FOOTPRINT

FOOT-CRS – A GIS-based tool for pesticide risk assessment and management at the catchment scale

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Stefan Reichenberger, FOOTWAYS S.A.S.

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footways

Today's talk

> Brief overview of the FOOTPRINT project

> The catchment-scale tool FOOT-CRS

> Feedback and discussion

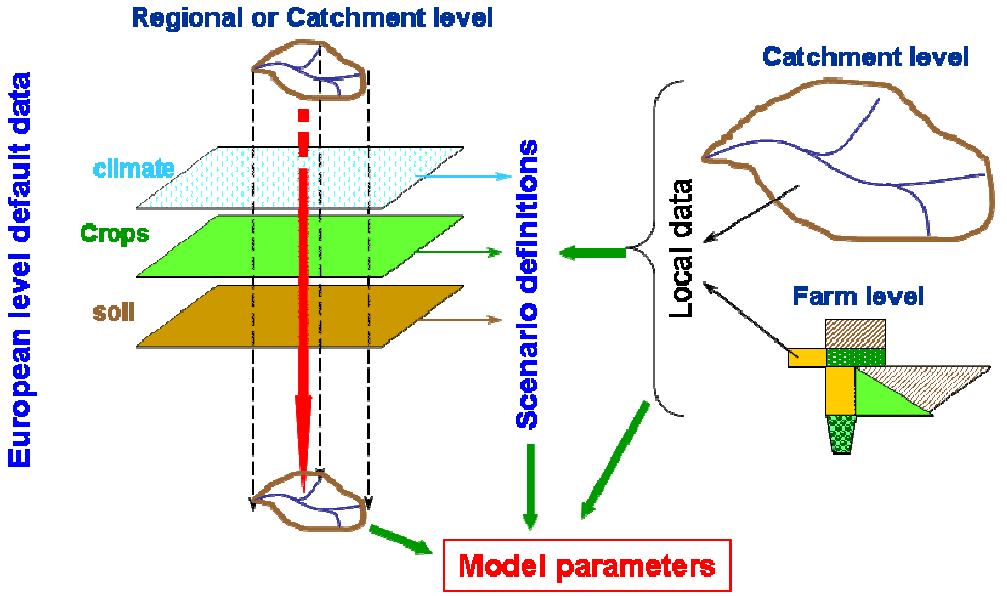
Introduction: The FOOTPRINT project

- 3.5-year project funded by the European Commission as part of FP6
- Very applied objectives: to develop 3 software tools to support pesticide risk assessment and management
- Consortium:
  - 15 partners from 9 European countries
  - Coordinator: Igor Dubus formerly at BRGM (F)
- Project finished officially in June 2009
- New company "FOOTWAYS" set up in June 2009
  - to disseminate, support and maintain the tools developed
  - to create new, innovative tools which go beyond FOOTPRINT

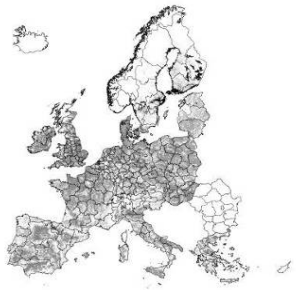
Project goals

- 1) to develop a suite of three pesticide risk assessment and management tools, for use at three different scales by three different user communities:
  - Policy makers/registration authorities at the national/EU scale (FOOT-NES)
  - Water quality managers at the catchment scale (FOOT-CRS)
  - Farmers and extension advisers at the local (farm) scale (FOOT-FS)
- 2) to evaluate the usability and performance of the FOOT tools at their various scales of application.

The FOOTPRINT agro-environmental scenarios



The FOOTPRINT modelling concept (1)



'Theoretical' pesticides

Koc & DT50

MACRO

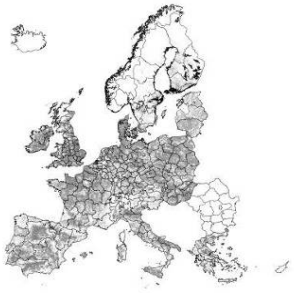
Leaching and drainage

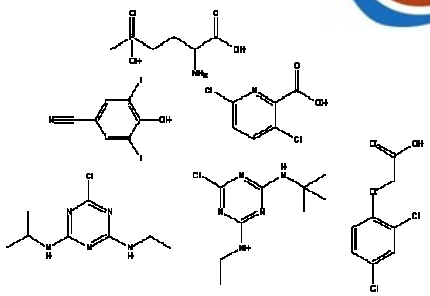
PRZM

Surface runoff and erosion

Pesticide losses, pesticide concentrations

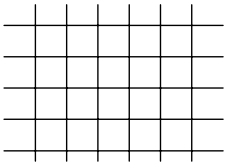
The FOOTPRINT modelling concept (2)





Koc, DT50

Rapid access to a large number of databases with modelling results



Pesticide losses, pesticide concentrations

The catchment-scale tool FOOT-CRS

The FOOT-CRS tool

> To be used at catchment level by 'water quality' managers, i.e. regional/local authorities, water agencies, water companies

