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GIS-based leaching risk assessment for the Northern zone

Lessons learned from the "Northern zone" project and ways forward

Workshop on pesticide fate in soil and water in the Northern zone, 7-8 September 2016 , Uppsala, SE

Stefan Reichenberger

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Background – Regulatory risk assessment in NZ

- Regulatory pesticide risk assessments for groundwater in the Northern zone currently rely on the use of two FOCUS and a series of national scenarios.

BUT…

- Neither the representativeness nor the protectiveness of these scenarios are known for the individual countries
  - Quantification needed to facilitate harmonising the regulatory requirements for GW risk assessments in the Northern zone in accordance with 1107/2009 EC

- EFSA (2013) opinion on FOCUS groundwater (FOCUS, 2009):
  - FOCUS scenarios are limited to demonstrating at least one safe use in a significant area in the EU.
  - However, at the national level the purpose of the assessment is to evaluate whether the (national) protection goal is met.
  - Hence, the FOCUS scenarios may not address all the needs of groundwater assessments at the national level
  - For national assessments, all crops and the entire potential use area must be considered

The „Northern zone“ project

The „Northern zone“ project - Overview

- Full title “How representative are the Northern groundwater scenarios of the actual conditions in the Northern zone?”
- Commissioned by the Nordic Council of Ministers and the Danish Environmental Protection Agency
- Aim: investigate both representativeness and protectiveness of the national and FOCUS leaching scenarios for the Northern zone.
- Conducted by Footways (largely posthumously) and supervised by Anne Louise Gimsing from the Danish EPA
- Results were presented at a workshop in April 2015 in Copenhagen and at SETAC Europe 2015 in Barcelona.
- Final report (Burns et al., 2015) is available online.

Representativeness vs. protectiveness

- **Representativeness** of a scenario refers to the agricultural area which has similar soil and climate conditions as the scenario.

- **Protectiveness** (or worst-case-ness) of a scenario, in turn, refers to the agricultural area which has similar or better-case soil/climate conditions.

- FOCUS (2009) uses “representativeness” more in the sense of “protectiveness”
  - “EU FOCUS scenarios are only aimed to be representative of an overall 90th percentile.”
  - “A scenario ‘covers’ an area when it represents either the same properties or represents a more vulnerable situation like higher rainfall amounts or lower organic carbon contents.”

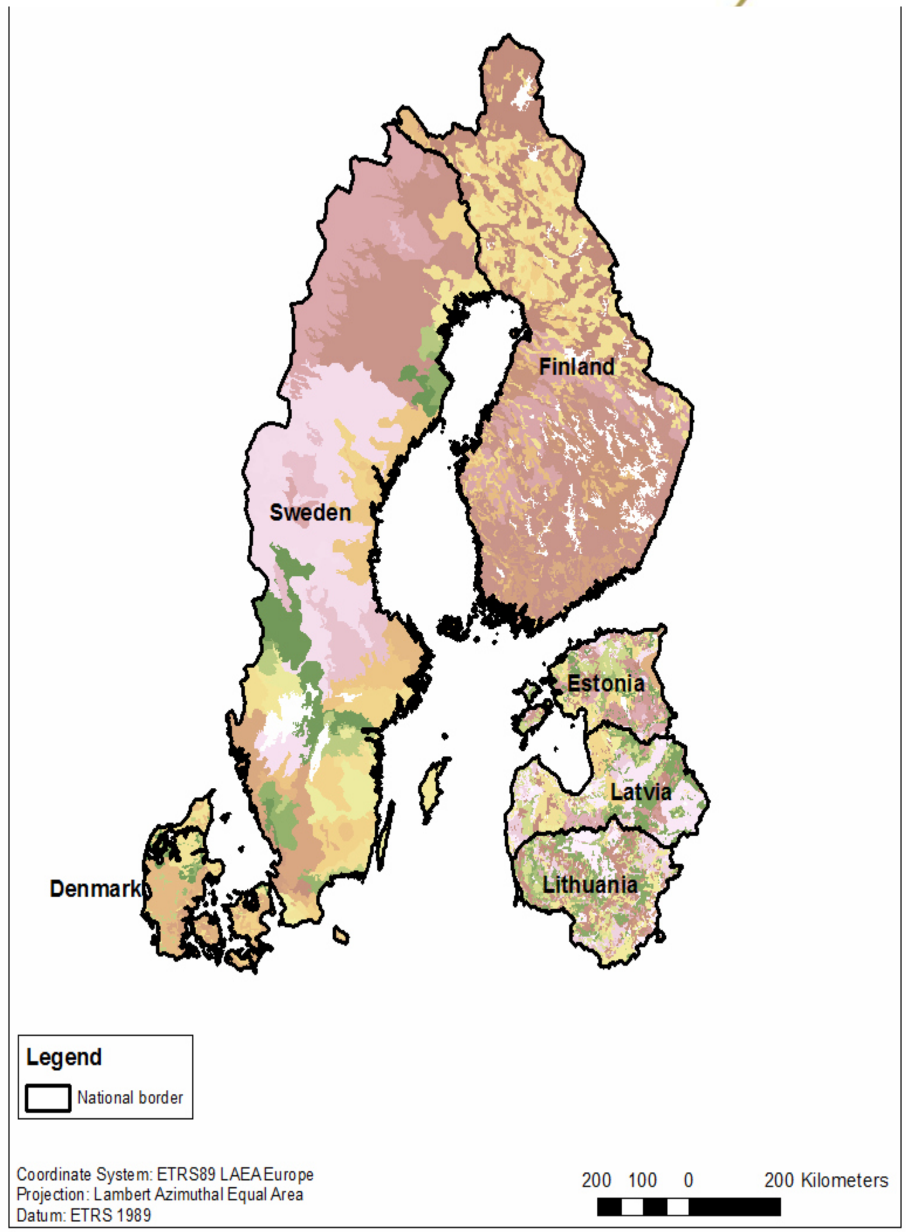
Representativeness analysis for soil

Materials and methods

Soil dataset used in study

1:1000000 Soil Geographical Database of Europe (SGDBE) (Le Bas et al., 1998):

- 1 polygon = 1 Soil Mapping Unit (SMU)
- 1 SMU consists of one or more Soil Typological Units (STU)
- STUs are not localized, but the area fraction of a given SMU covered by a given STU is known
- In the EU project FOOTPRINT (Dubus et al., 2009) all STUs of the SGDBE were classified into FOOTPRINT Soil Types (FSTs) by John Hollis using the classification flowchart he developed

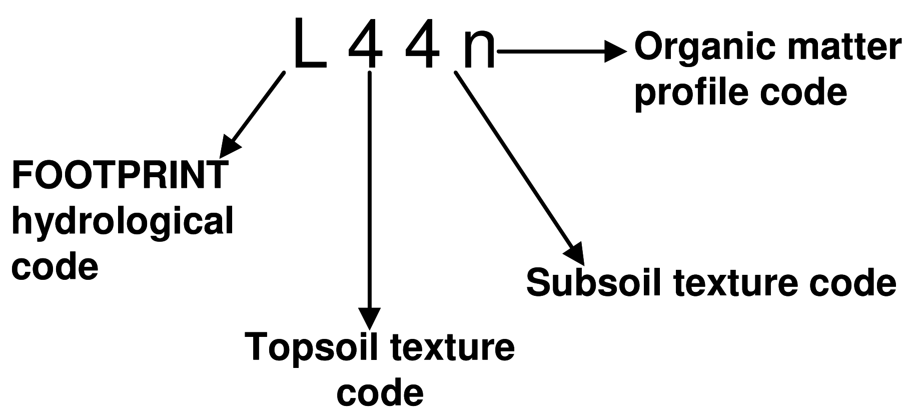


FOOTPRINT Soil Types – quick explanation

The FST typology is a functional classification that groups soils according to their hydrological, textural and sorption potential characteristics.

The FST name is a code consisting of

- a capital letter (L-Z): FOOTPRINT Hydrologic Group FHG
- a number (1-6): topsoil texture code
- a number (0-6): subsoil texture code
- one or more lowercase letters: organic matter profile code



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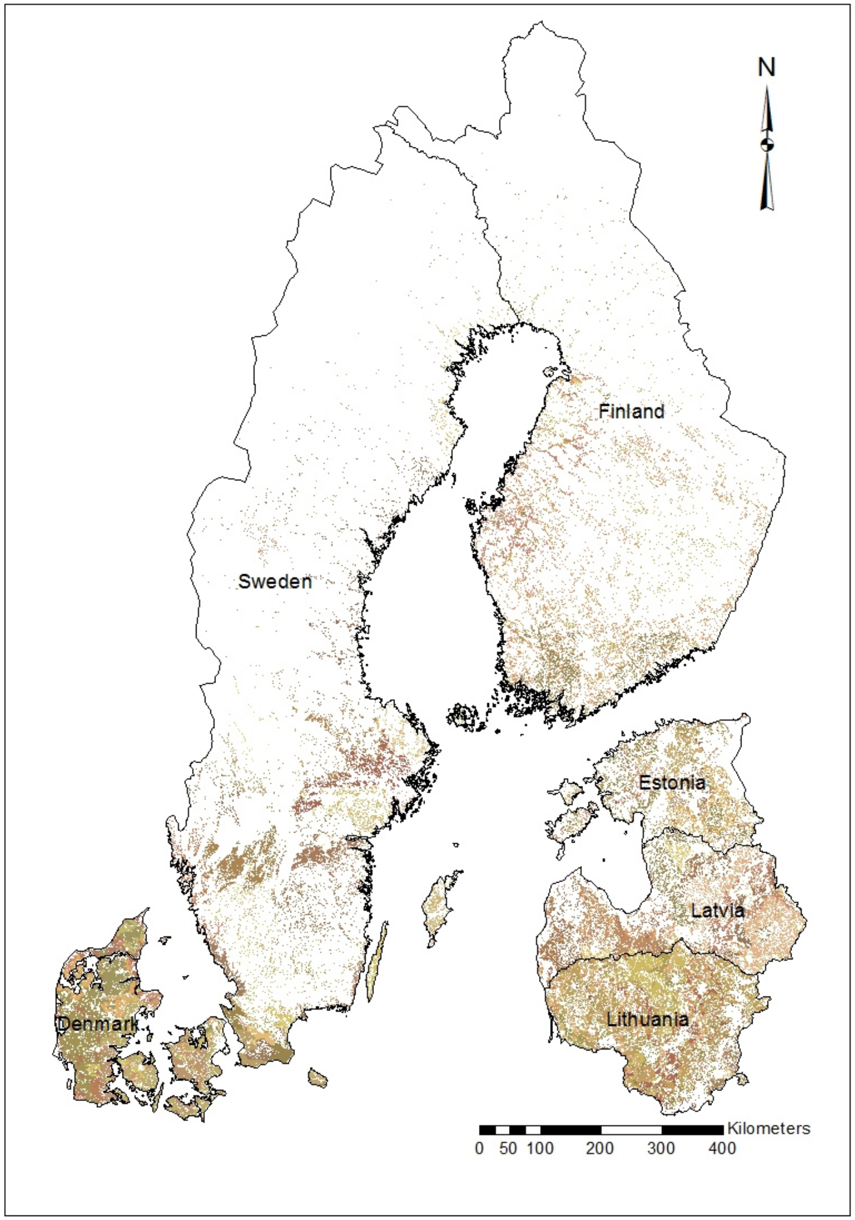
Step 1:
Calculate the spatial distribution of FOOTPRINT Soil Types (FST) for the agricultural area

- GIS intersection:
  - SGDBE soil map + CLC 2006 class 2
  - Calculate the areas for the intersected polygons
  - Relate Soil Mapping Units (SMUs) to modelled FSTs

- Area fractions:
  - FST area in a given SMU = area of SMU x area fraction covered by FST
  - summation of FST areas by country and whole zone

