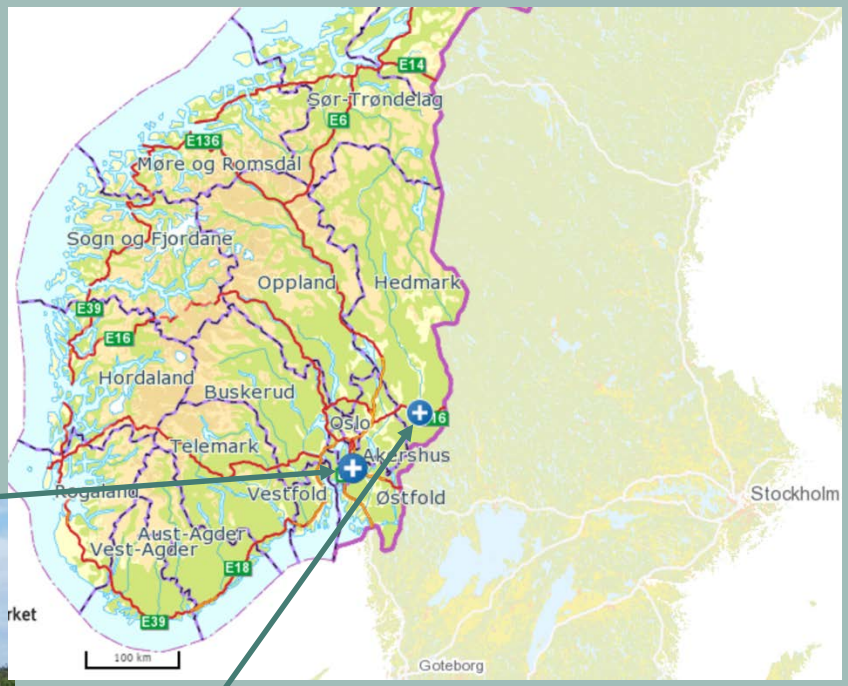
KEY PARAMETERS IN MACRO

- Chosen either because difficult to measure directly or because considered sensitive on basis of earlier experience.

  - Ksat_mic, micropore hydraulic conductivity
  - Kinematic exponent, describing flow rate of water in macropores
  - dtop, diffusion pathlength of the topsoil
  - dsub, diffusion pathlength of the subsoil
  - Koc, soil organic carbon partition coefficient
  - Degradation rate coefficients of pesticides

SAMPLING SITES AND DATE

- Fields with winter cereals
- Two soil types sampled 13th and 25th May 2016



Kroer, Ås

Hov, Kongsvinger

SOIL CHARACERISTICS

Site	Soil texture (USDA) (0-20 cm)	Classification USDA	Horizon cm	Clay %	Silt %	Sand %	pH	Org. C %
Kroer	Loam	Stagnic Podzoluvisol (Marine deposit)	Ap, 0-23	19.1	43.8	37.1	5.5	2.5
			Eg, 23-40	20.5	63.0	16.7	5.6	0.4
Hov	Sandy loam	Fluvic Cambisol (River deposits)	Ap, 0-20	5.4	83.8	10.8	5.4	1.17
			Bw, 28-50	4.1	86.7	9.2	6.2	0.29

COLUMNS

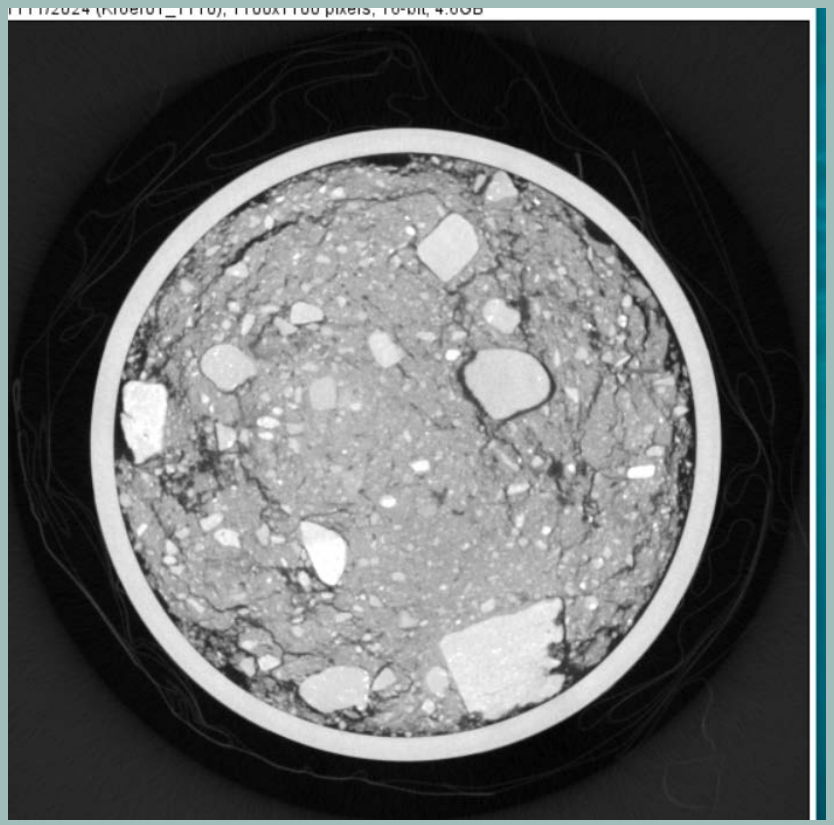
– Columns in aluminium, diameter: 10 cm, heigth: 20 cm