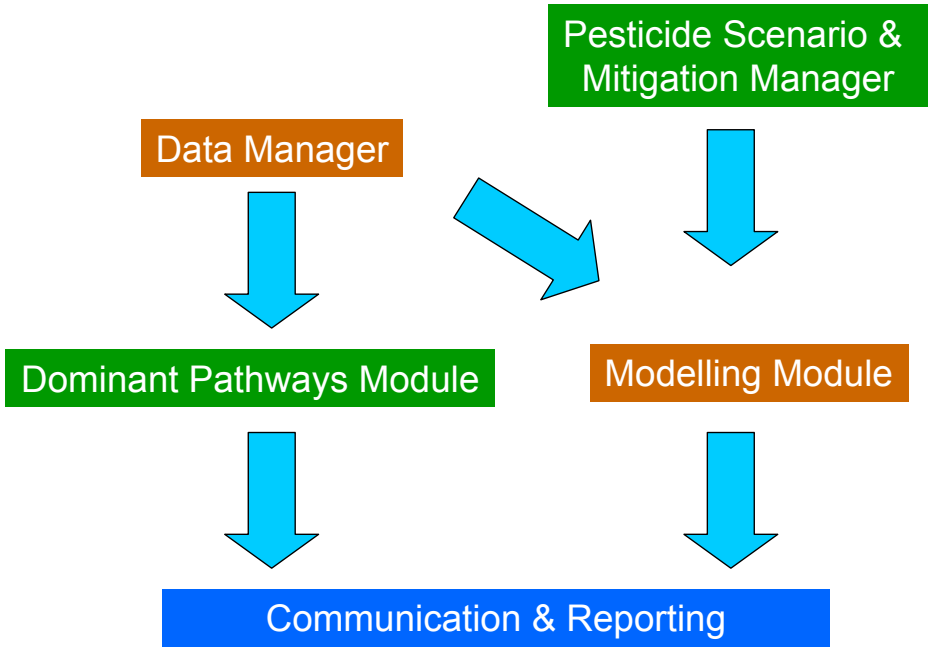
> Prospective and concrete-case exposure/risk assessment

> Emphasis on:

1. Identifying the areas most contributing to the contamination of water resources by pesticides
2. Defining and/or optimising action plans at the scale of the catchment

> Add-on (toolbar) in ArcGIS

Modular structure of FOOT-CRS (and FOOT-NES)



Basic concept of FOOT-CRS

> Modelling

- Groundwater (GW): leaching beyond bottom boundary of the soil profile (2 m)
- Surface water (SW): FOOT-CRS uses the actual surface water network
- Concentrations in surface water (PECsw) are calculated at the catchment outlet (i.e. for one point in space).

> FOOT-CRS output

- Maps and spatial cumulative distribution functions (CDFs) of pesticide leaching concentrations (PECgw)
- Maps and spatial CDFs of pesticide losses from fields and pesticide inputs into the surface water network
- Temporal CDFs of Predicted Environmental Concentrations in surface water (PECsw) at the catchment outlet. → exceedance frequencies and return periods of given monthly maximum concentrations

Modelling pesticide surface runoff and erosion inputs into sw in FOOT-CRS

> Modelling databases provide, for each of 240 simulation months:

- max. daily pesticide runoff loss (mg m^2 d^{-1})
- associated precipitation (mm d^{-1})
- max. daily pesticide erosion loss (mg m^2 d^{-1})

> To keep calculation times at an acceptable level, the surface runoff routing is not performed for each simulation month, but only 30 times to create the basis for interpolation

- 5 standard precipitation values (specific to the climate zone)
- 2 seasonal conditions (crop / no crop)
- 3 species: surface runoff water / pesticide dissolved in surface runoff / pesticide adsorbed to eroded sediment

> Afterwards, for each of 240 simulation months, calculate by interpolation using precipitation values:

- initial surface runoff volume
- fraction of initial surface runoff volume reaching the sw network
- fraction of pesticide runoff loss reaching the sw network
- fraction of pesticide erosion loss reaching the sw network