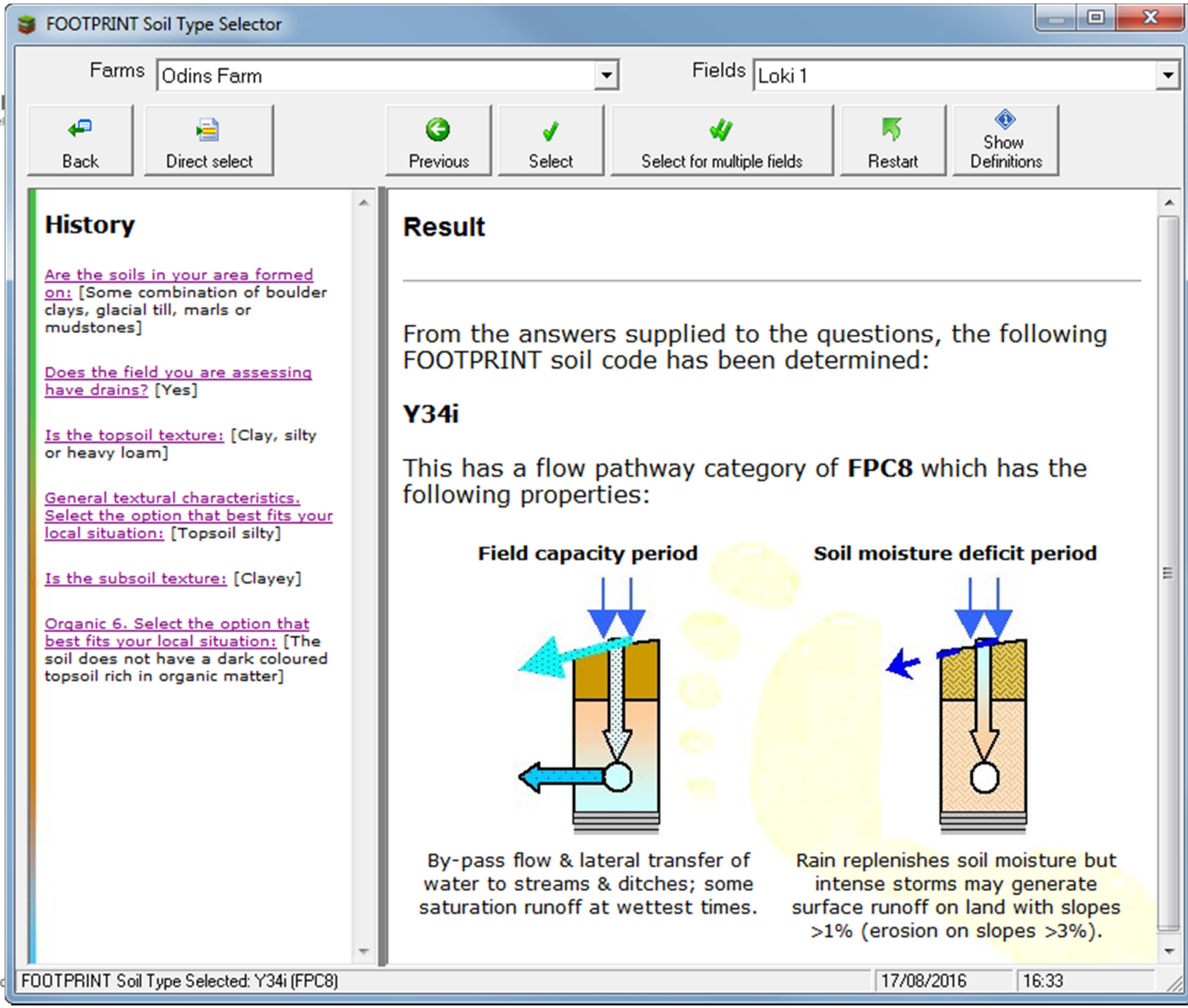


Relate soils of FOCUS / national scenarios and FSTs

- Classify soil profiles in FOCUS / national scenarios into FSTs (using the FOOTPRINT Soil Type Selector)

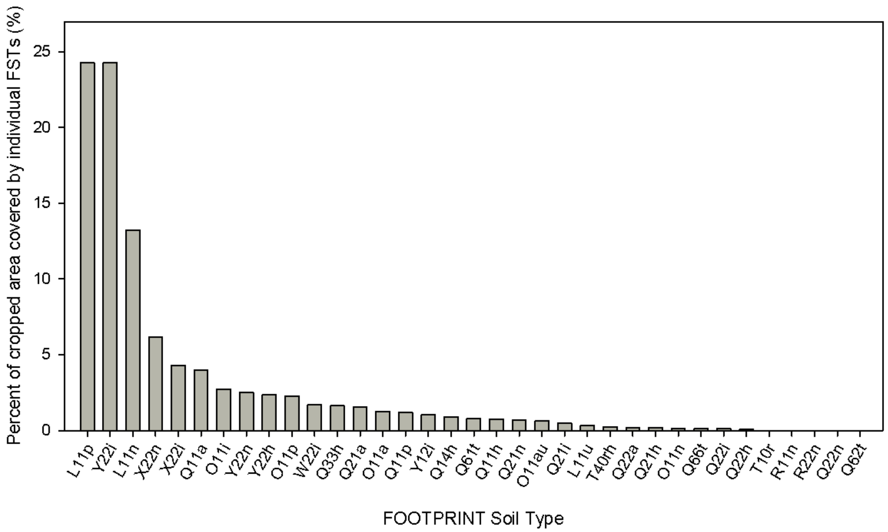
- Relate the translated FSTs for national modelling scenarios to calculated FST areas for each country and whole zone

- FST level may be too specific to attain significant spatial representativeness of the FOCUS/national soil scenarios
  → a series of relaxation rules for the matching was defined:
  1) Same FOOTPRINT Hydrological Group (FHG)
  2) Same surface and subsoil texture class (SST)
  3) Same FHG and SST

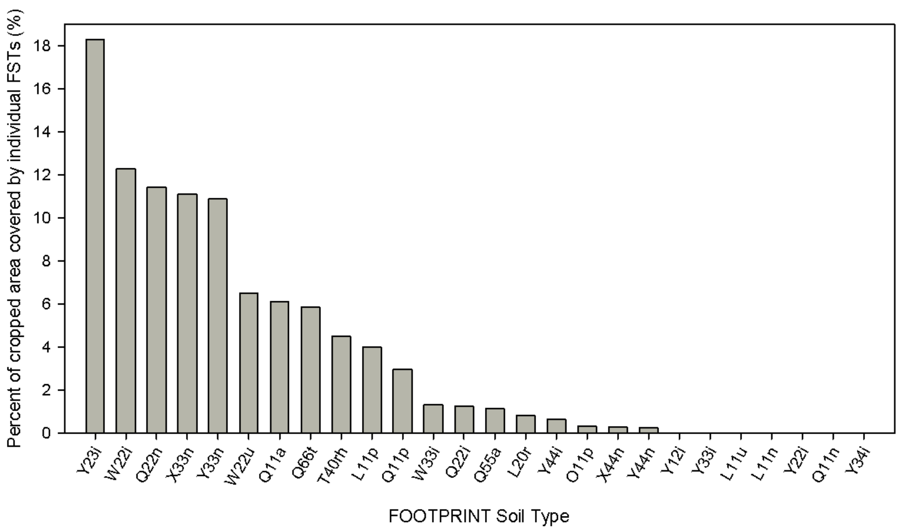

FOOTPRINT Soil Type Selector
Farms
Odins Farm
Fields
Loki 1
Back
Direct select
Previous
Select
Select for multiple fields
Restart
Show Definitions
History
Are the soils in your area formed on: [Some combination of boulder clays, glacial till, marls or mudstones]
Does the field you are assessing have drains? [Yes]
Is the topsoil texture: [Clay, silty or heavy loam]
General textural characteristics. Select the option that best fits your local situation: [Topsoil silty]
Is the subsoil texture: [Clayey]
Organic 6. Select the option that best fits your local situation: [The soil does not have a dark coloured topsoil rich in organic matter]
Result
From the answers supplied to the questions, the following FOOTPRINT soil code has been determined:
Y34i
This has a flow pathway category of FPC8 which has the following properties:
Field capacity period
Soil moisture deficit period
By-pass flow & lateral transfer of water to streams & ditches; some saturation runoff at wettest times.
Rain replenishes soil moisture but intense storms may generate surface runoff on land with slopes >1% (erosion on slopes >3%).
FOOTPRINT Soil Type Selected: Y34i (FPC8)
17/08/2016
16:33

Example results: Spatial distribution of FSTs for DK and EE

Denmark



Estonia



Representativeness of FOCUS and national scenarios (same FST)

FOCUS/National scenario			Representativeness of soil scenario (% of agricultural area)				
Country	Location	FST	DK	EE	FI	LV	SE
Norway	Rustad	Y34ih	0.0	0.0	0.0	0.65	0.0
Norway	Heia	Y22n	2.5	0.0	10.9	0.0	0.0
Denmark	Karup	L11n	13.2	0.0	0.01	0.70	14.8
Denmark	Langvad	Y22n	2.5	0.0	10.9	0.0	0.0
Sweden	Krusenberg	Y14i	0.0	0.0	0.0	0.0	0.0
Sweden	Önnestad	L11n	13.2	0.0	0.01	0.70	14.8
Sweden	Näsbygard	Y22n	2.5	0.0	10.9	0.0	0.0
FOCUS GW	Jokioinen	O11p	2.3	0.3	0.0	1.25	0.0
FOCUS GW	Hamburg	O11n	0.1	0.0	0.0	0.13	0.0

Representativeness of FOCUS and national scenarios (same FHG and SST)

FOCUS/National scenario			Representativeness of soil scenario (% of agricultural area)				
Country	Location	FST	DK	EE	FI	LV	SE
Norway	Rustad	Y34ih	0.0	0.0	0.0	5.7	0.0
Norway	Heia	Y22n	29.1	0.0	10.9	3.9	0.0
Denmark	Karup	L11n	37.9	4.0	0.01	7.7	14.8
Denmark	Langvad	Y22n	29.1	0.0	10.9	3.9	0.0
Sweden	Krusenberg	Y14i	0.0	0.0	0.0	0.0	0.0
Sweden	Önnestad	L11n	37.9	4.0	0.01	7.7	14.8
Sweden	Näsbygard	Y22n	29.1	0.0	10.9	3.9	0.0
FOCUS GW	Jokioinen	O11p	7.0	0.33	0.0	1.4	0.0
FOCUS GW	Hamburg	O11n	7.0	0.33	0.0	1.4	0.0

Summary of key results – Representativeness for soil

- Overall, representativeness was low for the matching rule “full FST code”.

- With a relaxation of the matching rules (“same FHG and SST”), representativeness of the FOCUS/national soil scenarios increased in general, but not always.

- There are doubts regarding the quality of the SGDBE for Sweden.

Representativeness analysis for climate

→ not enough time to present it here;
cf. supplementary slides section

Conclusions – Representativeness

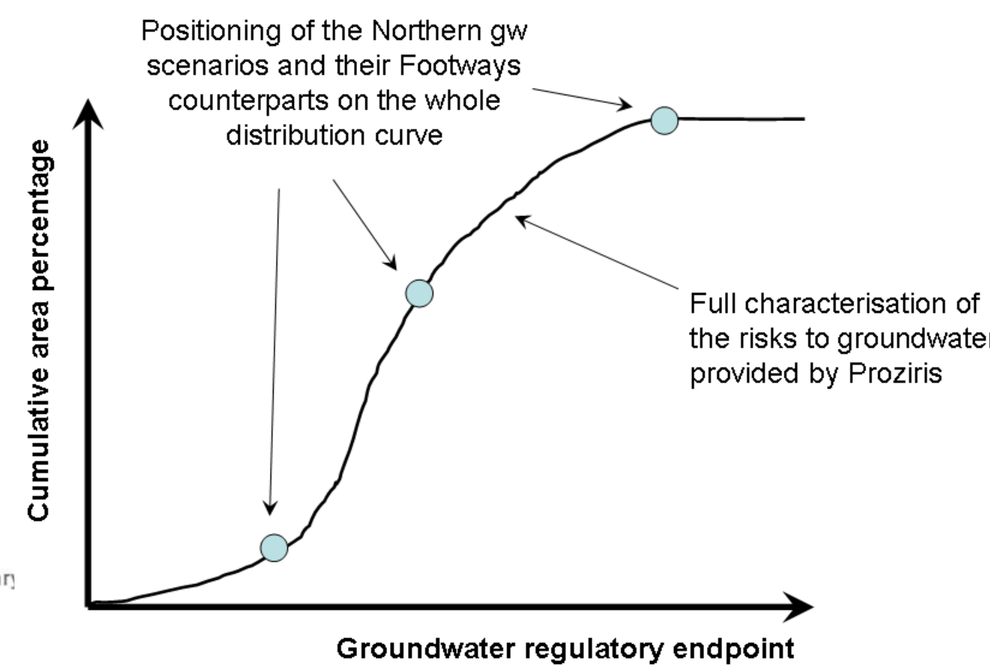
- The national / FOCUS soil and climate scenarios were found to be variably, but overall poorly, representative of the soil and climate conditions of the Northern zone.
  - Representativeness was worse for the climate scenarios than for the soil scenarios.
  - Representativeness for soil may have been underestimated due to low resolution / quality of the SGDBE for Sweden.
  - The lack of representativeness for climate may be largely due to the age of the FOCUS/national weather time series, which do not reflect recent changes in weather patterns as a consequence of climate change.
    - oldest weather series: Krusenberg (1961-1980)
    - most recent weather series: Ås (1981-2000)

- Due to the rapidly changing climate it is becoming increasingly difficult to do predictive modelling with historical weather data.