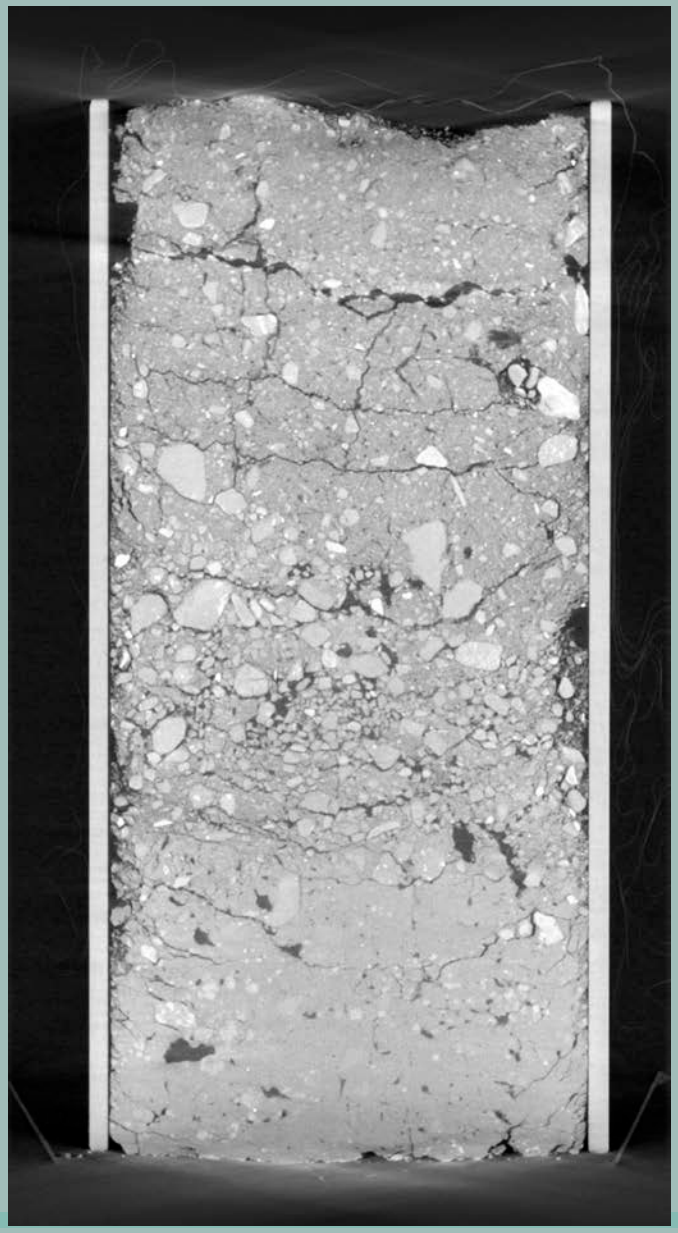
SAMPLING

– Two depths, 0-20 cm and 20-40 cm. 10 columns from each depth.

– «Undisturbed» columns

– Investigate soil structure by X-ray tomography and image analysis





SAMPLE PREPARATIONS

- All columns put on sand box for approx. one week to near saturation. Then drained and equilibrated at a pressure potential of - 30 cm for one week.
- 10 columns insulated with polyethylene foam camping mats. 4 cm.
- Temperature sensors inserted at 7 and 14 cm.

APPLICATION OF CHEMICALS AND FREEZING

– Pesticides and bromide applied and 5 columns from each depth put in freezer at -2 °C for 9 days. Then temperature reduced to – 3 °C to speed up freezing process. Temperature logged every 10 minutes. Rest of columns stored at 4°C.

	Normalised DT50lab, days	DT50field, days	Koc, mL/g (mean)	Application rate, g/ha
Clomazone	68	15-90	286.5	45
Diflufenican	128	103-282	3417	120
Boscalid	232	27 - 208	771	267
Propiconazole	106	20-411	949	125
MCPA	7-41 (24)*		74	1800
* PPDB				

IRRIGATION AND SAMPLING

- Irrigation and sampling of leachate.
- Drip irrigation on filter paper with 25 mm rainwater for 5 hours (approx. 200 ml per column).

- Test experiment: 4 columns of which 2 where frozen
- Each ~25 ml sampled, of which 4 ml for Br-analysis. Rest frozen for pesticide analysis. 5 sampling points during 6 hours, in total approx. 125 ml leachate per column.
- Plan is to run the Kroer soil first and then the Hov soil later this autumn.

Thank you for your attention

BIONÆR project: Innovative approaches and technologies for Integrated Pest Management (IPM) to increase sustainable food production (Smartcrop) (NFR projectnr.: 244526/E50)