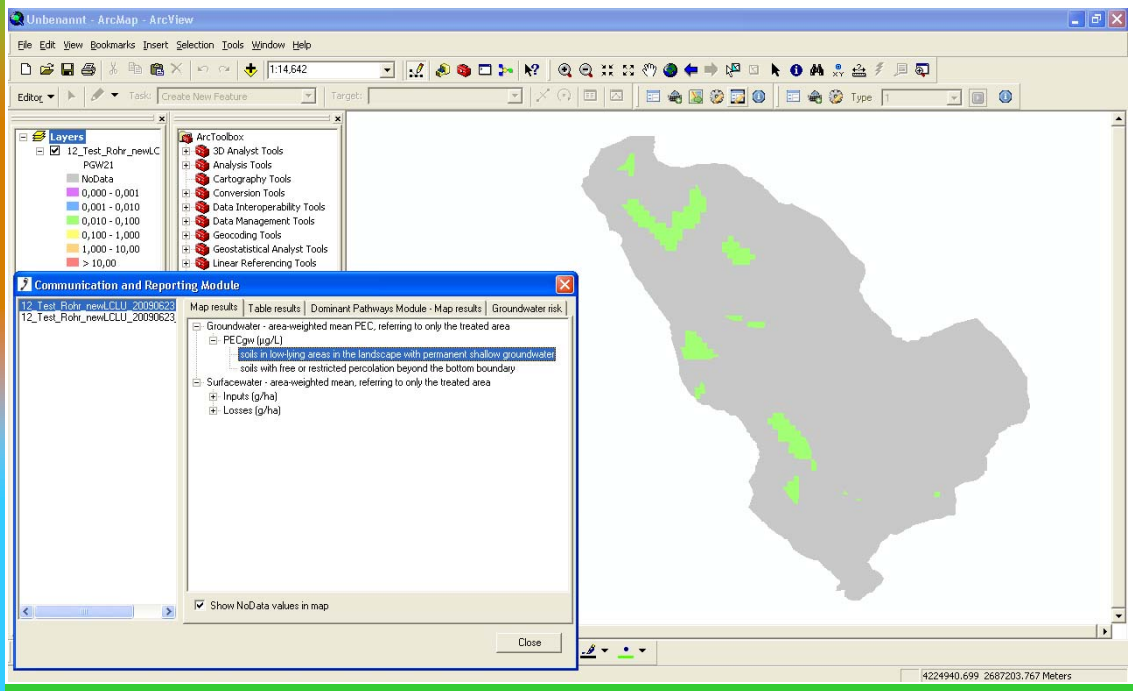
Basic principles of the surface runoff routing in FOOT-CRS

- Standard ArcGIS Spatial Analyst raster functionality is used („flow accumulation“, „downstream flow length“, etc.)
- Initial surface runoff is calculated with the Curve Number approach (CN have been adjusted to reflect exclusively surface runoff)
- “Infiltration capacity” is given as max[(initial abstraction – precipitation),0] → cells which generate initial surface runoff cannot infiltrate water coming from upslope
- It‘s assumed that infiltration and sedimentation are the only processes reducing pesticide load in surface runoff
- Outflow of eroded sediment from a cell is reduced by a slope-dependent reduction factor compared to the outflow of surface runoff water
- Wetlands intercept parts of the dissolved and particle-bound pesticide load, but pass on the full water volume to the surface water network

Example output of FOOT-CRS

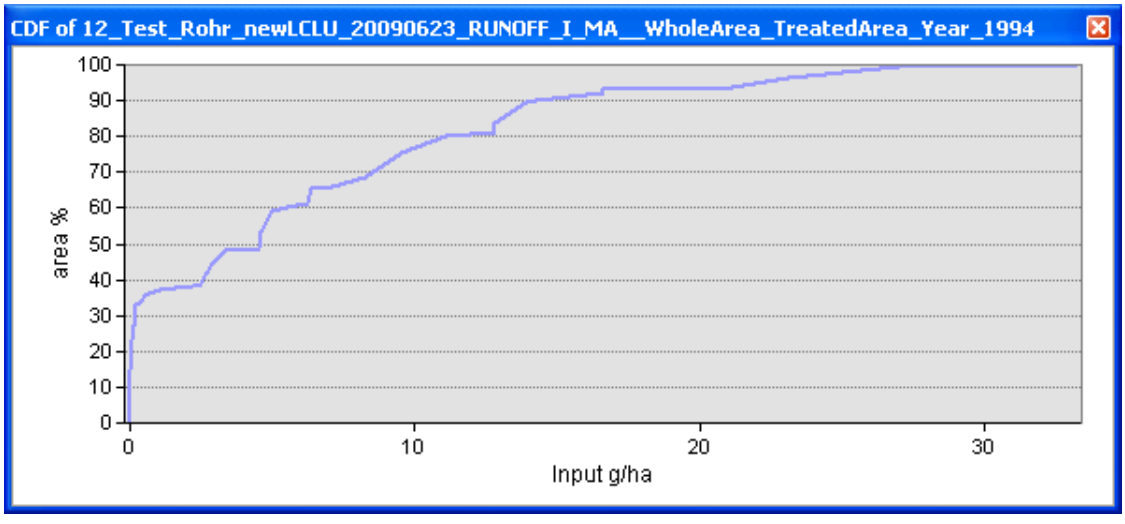
Maps of PECgw, losses from fields, inputs into surface water