Protectiveness analysis

General idea

- Protectiveness of a scenario can be quantified as a specific point on a spatial cumulative distribution function (CDF) of worst-case-ness of a country or zone.
- Approach: Compare the modelling results of the FOCUS/national scenarios with spatial CDFs produced by the GIS-based, spatially distributed modelling platform Proziris, for
  - different compounds
  - different leaching endpoints
  - different substance parameterisations



Materials and Methods

1) Select 11 pesticides (and their relevant metabolites) with at least some leaching potential

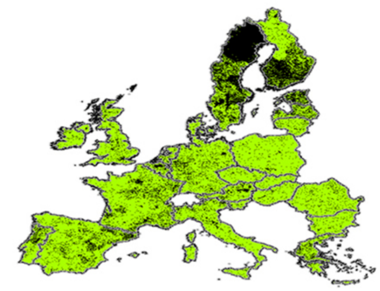
2) Modelling
   a) National (MACRO) and FOCUS (Pearl/Pelmo) scenarios
   b) Proziris: spatially distributed MACRO modelling

3) Calculation of risk indicators and generation of CDFs

4) Quantification of the protectiveness (in % of the agricultural area) of each FOCUS and national scenario by relating their results to the Proziris CDFs

Note: The potential problems with the quality of the underlying spatial data (Proziris climates, SGDBE) are less critical because we used only the CDF output, not the map output

Proziris, a spatially distributed modelling platform (R.I.P.)



- Developed by Footways to address the shortcomings of FOCUS and offer a higher-tier approach:
  - run GIS-based risk assessments at the national, zonal or EU scale
  - accounting for all occurring agro-environmental conditions
- Web platform facilitating spatially distributed modelling
- Agro-environmental scenarios established from readily available EU data (SGDBE, CAPRI)
- Web interface connected to a cluster (800 cores) dedicated to pesticide fate modelling (MACRO and PRZM)

Quantification of protectiveness

- Plot indicator results of FOCUS / national scenarios over the Proziris spatial CDFs
- Extract cumulative area percentage from Proziris CDF
  - All risk indicators
  - All active substances and metabolites
- Three plotting options:
  1) FOCUS/national results for standard parameterisation over Proziris CDFs for standard parameterisation ("standard/standard")
  2) FOCUS/national results for Danish parameterisation over Proziris CDFs for Danish parameterisation ("Danish/Danish")
  3) FOCUS/national results for Danish parameterisation over Proziris CDFs for standard parameterisation ("Danish/standard")

Step 1: Scenario results
80th percentile PECgw (standard)

	80th percentile annual PECgw (µg/L)														
simulated compound	Oennestad MACRO 160cm	Hamburg Pearl 100cm	Hamburg Pearl 200cm	Hamburg Pelmo 100cm	Hamburg Pelmo 200cm	Heia MACRO 220cm	Jokioinen Pearl 100cm	Jokioinen Pearl 150cm	Jokioinen Pelmo 100cm	Jokioinen Pelmo 150cm	Karup MACRO 250cm	Krusenberg MACRO 130cm	Langvad MACRO 250cm	Näsbygard MACRO 150cm	Rustad MACRO 220cm
124_triazole	7.350			0.470	0.470	3.820			0.230	0.230	2.400	13.700	1.700	3.100	4.420
bentazone	118.380			34.630	37.290	67.370			32.760	32.710	73.230	158.860	41.410	48.810	70.760
clopyralid	8.600			3.960	4.020	4.790			3.760	3.890	6.500	10.590	3.110	3.950	5.340
desami_diket_MBZ	2.500			0.330	0.230	1.530			0.280	0.270	0.880	2.120	0.940	0.720	2.080
desmethyl_sulfosu	0.170			0.040	0.040	0.100			0.030	0.030	0.080	0.370	0.030	0.090	0.100
diketo_MBZ	0.110	0.005	0.006	0.003	0.004	0.060	0.001	0.001	0.002	0.002	0.010	0.070	0.250	0.070	0.070
ethofumesate	15.090	2.160	2.160	1.570	1.550	6.510	0.740	0.780	0.540	0.570	3.820	16.550	1.440	4.510	9.070
Gwdummy_A	83.090	12.390	12.510	13.260	13.030	40.690	4.490	4.720	5.570	5.750	24.910	121.880	22.200	37.050	50.400
Gwdummy_B	214.160	42.630	43.430	54.190	55.560	113.060	28.700	32.340	38.550	34.720	116.230	165.930	47.050	70.220	122.960
Gwdummy_C	0.750	0.002	0.002	0.004	0.004	1.690	0.000	0.000	0.000	0.000	0.004	0.440	0.600	4.430	0.180
Gwdummy_D	40.700	2.470	2.560	3.170	3.430	18.990	0.560	0.710	0.840	1.290	6.750	27.290	12.300	17.270	22.190
Met_C	160.180	56.250	54.200	38.960	38.800	93.450	46.650	43.020	32.800	32.250	87.470	476.500	86.050	127.820	97.000
metribuzin	0.240	0.010	0.010	0.005	0.007	0.200	0.002	0.002	0.003	0.003	0.020	0.170	0.960	0.180	0.160
pirimicarb	1.020			0.010	0.010	0.210			0.000	0.000	0.000	0.230	0.000	0.180	0.000
R31805	0.000			0.000	0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000	0.000
R34865	0.000			0.000	0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000	0.000
sulfosulfuron	2.080			0.550	0.540	1.150			0.490	0.490	1.150	3.220	0.730	0.940	1.250
tebuconazole	0.000			0.000	0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000	0.000
mean	36.357			8.397	8.610	19.646			6.436	6.234	17.970	55.440	12.154	17.741	21.443
max	214.160			54.190	55.560	113.060			38.550	34.720	116.230	476.500	86.050	127.820	122.960
min	0.000			0.000	0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000	0.000
stdev	64.476			16.430	16.889	35.322			13.142	12.524	35.514	118.987	23.434	34.062	37.906
median	2.290			0.400	0.350	1.610			0.255	0.250	1.015	2.670	0.950	2.020	1.665

Step 2: Proziris CDFs
2nd highest annual PECgw (standard)

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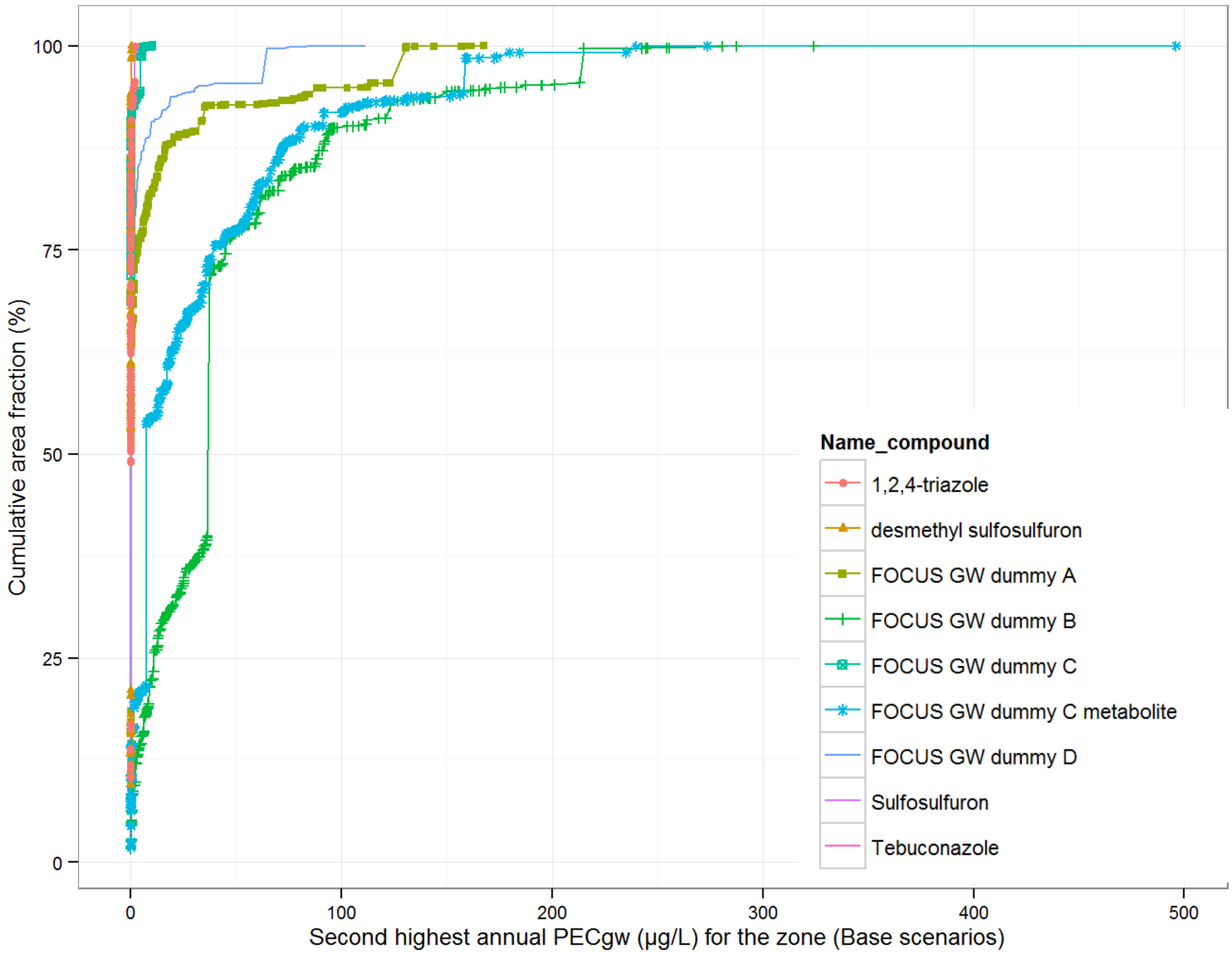

Step 3: Cumulative area percentages
80th percentile annual PECgw (standard/standard)

simulated compound	Oennestad MACRO 160cm	Hamburg Pearl 100cm	Hamburg Pearl 200cm	Hamburg Pelmo 100cm	Hamburg Pelmo 200cm	Heia MACRO 220cm	Jokioinen Pearl 100cm	Jokioinen Pearl 150cm	Jokioinen Pelmo 100cm	Jokioinen Pelmo 150cm	Karup MACRO 250cm	Krusenberg MACRO 130cm	Langvad MACRO 250cm	Näsbygard MACRO 150cm	Rustad MACRO 220cm
cumulative area percentage on the corresponding Proziris CDF for the whole zone; variable 80th percentile annual PECgw															
124_triazole	100.00			90.95	90.95	100.00			88.08	88.08	100.00	100.00	95.41	100.00	100.00
bentazone	98.88			75.08	78.11	90.92			72.31	72.28	91.88	99.75	78.63	81.75	91.66
clopyralid	95.91			80.05	80.31	89.74			77.83	79.91	93.48	97.51	73.04	80.05	90.52
desami_diket_MBZ	94.35			83.85	77.70	91.53			79.45	78.92	89.08	94.12	89.60	88.67	94.12
desmethyl_sulfosu	98.47			80.94	80.94	93.12			77.51	77.51	90.26	100.00	77.51	92.55	93.12
diketo_MBZ	94.02	82.35	83.08	77.62	78.24	92.50	69.57	69.57	71.05	72.35	84.73	93.07	99.44	93.07	93.07
ethofumesate	99.98	93.26	93.26	92.97	92.97	99.51	92.54	92.54	91.32	91.32	94.36	99.98	92.84	94.49	99.98
Gwdummy_A	93.97	83.86	83.86	85.02	84.02	92.72	76.44	76.44	77.03	77.37	89.14	95.44	88.86	92.72	92.78
Gwdummy_B	95.48	73.06	73.27	78.10	78.12	90.92	36.37	37.35	72.68	38.44	90.92	94.55	76.36	82.27	91.14
Gwdummy_C	92.66	84.26	84.26	85.16	85.16	92.99	68.65	68.65	68.65	68.65	85.16	90.97	92.32	94.41	90.76
Gwdummy_D	95.40	79.90	81.09	83.39	84.39	93.72	74.24	75.28	76.07	77.85	88.09	94.27	91.02	92.32	93.77
Met_C	98.50	79.18	78.50	73.86	73.86	91.81	77.15	75.67	68.48	68.23	90.13	99.99	90.13	93.35	91.81
metribuzin	93.14	82.43	82.43	77.91	78.08	93.13	71.26	71.26	72.11	72.11	84.70	93.02	99.88	93.02	93.02
pirimicarb	99.91			98.37	98.37	99.85			91.19	91.19	92.78	99.85	92.80	99.85	94.38
R31805	100.00			100.00	100.00	100.00			100.00	100.00	100.00	100.00	100.00	100.00	100.00
R34865	73.29			73.29	73.29	73.29			73.29	73.29	81.55	73.29	81.55	73.29	81.55
sulfosulfuron	98.43			76.15	75.63	90.07			72.23	72.23	90.07	99.99	79.77	85.02	92.14
tebuconazole	99.88			99.88	99.88	99.88			99.88	99.88	99.88	99.88	99.88	99.88	99.88
mean	95.68			84.03	83.89	93.09			79.40	77.76	90.90	95.87	88.84	90.93	93.54
max	100.00			100.00	100.00	100.00			100.00	100.00	100.00	100.00	100.00	100.00	100.00
min	73.29			73.29	73.29	73.29			68.48	38.44	81.55	73.29	73.04	73.29	81.55
stdev	6.18			8.89	8.85	6.21			10.19	13.98	5.33	6.46	8.90	7.67	4.49
median	97.17			82.16	80.62	92.85			76.55	77.44	90.20	98.63	90.58	92.87	93.05

Key results - 80th percentile annual PECgw

- Standard/standard:
  - Mean protectiveness was highest for Krusenberg and Önnestad (96 %) and lowest for Jokioinen/Pelmo (78-79 %)
  - The protectiveness of the MACRO scenarios was ≥ 73 %
  - For Jokioinen/Pearl (both output depths) and Jokioinen/Pelmo (150 cm) an outlier with only 36-38 % was observed for FOCUS GW Dummy B
  - Otherwise, the protectiveness of the FOCUS scenarios (Pelmo and Pearl) was ≥ 68 %

- Danish/standard:
  - Lower sorption and slower degradation lead to higher leaching than the standard parameterisation) → Protectiveness values squeezed into upper end of the CDF → Higher protectiveness than standard/standard
  - However, protectiveness values established with this option are difficult to interpret because they combine soil and climate characteristics with substance parameters (Koc, DT50, nf).
  - Mean protectiveness was highest for Karup (98 %) and lowest for Jokioinen / Pelmo / 150 cm (95 %).

Conclusions on protectiveness

- Mean protectiveness of national MACRO scenarios is sufficiently high to justify their use for tier 2 regulatory leaching risk assessments for the Northern zone
- However, the protectiveness of a given scenario / model / output depth combination varied between the 18 substances. This variability implies:
  - The uncertainty of the protectiveness of a scenario-based approach will increase with decreasing number of scenarios.
  - One should thus never rely on a single scenario in regulatory modelling.
  - Instead, at the zonal level all seven national (DK, SE and NO) scenarios should be simulated.

- The protectiveness of the FOCUS scenarios H and J was on average only slightly lower than the one of the national MACRO scenarios, but more variable, with occasional negative outliers. → Uncertainty of decisions based on H and J would be higher than uncertainty of decisions based on the national MACRO scenarios.

- In higher-tier assessments the exceedance area percentage of the 0.1 µg/L limit has to be exactly known. → For higher tier-simulations, a GIS-based, fully spatially probabilistic approach like Proziris should be used.

Overall conclusions of the Northern zone project

Overall conclusions of the Northern Zone project (1)

- Limitations regarding the availability / quality of spatial input data for modelling have been identified for the Northern zone.
- The national / FOCUS soil and climate scenarios were found to be variably, but overall poorly, representative of the soil and climate conditions of the Northern zone.
- However, the national / FOCUS leaching scenarios were found to be quite protective for the various Northern zone countries.
- Mean protectiveness of national MACRO scenarios is sufficiently high to justify their use for tier 2 regulatory leaching risk assessments for the Northern zone
- At the zonal level all seven national (DK, SE and NO) scenarios should be simulated.

Overall conclusions of the Northern Zone project (2)

- Due to the rapidly changing climate it is becoming increasingly difficult to do predictive modelling with historical weather data. Regulatory modelling should use both
  - the most recent historical weather data (e.g. the last 30 years)
  - time series resulting from climate projections.
- The advantages of a GIS-based, fully spatially probabilistic approach such as Proziris over an approach based on only a few soil/climate scenarios have been demonstrated:
  - Improved characterisation of protectiveness
  - Provides a solution to limitations outlined in the EFSA (2013) opinion on FOCUSgw
  - Provides possibility of harmonisation within and between registration zones in Europe
  - Some limitations of Proziris have been identified, but they are not system-inherent.
  - Unfortunately, Proziris does not exist any more.

3. Recent publications

Recent publications

- Steffens et al. (2015). Direct and indirect effects of climate change on herbicide leaching - a regional scale assessment in Sweden. Science of the Total Environment 514 (2015) 239–249
  - Simulation study with MACRO-SE to assess the direct and indirect effects of climate change on herbicide leaching to groundwater
  - It is very important to account for the indirect effects of climate change on the leaching of herbicides alongside the direct effects, as the risks for groundwater contamination can be significantly affected.
  - Estimated direct effects of climate change were small, while changes in cropping patterns and herbicide use were projected to double the area at risk of groundwater contamination.
  - There is a need for ensemble modelling as there are strong interactions between climatic factors and future scenarios on cropping patterns and herbicide use with respect to the predicted leaching risk.

- Moeys et al. (2015). Testing a regional scale pesticide fate model against monitoring data: necessity or endless quest?
  - Comparison of GIS-based leaching simulations (MACRO-SE) with GW monitoring data
  - General considerations on the evaluation of regional models

Recent publications (2)

- Stenrød et al (2016). Pesticide regulatory risk assessment, monitoring, and fate studies in the northern zone: recommendations from a Nordic-Baltic workshop.
  - Need to identify the specific environmental conditions in the northern zone and to ascertain how this picture can be harmonized in (regulatory) pesticide fate modeling.
  - Both weather and soil conditions vary markedly between different areas within the northern zone.
  - Agricultural practices in the Nordic and Baltic countries differ markedly
  - Aim: Develop harmonized FOCUS surface runoff and groundwater leaching scenarios adapted to northern zone conditions.

- Brüsch et al. (2016): Monitoring of pesticide leaching from cultivated fields in Denmark
  - Brief overview of the Danish PLAP monitoring programme (period 1999-2014)
  - Leaching of pesticides is more pronounced in fractured clayey soils than in sandy soils due to fast transport in fractures in the former soils, in contrast to slower matrix transport in the sandy soils

- Northern zone (2016). Guidance document on work-sharing in the Northern zone in the authorization of plant protection products. Version 5, May 2016.
  - At tier 2, the four scenarios Krusenberg, Önnestad, Näsbygard and Rustad shall be used for SE and NO; the Heia scenario was removed

4. Suggestions and recommendations

Suggestions / recommendations (1)

- GIS-based leaching assessments:
  - Requirement: Harmonised soil map for the agricultural areas of the Northern zone based on recent national datasets
  - Harmonisation of soil maps can be done using the FST methodology (cf. MACRO-SE)
  - A harmonised agro-environmental scenario map (soil, climate, land use) for the Northern zone is also desirable (and feasible)

- Account for climate change in regulatory modelling:
  - Weather series of FOCUS and national scenarios (tier 1 and 2) need to be periodically benchmarked against weather data of last 20 or 30 years
  - Ensemble modelling using different climate projections, land use und pesticide use scenarios (cf. Steffens et al., 2015)
  - Climate zonations for GIS-based assessments need to be periodically revised (unless gridded weather data are used)

- A system like Proziris should be set up as an official regulatory tool for higher-tier simulations (tier 3) for the Northern zone.

Suggestions / recommendations (2)

- Full transparency (underlying geodata and weather time series, parameterisation, post-processing etc.) and informatic validation of the system must be guaranteed and agreed at the zonal and EU level.

- As an upgrade of the defunct Proziris platform, such a system should contain
  - A science-based climate zonation (e.g. according to Blenkinsop et al., 2008; cf. also Bach et al., 2014) or a climate grid like MARS 25 * 25
  - Both historical weather data and data resulting from climate projections
  - The latest available national soil maps/databases joined to a single map/database (with STUs translated into FOOTPRINT Soil Types)
  - Reliable crop dates (emergence, harvest etc.) for each climate zone / grid cell
  - A functionality to modify crop dates, climate zones and land use according to climate change projections
  - A functionality to calculate, apart from spatial CDFs, also spatio-temporal CDFs of leaching concentrations and fluxes

- Knoell would be able to help with the development of such a tool

Many thanks for your attention!

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Supplementary slides

Supplementary slides – FOOTPRINT Soil Types

General concept of FSTs

- The system of FOOTPRINT Soil Types (FSTs) has been derived during the EU project FOOTPRINT (2006-2009), mainly by John Hollis (UK).

- Objective: characterize a limited number of soil types suitable for modelling the environmental fate of pesticides in Europe such that they represent
  - all relevant pollutant transfer pathways (surface runoff, erosion, lateral subsurface flow, drainage and leaching) from soil to surface water and groundwater
  - the complete range of soil sorption potential relevant to ‘reactive’ pollutants

- Applicability of the FST system
  - pesticides
  - other contaminants (e.g. nitrate)

- The FST system is described in detail in the FOOTPRINT Final Report (Dubus et al., 2009).

General concept of FSTs (2)

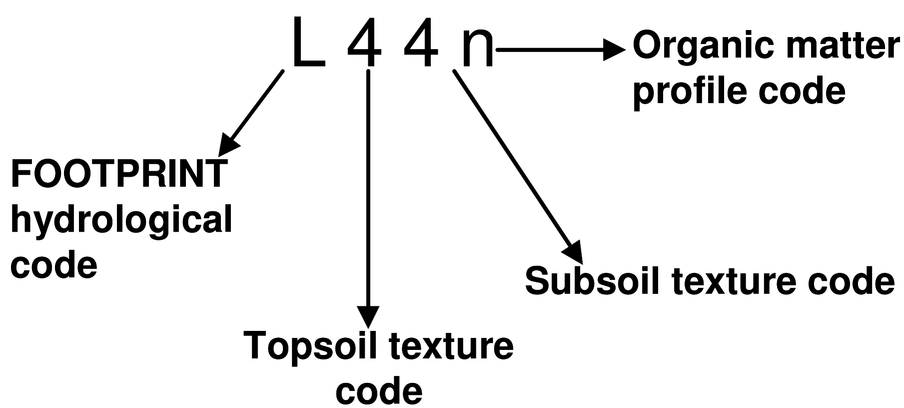
- The FST typology is a functional classification that groups soils according to their hydrological, textural and sorption potential characteristics.
  - The system contains 986 potentially occurring FSTs („FSTmap“)
  - 367 of these occur in the Soil Geographical Database of Europe SGDBE (Le Bas et al., 1998) for the EU24
  - 269 of these have been identified as agriculturally relevant and been parameterised during FOOTPRINT for MACRO and PRZM („FSTmodelled“)
  - If an FST resulting from the classification does not belong to the 269 FSTmodelled, the most similar FSTmodelled is used for the simulation (correspondence table).