> Select variable for map display + automatically create standard legend



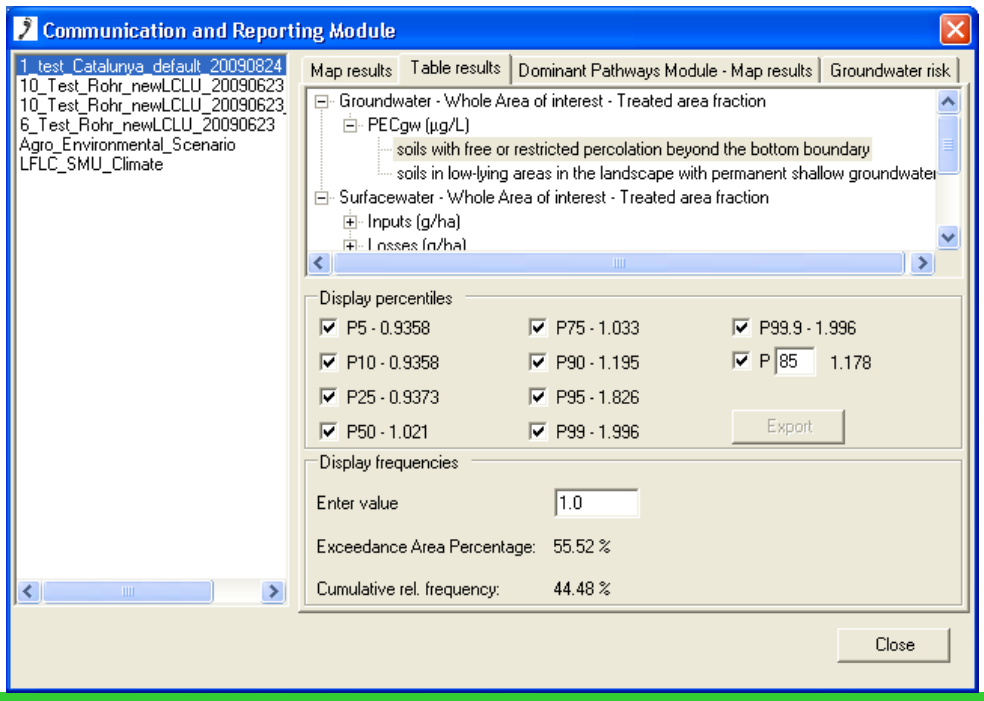
Spatial CDFs (1)

> Spatial Cumulative Distribution Functions (CDF) are automatically created for each spatial output variable in dbf format + as basic graphs in ArcGIS.



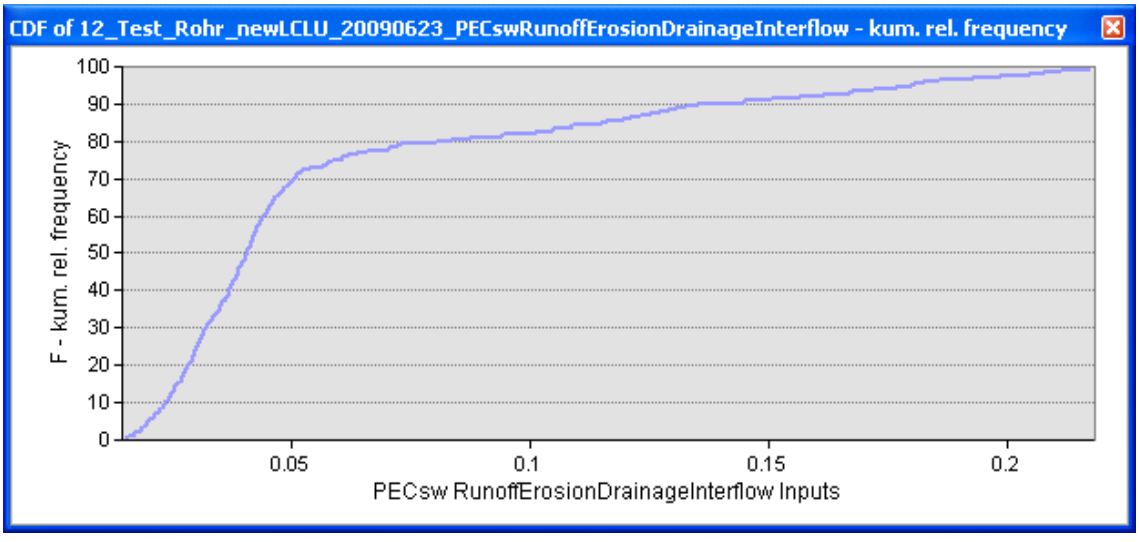
Spatial CDFs (2)

> Select variable + automatically calculate percentiles and area percentages of exceedance



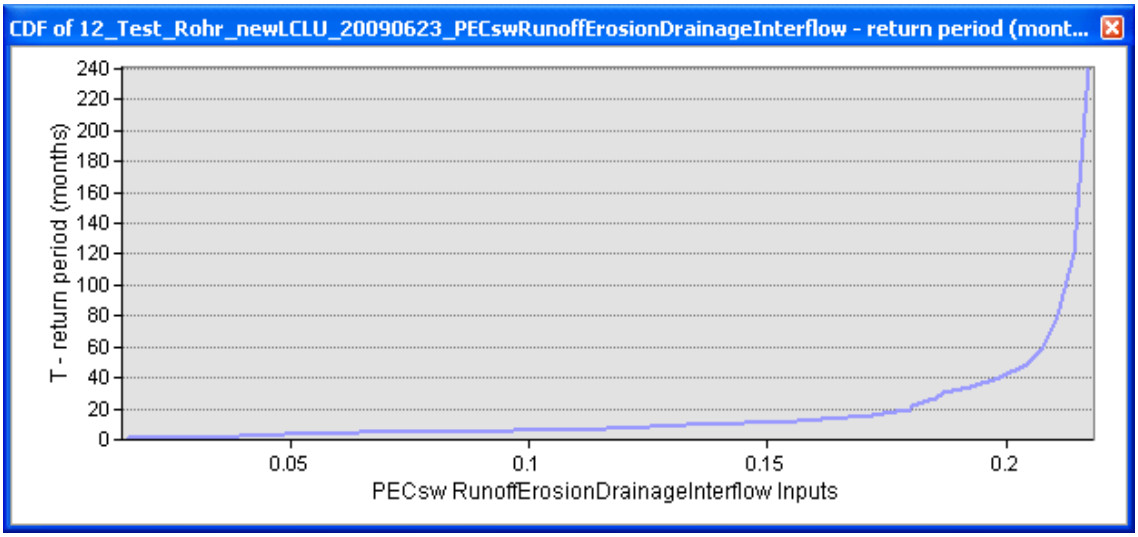
Temporal CDFs for PECsw (1)