- The FST system consists of three parts, which are basically independent of each other:
  - The FST flowchart to classify a given soil typological unit into the FST system (i.e. assign an FST to a given STU)
  - The parameterisation method for MACRO and PRZM
  - The standard profiles for each FST (in FOOTPRINT such profiles were derived by John Hollis from SPADE-1 and SPADE-2)

The FST code

The FST name is a code consisting of

- a capital letter (L-Z): FOOTPRINT Hydrologic Group FHG
- a number (1-6): topsoil texture code
- a number (0-6): subsoil texture code
- one or more lowercase letters: organic matter profile code



The FOOTPRINT Hydrologic Group (FHG)

FOOTPRINT hydrological code	Description	MACRO bottom boundary condition	PRZM Soil Hydrologic Group
L	Permeable, free draining soils on permeable sandy, gravelly, chalk or limestone substrates with deep groundwater (below 2 m depth).	Unit hydraulic gradient	A
M	Permeable, free draining soils on hard but fissured substrates (including karst) with deep groundwater (below 2 m depth).	Unit hydraulic gradient	B
N	Permeable, free draining soils on permeable soft loamy or clayey substrates with deep groundwater (below 2m depth).	Unit hydraulic gradient	B-C
O	Permeable soils on sandy or gravelly substrates with intermediate groundwater (at 1 - 2 m depth)	Zero flow	A
P	Permeable soils on soft loamy or clayey substrates with intermediate groundwater (at 1 - 2 m depth)	Zero flow	B-C
Q	All soils with shallow groundwater (within 1 m depth) and artificial drainage	Zero flow	A
R	Permeable, free draining soils with large storage, over hard impermeable substrates below 1 m depth	Zero flow	B
S	Permeable, free draining soils with moderate storage, over hard impermeable substrates at 0.5 - 1 m depth	Zero flow	B-C
T	Shallow, permeable, free draining soils with small storage, over hard impermeable substrates within 0.5 m depth	Zero flow	C
U	Soils with slight seasonal waterlogging ('perched' water) over soft impermeable clay substrates	Zero flow	B-C
V	Soils with prolonged seasonal waterlogging ('perched' water) over soft impermeable clay substrates	Zero flow	C
W	Free draining soils over slowly permeable substrates	Percolation rate regulated by water table height	B

The FOOTPRINT Hydrologic Group (FHG)

FOOTPRINT hydrological code	Description	MACRO bottom boundary condition	PRZM Soil Hydrologic Group
X	Slowly permeable soils with slight seasonal waterlogging ('perched' water) over slowly permeable substrates	Percolation rate regulated by water table height	B
Y	Slowly permeable soil with prolonged seasonal waterlogging ('perched' water) over slowly permeable substrates	Percolation rate regulated by water table height	B-C
Z	All undrained peat or soils with peaty tops	Not modelled	D

5 fundamental types of site hydrology:

- Soils L, M, N: free draining (better: free percolation)
- Soils O, P, Q: groundwater in the profile
- Soils R, S, T, U, V: impermeable substrate
  - R: deep soil over hard substrate
  - S, T: shallow soil over hard substrate
  - U, V: deep soil over soft substrate
- Soils W, X, Y: slowly permeable substrate
- Soils Z: undrained peat → not modelled

Implications of the FHG for MACRO modelling

- Leaching:
  - L, M, N, W, X, Y soils have leaching flux concentrations
  - O, P, Q soils have resident concentrations
  - R, S, T, U, V soils have neither of them

- Lateral water movement:
  - Q, U, V, Y soils have artificial drains
  - O, P, R, S, T, W, X soils have lateral subsurface flow (écoulement hypodermique)
  - L, M, N soils have neither of them
  - Artificial drains and lateral subsurface flow are technically modelled in the same way in MACRO (albeit with different parameter values). However, the interpretation is / can be different.

Implications of the FHG for PRZM modelling

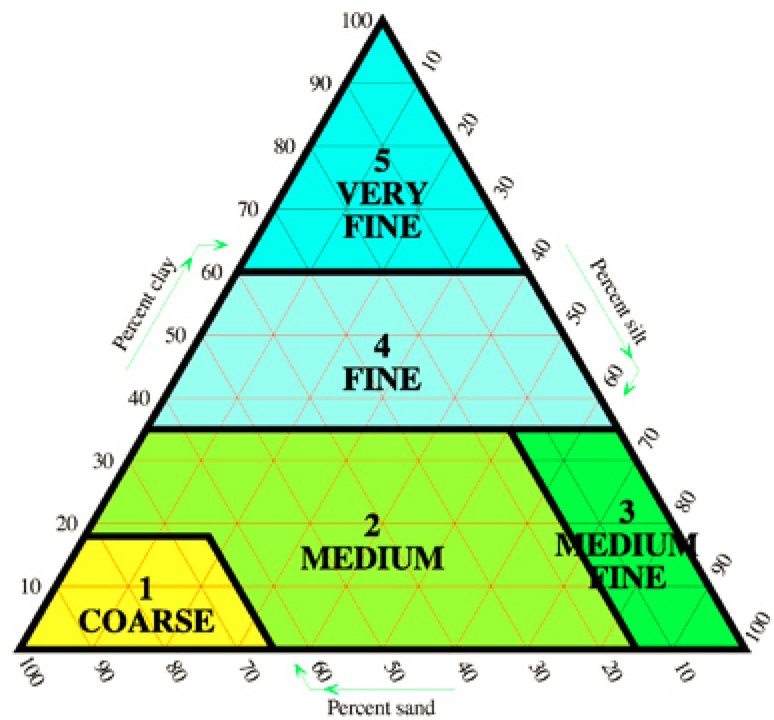
- The FHG determines the PRZM soil hydrologic group und thus the set of SCS Curve Numbers for the modelling.
- The Curve Numbers in turn determine the frequency and magnitude of surface runoff events in PRZM.

The topsoil texture code

- Refers to texture of uppermost horizon (usually A)
- Texture triangle according to FAO (1998)
- Silt: 2-50 µm particle diameter
- Classes
  - 1 = coarse (sand or sandy loam)
  - 2 = medium (loamy)
  - 3 = medium fine (silty)
  - 4 = fine (clayey)
  - 5 = very fine (very clayey)
  - 6 = peat

The subsoil texture code

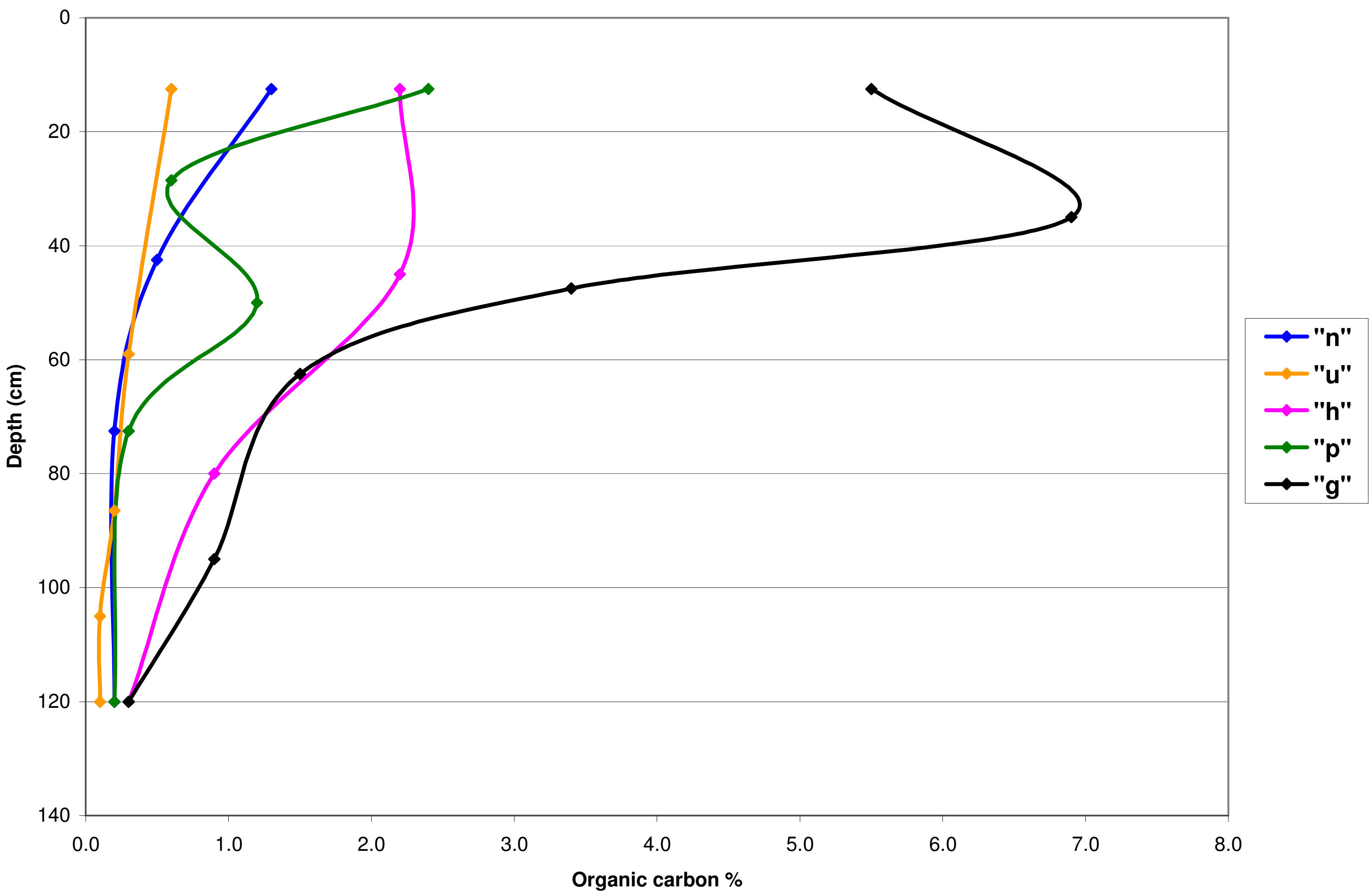
- Refers to texture of the subsoil (usually the layer below the topsoil and usually a B horizon)
- Classes
    - ➢ 0 = no subsoil present
    - ➢ 1 = coarse (sand or sandy loam)
    - ➢ 2 = medium (loamy)
    - ➢ 3 = medium fine (silty)
    - ➢ 4 = fine (clayey)
    - ➢ 5 = very fine (very clayey)
    - ➢ 6 = peat



The organic matter profile code

FOOTPRINT organic profile code	Description	SOIL (from SGDBE)
a	Alluvial soils with an uneven distribution of organic matter down the profile	Fluvisols, fluvic subgroups
g	With a thick (artificially deepened) topsoil relatively rich in organic matter	Plaggen soils
h	With an organic-rich topsoil	Chernozems, phaeozems humic & mollic subgroups
i	With a clay increase in the subsoil	Planosols, luvisols, podzoluvisols, luvic & planic subgroups
n	With a 'normal' organic profile	
f	Permafrost soils (non-agricultural) with an uneven distribution of organic matter down the profile	Gelic subgroups
o	Soils in volcanic material with organic-rich upper layers	Andosols
p	Podzols' with a relatively organic rich topsoil and an relatively organic rich subsoil layer	Podzols
r	Soils where the organic profile is limited by rock within 1 m depth	Rendzinas rankers and lithosols
t	With a peaty topsoil	Histosols & histic subgroups
u	Undeveloped' soils with relatively small organic matter content.	Regosols

Organic matter profile code: example depth profiles



FST properties and parameters

- Generic FST profiles and horizon properties were derived during the FOOTPRINT project by John Hollis as follows:
  - Classify all Soil Typological Units (STUs) in the SGDBE (Le Bas et al., 1998) into FSTs for the EU 25 (without Malta and Cyprus)
  - Use the profile and horizon data of the STUs in the SPADE-1 and SPADE-2 (Hollis et al., 2006) databases to derive mean FST profiles and horizons
    → one table with soil properties for all 269 modelled FSTs („FOOTPRINT soil properties database“) (no model parameters yet!)
- Parameterization methodology is fully documented and published:
  - FOOTPRINT DL21 (Jarvis et al., 2007)
  - FOOTPRINT DL20 (Reichenberger et al., 2008)
  - FOOTPRINT Final Report (Dubus et al., 2009)
  - update of the flowcharts to determine the structure class (Jarvis et al., 2009)

- The FST system does not depend on the profile and horizon properties derived from SPADE-1 and SPADE-2.

Supplementary slides - Representativeness analysis for soil

Problem for Lithuania

- After performing the representativeness analysis for the factor soil it was discovered that the results for the spatial distribution of FSTs in Lithuania were not correct.
  - In Proziris there exists a mismatch between versions of the SMU shapefile (corresponding to the SGDBE v2 available from JRC) and the SMU/STU relation which corresponds to the older, more detailed version used in FOOTPRINT (SGDBE v1).
  - Version mismatch → database mismatch → 90 % of the agricultural area of Lithuania has no STU and thus no FST attached to it.
  - Therefore, the results for Lithuania represent only 10 % of the agricultural area of Lithuania and are probably biased towards soil L11n.
  - The fact that 90 % of the agricultural area of Lithuania are missing also affects the results obtained for the entire zone. However, results for the other individual countries remain valid.

- The version mismatch between the SMU shapefile and the SMU/STU relation can be fixed in future projects.
- However, first the SMU/STU/FST relation has to be adapted to the SGDBE v2 (ongoing).

Main results – Representativeness for soil

- Overall, representativeness was low for the matching rule “full FST code”.
  - The sandy scenarios Karup and Önnestad were quite representative for DK and SE (13 and 15 %).
  - The FSTs corresponding to the Swedish national scenarios Krusenberg and Näsbygard were not found to be representative for Sweden at all.
  - However, Näsbygard was found to be representative for 11 % of the agricultural area of Finland.
  - None of the FOCUS/national scenarios attained any significant representativeness for EE and LV.

- With a relaxation of the matching rules, representativeness of the FOCUS/national soil scenarios generally increased. However, with rule “same FHG and same SST”
  - Representativeness of Näsbygard and Krusenberg for Sweden remains zero, because according to the SGDBE soil hydraulic group Y does not occur in Sweden. Given that the Swedish national soil scenarios have been selected carefully and are based on real field sites, it seems that this lack of representativeness is due to low resolution and possibly low quality of the SGDBE for Sweden.
  - Representativeness of Krusenberg is also zero for the other Northern zone countries. Here the reason is mainly that the abrupt textural change from sand to clay in the Krusenberg soil does not occur in the SGDBE for the Northern zone (except in 0.9 % of the agricultural area in Denmark).
  - Representativeness of the FOCUS soil scenarios Hamburg and Jokioinen remains low except for Denmark, because the site hydrology does not match.

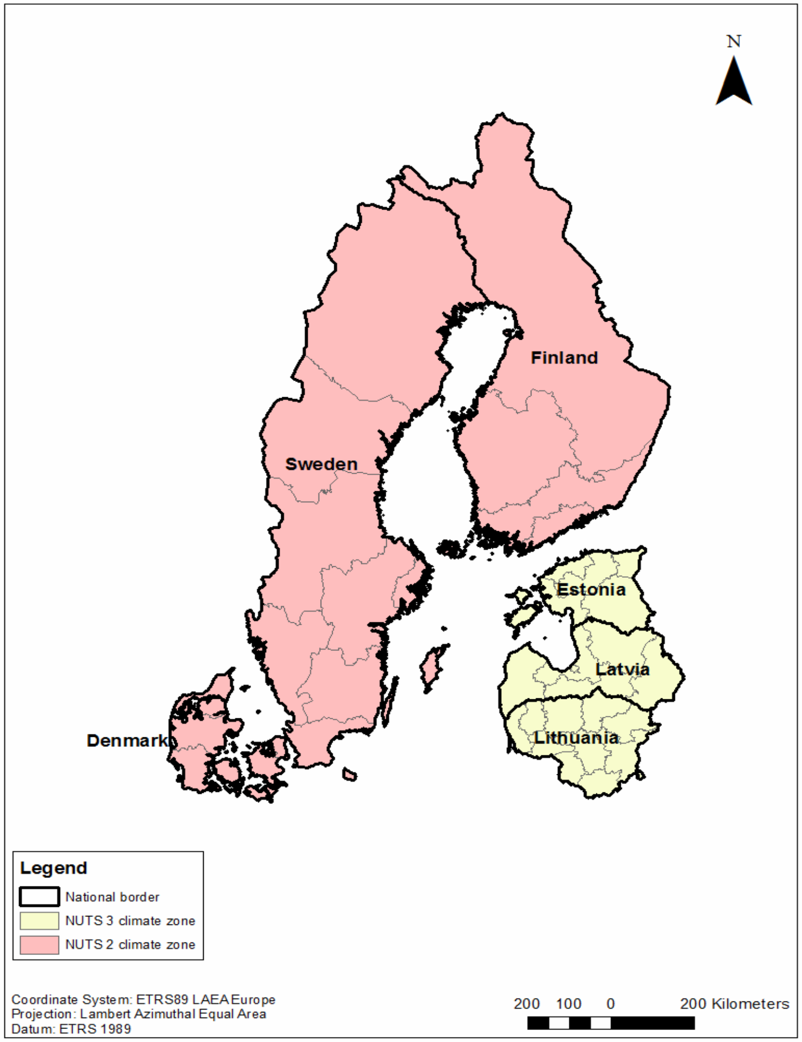
Supplementary slides - Representativeness analysis for climate

Proziris climates for the Northern zone

- 39 climate zones defined in the Northern zone based on NUTS units
  - NUTS2 for DK, SE and FI
  - NUTS3 for EE, LV and LT
- Weather stations taken as the centroid of the agricultural area (according to CLC2006) of the NUTS region
- 10 year daily data obtained from climate modelling consultancy CAP2020 (France)

- Bad idea:
  - arbitrary climate zones
  - arbitrary location of weather stations
  - only synthetic weather data (albeit resulting from a calibrated climate model)

- We should have used MARS 25 * 25 km^2!



Calculation of climatic variables

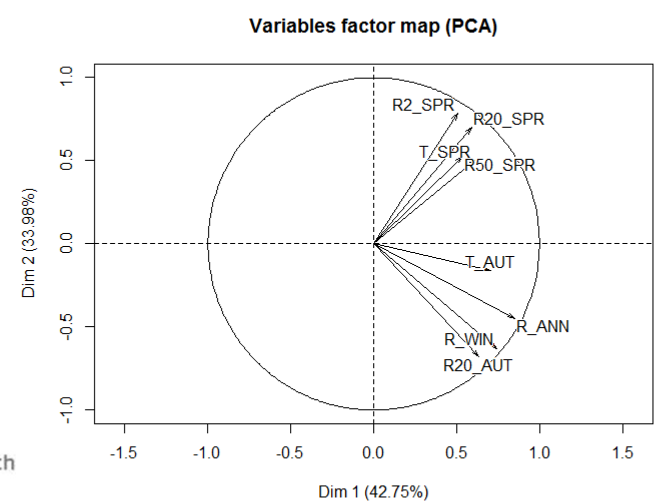
- For each meteorological series of the relevant FOCUS/national scenarios and of the 39 Footways climatic zones for the Northern countries the 8 climatic variables reported by Blenkinsop et al. (2008) were calculated.

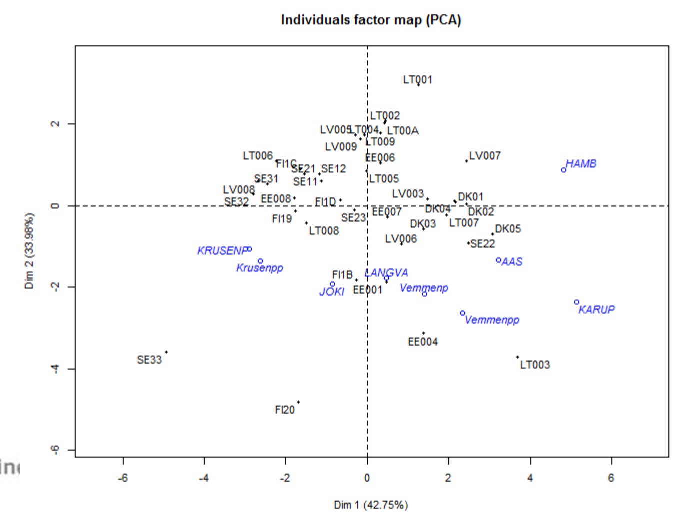
  - T_SPR: mean April to June temperature (°C)
  - T_AUT: mean Sep to Nov temperature (°C)
  - R_WIN: rain Oct to Mar rainfall (mm/a)
  - R_ANN: mean annual rainfall (mm/a)
  - R2_SPR: number of days (April to June) with daily rainfall > 2 mm (count/a)
  - R20_SPR: number of days (April to June) with daily rainfall > 20 mm (count/a)
  - R50_SPR: number of days (April to June) with daily rainfall > 50 mm (count/a)
  - R20_AUT: number of days (Sep to Nov) with daily rainfall > 20 mm (count/a)

- These 8 indicators were identified during the FOOTPRINT project (Dubus et al., 2009) as those meteorological variables which most influence pesticide leaching, based on the results of the analysis by Nolan et al. (2008).

PCA and Cluster Analysis

- A Principal Component Analysis (PCA) was performed with the 39 Footways weather stations and the 8 variables.
- The results of the PCA were used for a k-means Cluster Analysis to group the 39 stations into clusters.
- The values of the 8 variables of the FOCUS/national scenarios were transformed into PC scores and the distances to each cluster centroid and each Footways weather station calculated in the space of the 3 first principal components, to determine the closest cluster or Footways station, respectively.





Results and Discussion – Representativeness for climate

- No detailed results shown, because 39 Proziris climates were not well chosen
- Variables of Blenkinsop et al. (2008):
  - FOCUS/national scenarios on average wetter (R_ANN, R_WIN, R20_AUT) than Proziris weather series
  - Other variables relatively similar
- Principal Component Analysis
  - three PCs which explained 90.6 % of the total variance.
  - distribution of PC2 quite different between FOCUS/national and Proziris stations
- Cluster analysis
  - Optimal number of 6 clusters.
  - Only 3 out of 9 FOCUS/national weather series can be considered as members of one of the six clusters.
  - These 3 stations belong to cluster 2, which represents only 5.3 % of the NZ agricultural area

- Climate change
  - recent changes of climate and weather patterns are not reflected in the FOCUS and national scenarios
    - oldest weather series: Krusenberg (1961-1980)
    - most recent weather series: Ås (1981-2000)
  - Footways stations reflect only weather of the last 10 years (2004-2013): extrapolation to future?
  - Climate is changing so fast that it is becoming increasingly difficult to do predictive modelling with historical weather data.

Supplementary slides – Protectiveness analysis

Proziris modelling

- Agro-environmental scenario map/database based on
  - CAPRI land cover / land use
  - SGDBE soil map
  - NUTS2/NUTS3 climate zones
- Models used: MACRO 5.2
- Simulation period: 10 years (plus 6 years warm-up)
- Soil parameterisation:
  - FST parameterisation methodology developed in FOOTPRINT
- Proziris was run for the whole NZ with:
  - same substance properties and application practices as the national/FOCUS scenarios
  - both standard and Danish substance parameterisation.

Selection of substances to be modelled

11 active substances (real and hypothetical ones), and their 7 relevant metabolites were selected according to the following criteria:

- dummy substances: regularly used in GW modelling
- real substances: registered in Northern zone countries
- real substances: regularly detected in GW monitoring
- substances should reflect a broad range of physico-chemical properties, excluding substances where no leaching is to be expected

Selected substances

ID	Compound	Metabolite 1	Metabolite 2
1	FOCUS GW dummy A	-	-
2	FOCUS GW dummy B	-	-
3	FOCUS GW dummy C	FOCUS GW dummy C_met	-
4	FOCUS GW dummy D	-	-
5	Sulfosulfuron	desmethyl sulfosulfuron	-
6	Tebuconazole	1,2,4-triazole (fast)	1,2,4-triazole (slow)
7	Ethofumesate	-	-
8	Bentazone	-	-
9	Metribuzin	diketo-metribuzin	desamino-diketometribuzin
10	Clopyralid	-	-
12	Pirimicarb	2-dimethylamino-5,6-dimethyl-pyrimidin-4-ol (R31805)	5,6-dimethyl-2-(methylamino)pyrimidin-4-ol (R34865)

Application details

ID	Name of compound	Crop	Application date rule	Application rate (g a.i./ha)
1	FOCUS GW dummyA	Winter soft wheat	Emergence -1 d	1000
2	FOCUS GW dummy B	Winter soft wheat	Emergence -1 d	1000
3	FOCUS GW dummy C	Winter soft wheat	Emergence -1 d	1000
4	FOCUS GW dummy D	Winter soft wheat	Emergence -1 d	1000
5	Sulfosulfuron	Winter soft wheat	ZDATEMIN	20
6	Tebuconazole	Winter soft wheat	ZDATEMIN + (IDMAX - ZDATEMIN)/3	250
7	Ethofumesate	Sugar beet	Emergence -1 d	333.3 (every year)
8	Bentazone	Winter soft wheat	ZDATEMIN	1440
9	Metribuzin	Potatoes	ZDATEMIN + 1	350
10	Clopyralid	Winter soft wheat	ZDATEMIN	125
12	Pirimicarb	Winter soft wheat	ZDATEMIN + (IDMAX - ZDATEMIN)/2	125