> Temporal CDFs (240 data points) of PECsw (µg L^{-1}) at the catchment outlet, for different pesticide input pathways. → Exceedance frequencies and return periods of given monthly maximum concentrations.



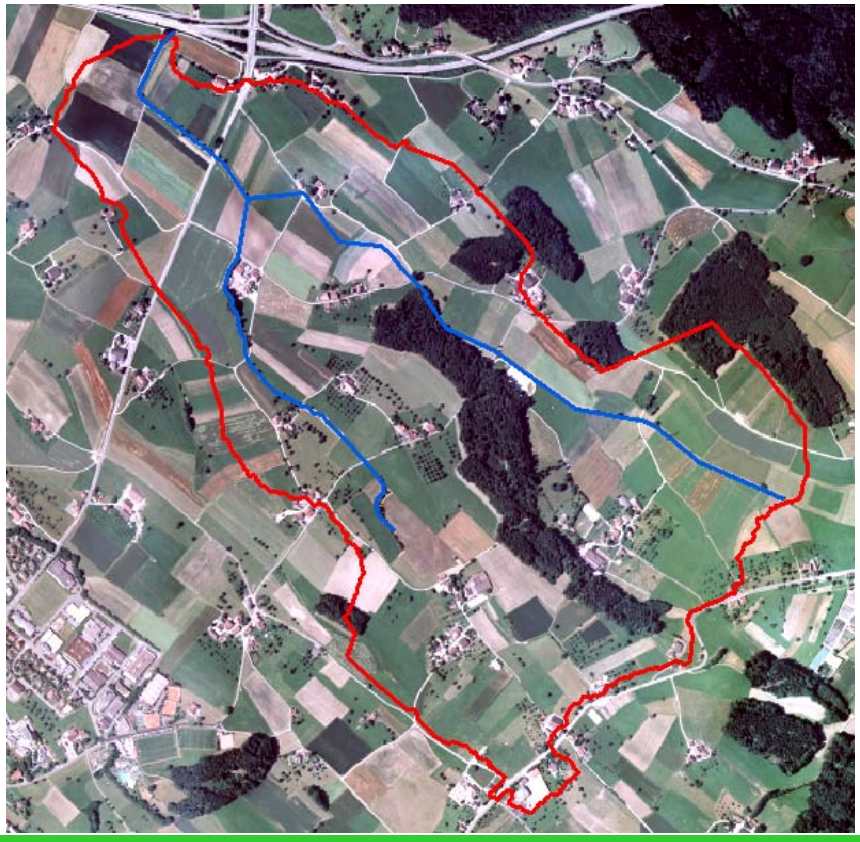
Temporal CDFs for PECsw (2)

> Temporal CDFs (240 data points) of PECsw (µg L^{-1}) at the catchment outlet, for different pesticide input pathways. → Exceedance frequencies and return periods of given monthly maximum concentrations.