Pesticide properties

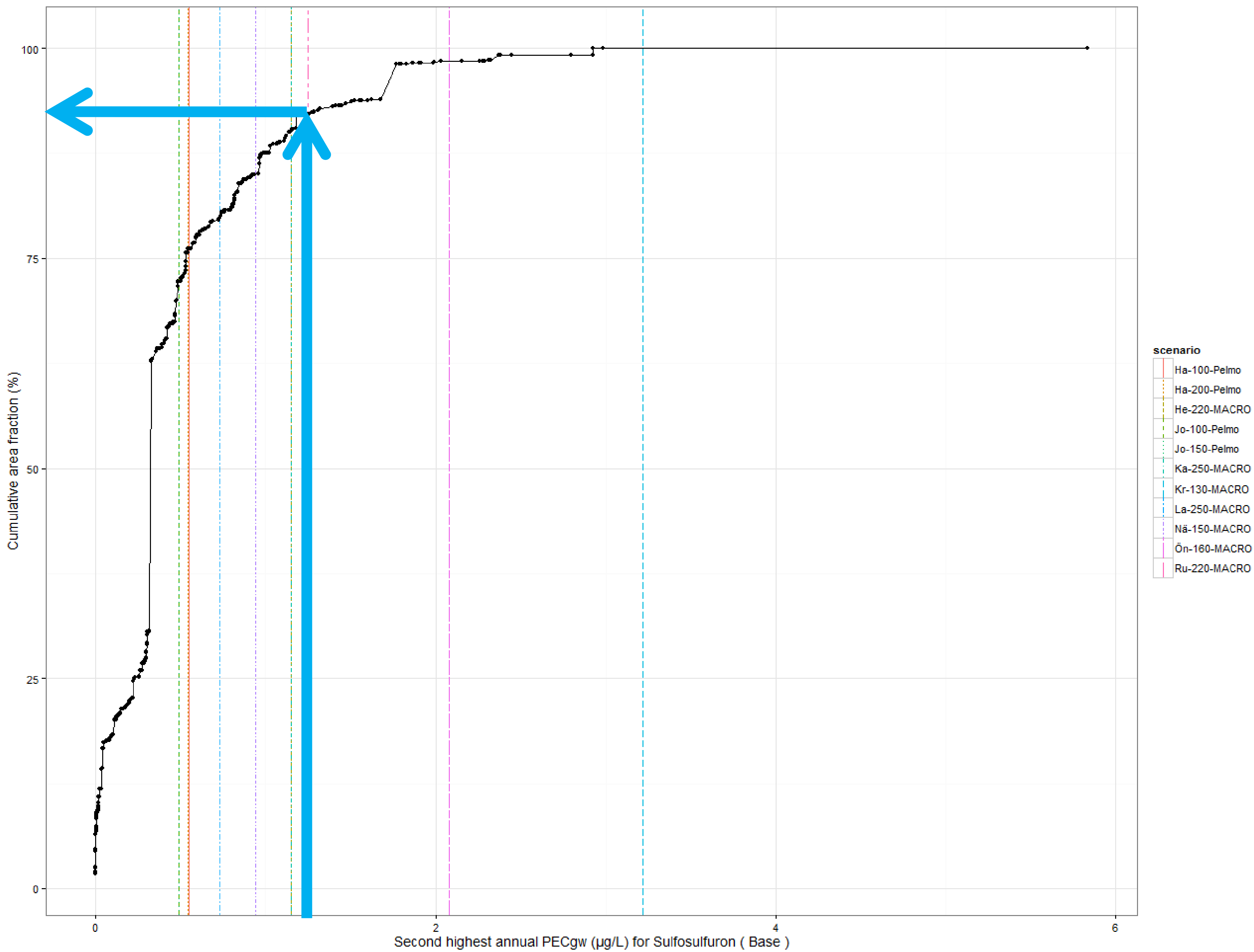
- Physicochemical properties required to parameterise both the FOCUS models and Proziris were obtained from the PPDB (http://sitem.herts.ac.uk/aeru/ppdb/en/index.htm).
- Where there were insufficient data in the PPDB, often concerning the metabolites, alternative sources of information were consulted, including EFSA conclusions for parent compounds.
- Properties were also adjusted, separately, according to Danish requirements ("Danish parameterization") by multiplying the standard values with generic multiplication factors derived by Stenemo and Lousa Alvin (2013):
  - Koc values: factor 0.65
  - Freundlich exponent: factor 1.039
  - DT50 in soil: factor 1.54

Evaluation depth for leaching

- For all national scenarios:
  - bottom of the profile (as in MACROinFOCUS 5.5.3 for the Danish, Swedish and Norwegian scenarios)
- For the FOCUS scenarios Hamburg and Jokioinen
  - 1 m depth
  - bottom of the profile
- Proziris:
  - bottom of the profile (2 m)

Risk indicators

Indicator name	Corresponding value for FOCUS/national scenarios (20 years)	Corresponding value for Proziris (10 years)
Max annual PECgw (µg/L)	Highest value out of 20 annual values	Highest value out of 10 annual values
Overall mean PECgw	Mean flux concentration over whole evaluation period	
80^{th} percentile of annual PECgw (µg/L)	Mean of 16^{th} lowest (5^{th} highest) and 17^{th} lowest (4^{th} highest) annual values	2^{nd} highest of 10 annual values
Median of annual PECgw (µg/L)	Median of 20 annual values	Median of 10 annual values
80^{th} percentile of total annual leaching losses (mg/m²)	Mean of 16^{th} lowest (5^{th} highest) and 17^{th} lowest (4^{th} highest) annual values	2^{nd} highest of 10 annual values
Median of total annual leaching losses (mg/m²)	Median of 20 annual values	Median of 10 annual values
Overall mean annual pesticide leaching flux (mg/m²)	Total leaching flux divided by 20 years	Total leaching flux divided by 10 years
Maximum annual leaching loss	Highest value out of the 20 annual values	Highest value out of 10 annual values

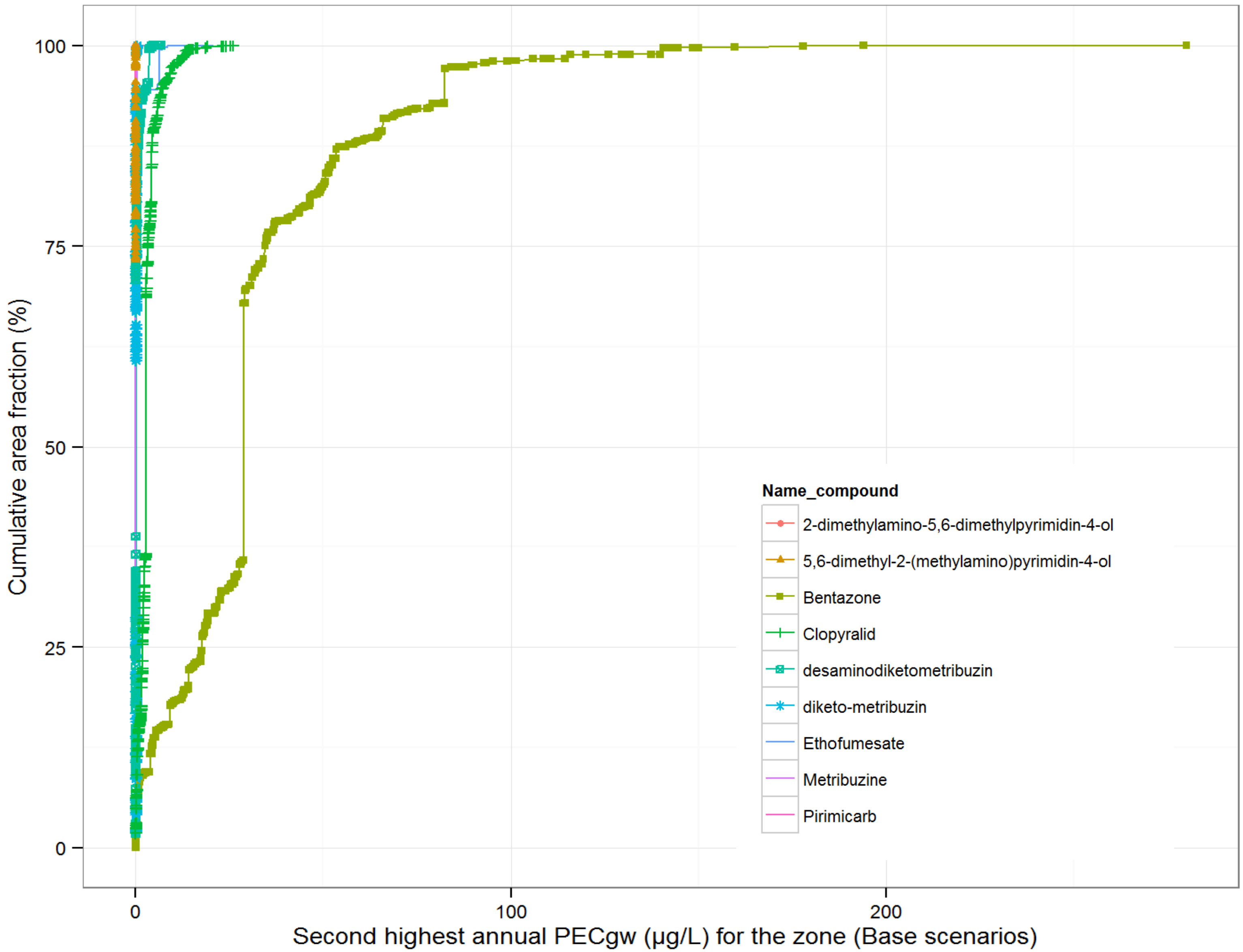

Cumulative area fraction (%)
100
75
50
25
0
0
2
4
6
Second highest annual PECgw (µg/L) for Sulfosulfuron (Base)
scenario
Ha-100-Pelmo
Ha-200-Pelmo
He-220-MACRO
Jo-100-Pelmo
Jo-150-Pelmo
Ka-250-MACRO
Kr-130-MACRO
La-250-MACRO
Nä-150-MACRO
Ön-160-MACRO
Ru-220-MACRO

80th percentile PECgw (Danish)