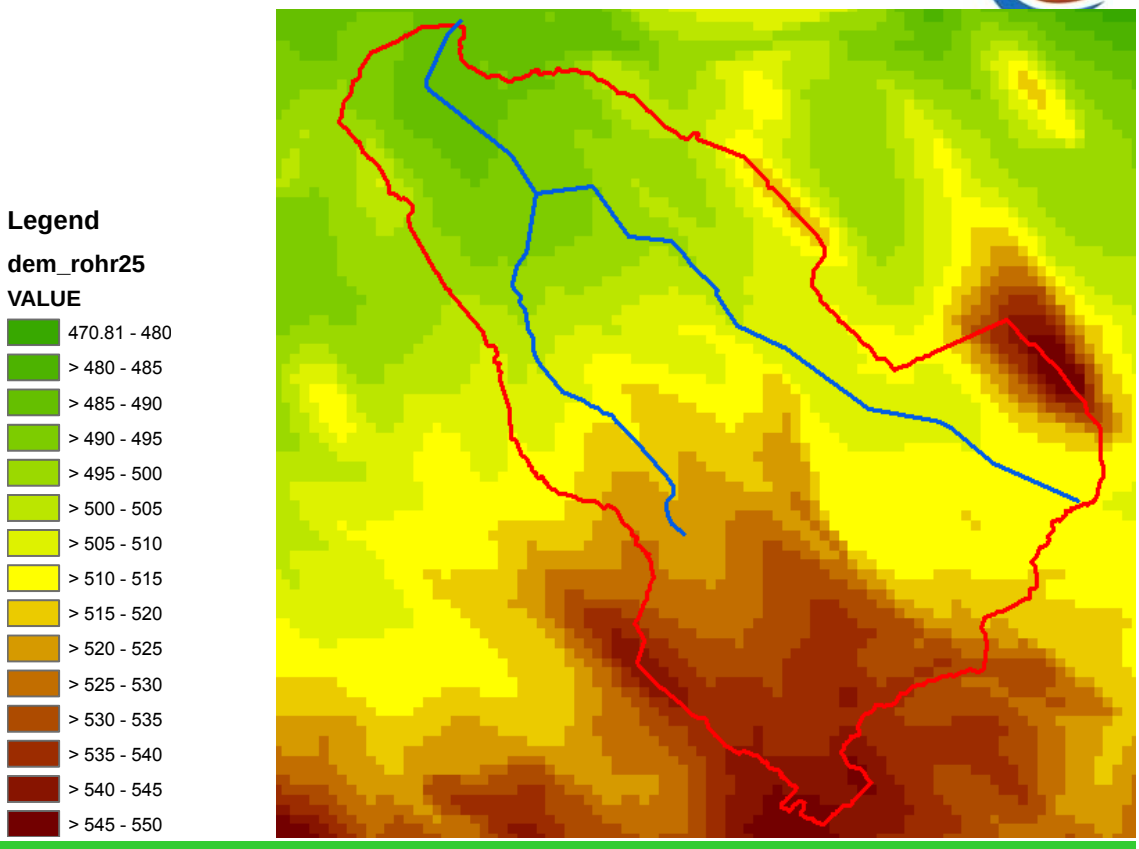


FOOT-CRS example calculations for the Rohr catchment in Switzerland (2.1 km^2 area; dataset provided by EAWAG)

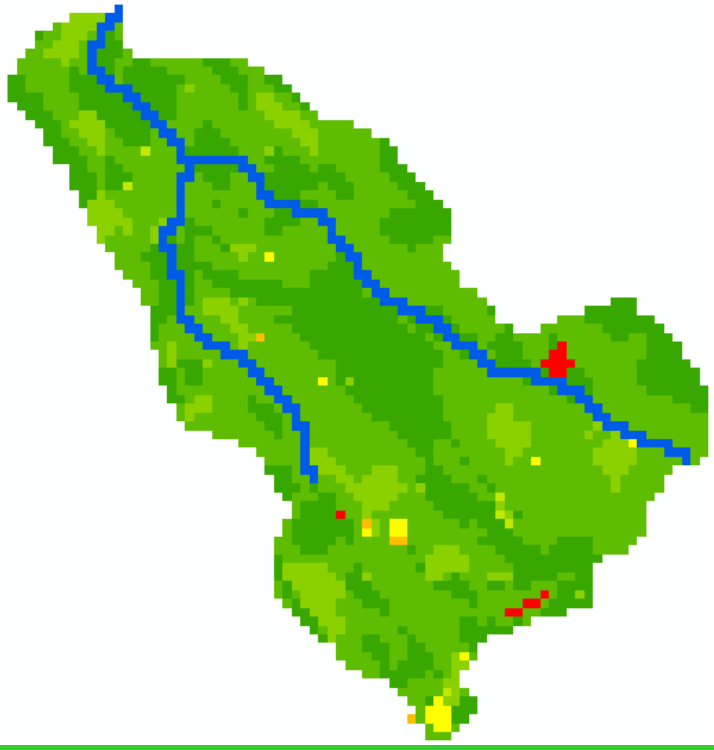
The Rohr catchment: aerial photo



The Rohr catchment: elevation



Initial surface runoff in mm
(40 mm rainfall, cropping season)



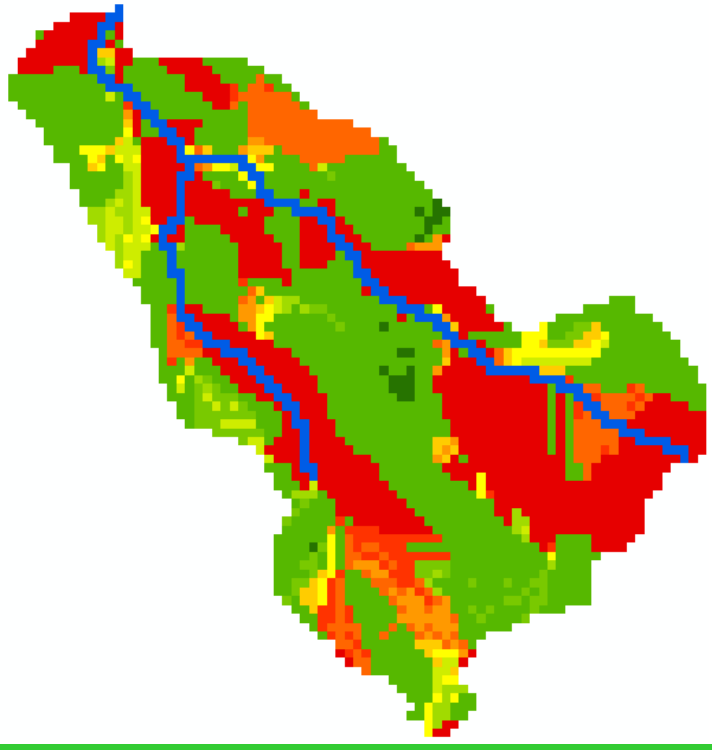
Legend

ir_p4cn1

<VALUE>

- 0
- > 0 - 5
- > 5 - 10
- > 10 - 15
- > 15 - 20
- > 20 - 25
- > 25 - 30
- > 30 - 35
- > 35 - 40

Fraction of initial surface runoff volume reaching the sw network



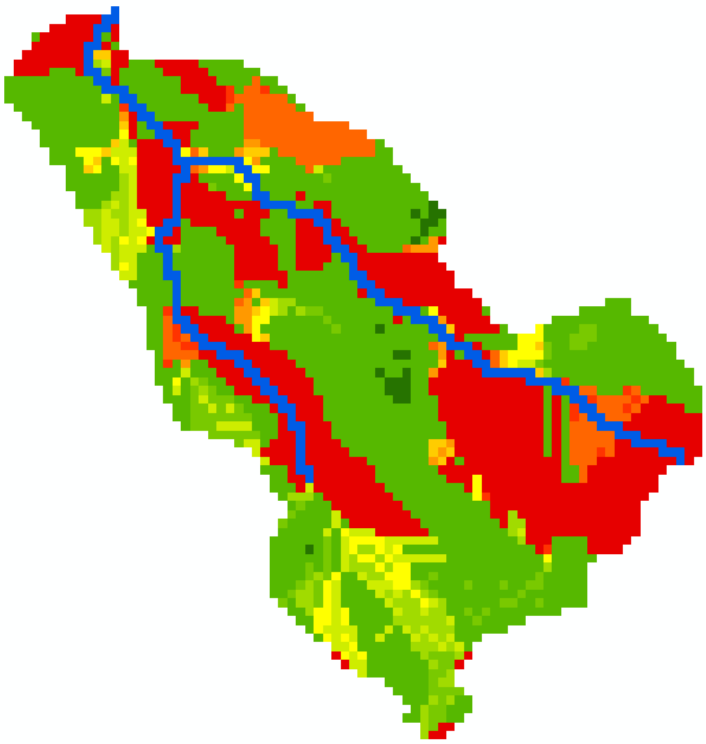
Legend

oft41wa

<VALUE>

- 0
- > 0 - 0.1
- > 0.1 - 0.2
- > 0.2 - 0.3
- > 0.3 - 0.4
- > 0.4 - 0.5
- > 0.5 - 0.6
- > 0.6 - 0.7
- > 0.7 - 0.8
- > 0.8 - 0.9
- > 0.9 - 1

Fraction of pesticide surface runoff loss reaching the sw network



Legend

oft41pr

<VALUE>

- 0
- > 0 - 0.1
- > 0.1 - 0.2
- > 0.2 - 0.3
- > 0.3 - 0.4
- > 0.4 - 0.5
- > 0.5 - 0.6
- > 0.6 - 0.7
- > 0.7 - 0.8
- > 0.8 - 0.9
- > 0.9 - 1

Fraction of pesticide erosion loss reaching the sw network

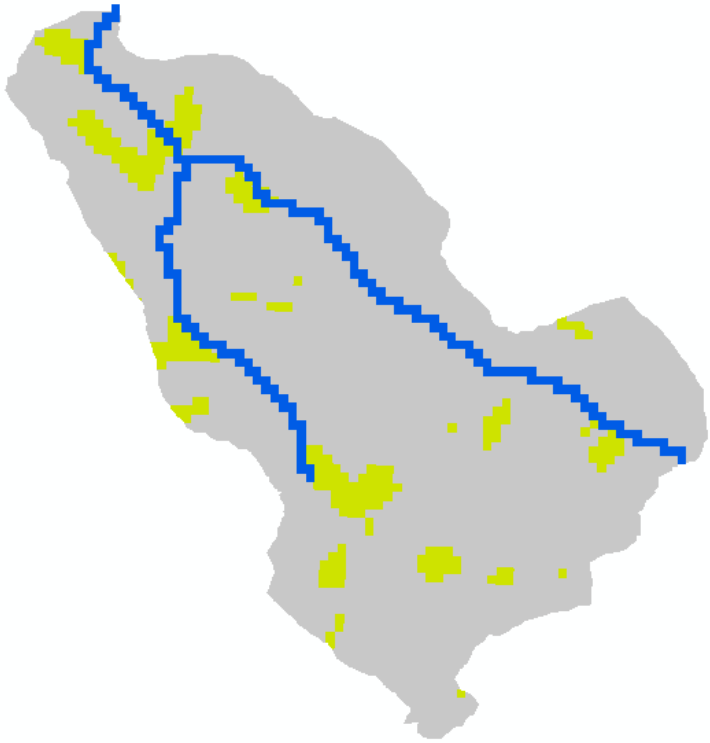
Legend

oft41ps

<VALUE>

- 0
- > 0 - 0.1
- > 0.1 - 0.2
- > 0.2 - 0.3
- > 0.3 - 0.4
- > 0.4 - 0.5
- > 0.5 - 0.6
- > 0.6 - 0.7
- > 0.7 - 0.8
- > 0.8 - 0.9
- > 0.9 - 1