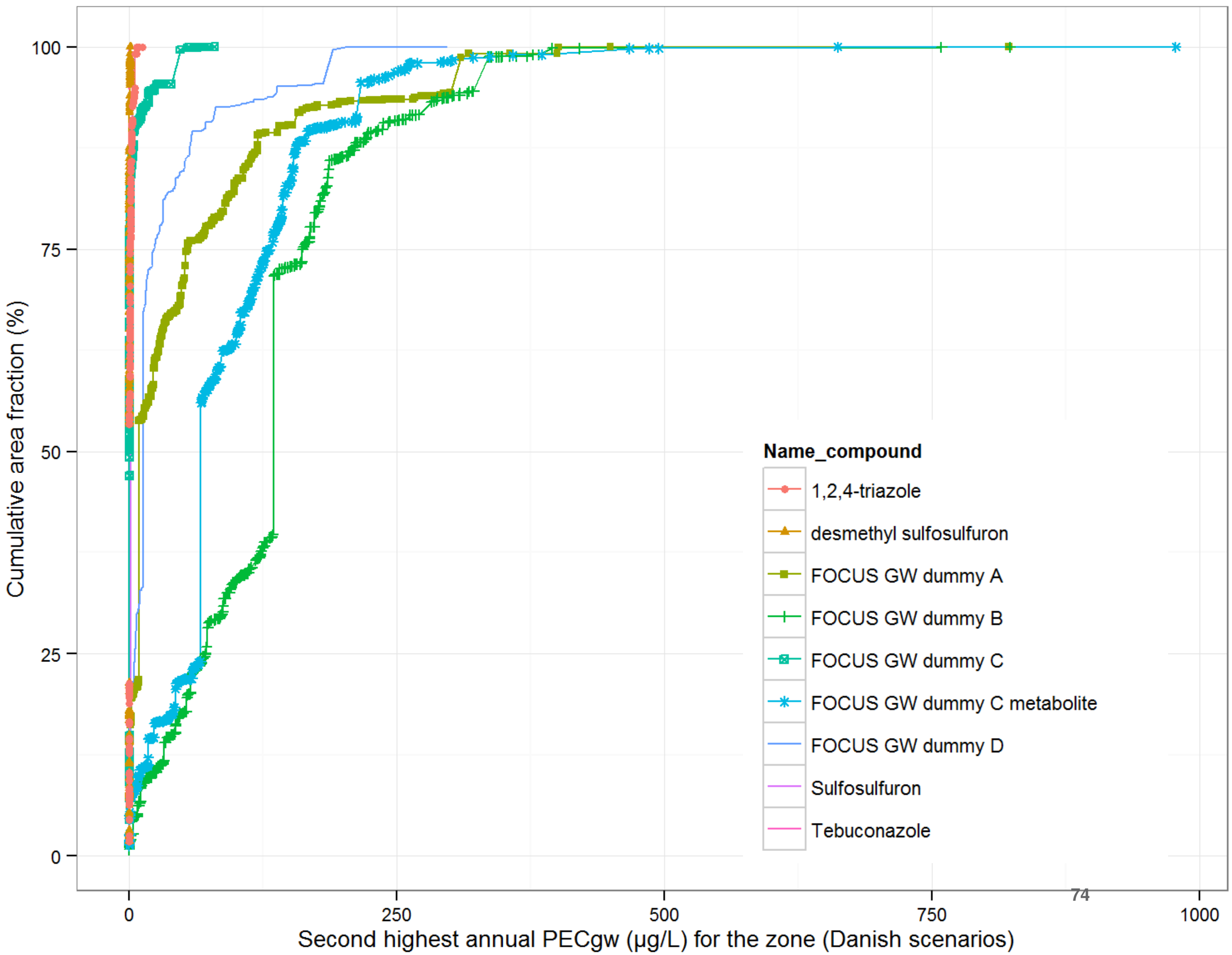
knoell worldwide registration

simulated compound	Hamburg Pearl 100cm	Hamburg Pearl 200cm	Hamburg Pelmo 100cm	Hamburg Pelmo 200cm	Jokioinen Pearl 100cm	Jokioinen Pearl 150cm	Jokioinen Pelmo 100cm	Jokioinen Pelmo 150cm	Karup MACRO 250cm	Langvad MACRO 250cm
	80th percentile annual PECgw (µg/L)									
124_triazole_DK			3.370	3.440			2.920	3.000	13.470	11.590
bentazone_DK			84.080	84.130			91.410	93.630	146.980	112.450
clopyralid_DK			7.370	7.160			9.180	8.320	11.510	7.900
desami_diket_MBZ_DK			1.300	1.310			2.220	2.120	7.650	2.840
desmethyl_sulfosu_DK			0.160	0.160			0.150	0.140	0.230	0.250
diketo_MBZ_DK	0.290	0.270	0.180	0.150	0.280	0.310	0.320	0.290	0.590	0.560
ethofumesate_DK	17.600	17.870	13.140	13.550	13.520	13.340	10.990	11.060	26.980	15.010
Gwdummy_A_DK	66.520	66.680	65.690	66.360	50.000	48.690	50.250	51.780	121.790	94.480
Gwdummy_B_DK	100.520	104.610	118.280	122.600	103.520	101.750	107.390	108.980	227.530	119.400
Gwdummy_C_DK	1.780	1.890	5.570	5.430	0.320	0.350	1.850	1.960	4.010	9.680
Gwdummy_D_DK	28.200	28.210	31.910	31.240	17.570	18.310	21.300	20.740	70.750	41.420
Met_C_DK	135.630	126.480	114.800	111.400	150.120	120.420	111.190	109.200	164.330	206.150
metribuzin_DK	0.610	0.600	0.380	0.320	0.620	0.670	0.730	0.660	1.300	2.360
pirimicarb_DK			1.690	1.690			0.800	0.520	3.830	0.050
R31805_DK			0.006	0.007			0.001	0.000	0.000	0.000
R34865_DK			0.006	0.006			0.001	0.000	0.000	0.000
sulfosulfuron_DK			1.450	1.430			1.600	1.640	2.560	2.150
tebuconazole_DK			0.000	0.000			0.000	0.000	0.000	0.000
mean			24.966	25.021			22.906	23.002	44.639	34.794
max			118.280	122.600			111.190	109.200	227.530	206.150
min			0.000	0.000			0.000	0.000	0.000	0.000
stdev			41.037	41.240			39.117	39.383	70.913	58.804
median			2.530	2.565			2.035	2.040	5.830	5.370

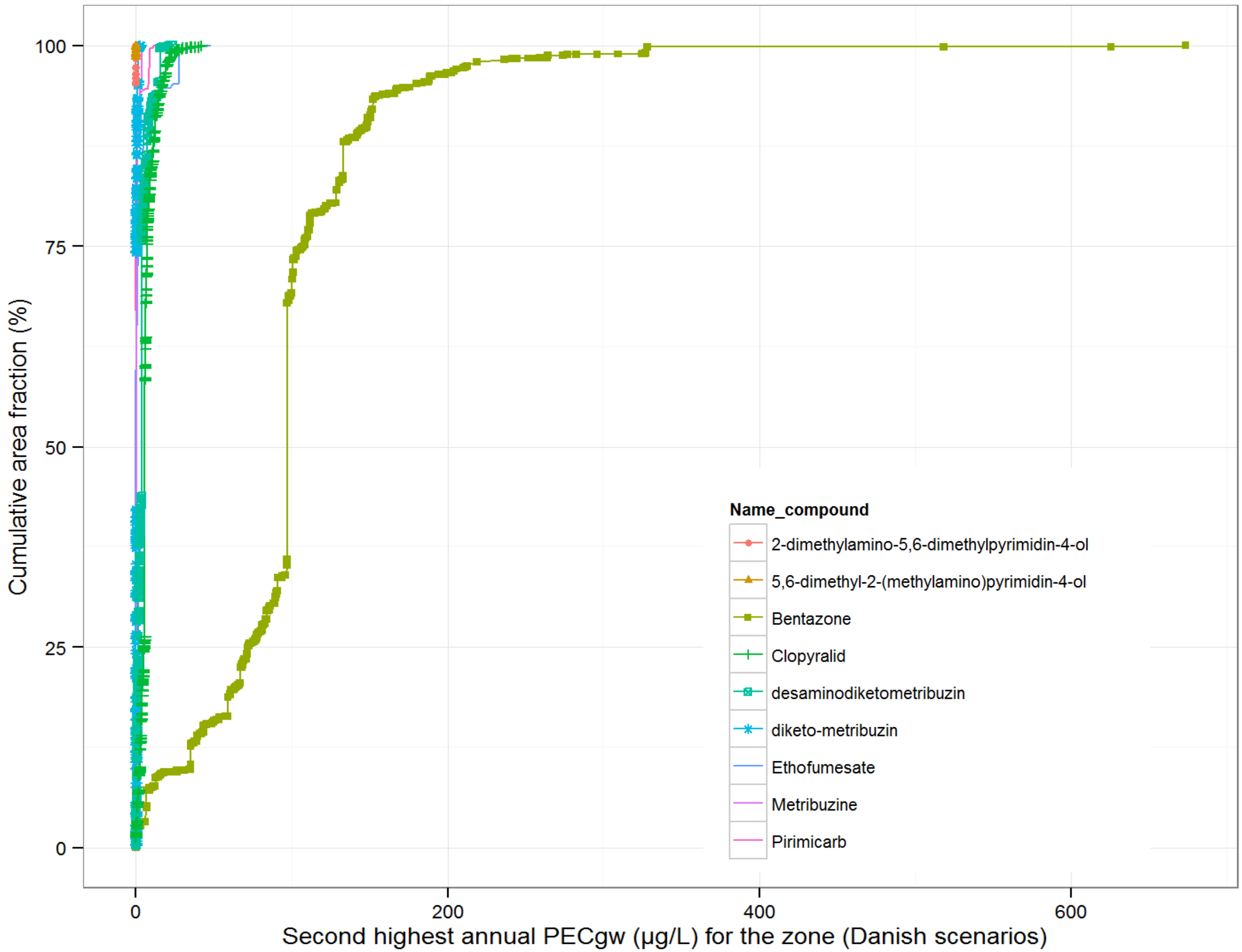
2nd highest annual PECgw (standard) (2)



2nd highest annual PECgw (Danish) (1)



2nd highest annual PECgw (Danish) (2)



Cumulative area percentage: 80th percentile annual PECgw (Danish/standard)

simulated compound	Hamburg Pearl 100cm	Hamburg Pearl 200cm	Hamburg Pelmo 100cm	Hamburg Pelmo 200cm	Jokioinen Pearl 100cm	Jokioinen Pearl 150cm	Jokioinen Pelmo 100cm	Jokioinen Pelmo 150cm	Karup MACRO 250cm	Langvad MACRO 250cm
	cumulative area percentage on the corresponding Proziris CDF for the whole zone; variable median annual PECgw									
124_triazole_DK			100.00	100.00			100.00	100.00	100.00	100.00
bentazone_DK			97.13	97.30			97.59	97.87	99.75	98.36
clopyralid_DK			94.73	94.69			96.51	95.68	98.17	95.47
desami_diket_MBZ_DK			91.18	91.18			94.34	94.12	100.00	94.54
desmethyl_sulfosu_DK			98.47	98.47			94.20	94.17	98.67	98.67
diketo_MBZ_DK	99.68	99.67	99.22	98.97	99.67	99.87	99.87	99.68	100.00	100.00
ethofumesate_DK	99.98	99.98	99.98	99.98	99.98	99.98	99.98	99.98	100.00	99.98
Gwdummy_A_DK	92.88	92.88	92.88	92.88	92.78	92.78	92.78	92.78	95.44	94.85
Gwdummy_B_DK	90.01	90.17	91.14	91.14	90.17	90.01	90.17	90.19	99.72	91.14
Gwdummy_C_DK	93.07	93.27	99.84	99.84	90.83	90.97	93.07	93.27	94.14	99.96
Gwdummy_D_DK	94.27	94.27	94.90	94.90	92.32	92.55	93.77	93.76	99.67	95.40
Met_C_DK	93.71	93.35	93.12	92.93	93.76	93.13	92.93	92.66	98.50	99.18
metribuzin_DK	99.24	99.24	98.34	98.22	99.24	99.24	99.48	99.24	99.88	100.00
pirimicarb_DK			99.99	99.99			99.91	99.89	100.00	98.82
R31805_DK			100.00	100.00			100.00	100.00	100.00	100.00
R34865_DK			100.00	100.00			100.00	73.29	73.29	73.29
sulfosulfuron_DK			93.21	93.16			93.75	93.89	99.14	98.43
tebuconazole_DK			99.88	99.88			99.88	99.88	99.88	99.88
mean			96.89	96.86			96.57	95.02	97.57	96.55
max			100.00	100.00			100.00	100.00	100.00	100.00
min			91.14	91.14			90.17	73.29	73.29	73.29
stdev			3.38	3.38			3.40	6.34	6.28	6.35
median			98.41	98.35			97.05	94.93	99.74	98.75

Supplementary slides – Miscellaneous

Leaching scenarios used in the Northern zone

Scenario type	Country	Scenario name	Model	Software package used
FOCUS		Jokioinen	Pearl	Pearl 4.4.4
			Pelmo	Pelmo 4.4.3
		Hamburg	Pearl	Pearl 4.4.4
			Pelmo	Pelmo 4.4.3
National	Denmark	Karup	MACRO 5.2	FOCUS MACRO 5.5.4
		Langvad		
National	Sweden	Näsbygård		
		Krusenberg		
		Önnestad		
National	Norway	Heia		
		Rustad		

Some thoughts on soil data

- Soil Geographical Database of Europe:
  - SGDBE (Le Bas et al. 1998) is based on national soil maps from the 1990's or earlier and therefore does not necessarily reflect the latest status of soil mapping in the respective countries
  - more recent national soil maps/databases (if and where available) should be used in the future for spatially probabilistic risk assessments
  - I am working on an update of the SMU-STU-FST table for the SGDBE v2; however, I feel that the SGDBE should only be used in the Northern zone to fill holes not covered by more detailed maps
- Situation in Sweden (Moeys, personal communication):
  - Soil map and "agro-environmental scenario" map available for 15 of 21 Swedish counties.
  - New map of arable soils in Sweden (by SLU-Skara and Swedish Geological Survey), available online (http://maps-test.sgu.se:8080/TestSguMapViewer2/kartvisare-lerhaltskarta-sv.html) and open source → potential for updating maps of FSTs and agroenv. scenarios
- Soil diversity
  - Moderate diversity of soils in the Northern zone (compared with Central and Southern zones) due to young age and predominantly glacial origin
  - Detailed soil maps only needed for agricultural areas
  - Differences between soils in freeze/thaw regimes can be dealt with in models (MACRO 6)

→ A harmonized soil map for the *agricultural* areas of the Northern zone based on recent national datasets would be useful and is feasible