Max. daily pesticide runoff losses (g ha^{-1}) from treated fields (dummy modelling data; example year)



Pesticide runoff losses (g/ha)

12_Test_Rohr_newLCLU_20090623

LRU_94__1

- NoData
- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- 1000 - 10000
- 10000 - 100000

Max. daily pesticide runoff inputs (g ha^{-1}) into sw (dummy modelling data; example year)

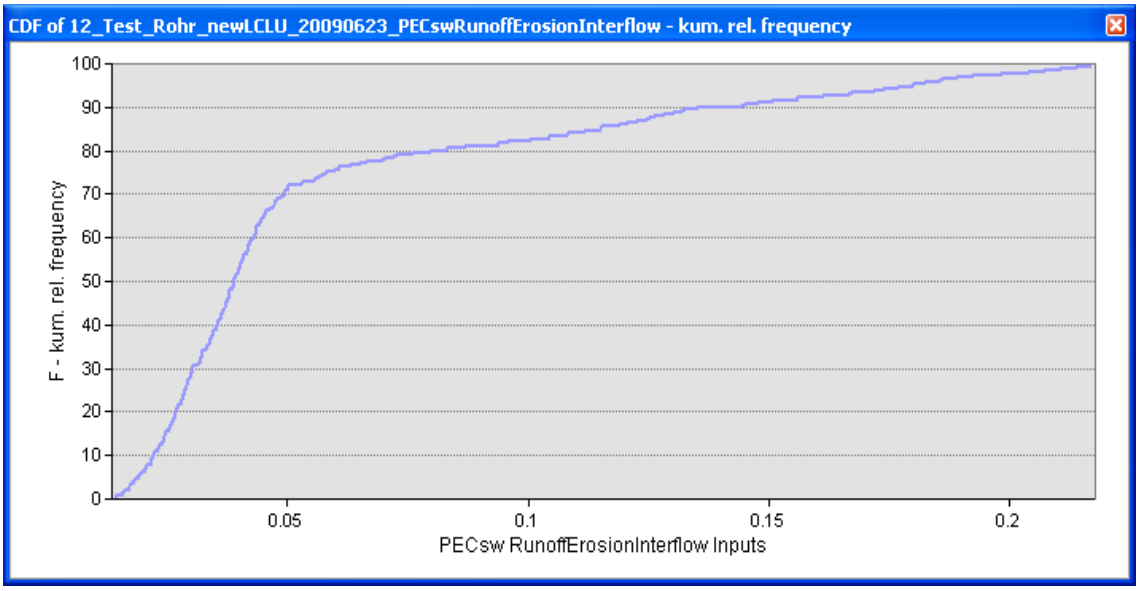
Pesticide runoff inputs (g/ha)

12_Test_Rohr_newLCLU_20090623

IRU_94__1

- NoData
- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- 1000 - 10000
- 10000 - 100000

PECsw at the catchment outlet (µg L^{-1}) (surface runoff + erosion + interflow)



Conclusions and perspectives

- The first generation tool FOOT-CRS is expected to make a valuable contribution to help achieve the objectives of the Water Framework Directive and to securing drinking water supplies in intensively used agricultural regions.
- The three FOOTPRINT tools
  - will be available on the FOOTPRINT website from late 2009 on
  - will be actively supported by the dedicated dissemination organisation FOOTWAYS
- FOOTWAYS is developing new, innovative tools which address existing limitations of FOOTPRINT
- The first training session on FOOT-CRS will be in January 2010 → check out the FOOTWAYS web site from next week!
- Evaluation results for the FOOTPRINT tools will become available in early 2010 for a number of study areas.

Thank you for your attention!

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Acknowledgements

> to the European Commission for the funding of FOOTPRINT

> to FOOTWAYS partners for their support

The five modules of FOOT-CRS and FOOT-NES (1)

1. Pesticide Scenario and Mitigation Manager

- Here the user specifies the pesticide application(s)
- Also allows to explore the effects of mitigation (= risk reduction) measures

2. Modelling Module

- Does the actual calculations
- Extracts values from the Modelling Databases
- Calculates concentrations in surface water
- Produces maps and Cumulative Distribution Functions (tables and graphs)

The five modules of FOOT-CRS and FOOT-NES (2)

3. Communication and Reporting

- Presentation of the output variables of the Modelling Module (maps, graphs, percentiles)
- Provides standard legends for output maps.

4. Data Manager

- Facilitates import of user data to be used in the Modelling Module (soil map, land cover, land use etc.)
- Administration of default and imported input data

5. Dominant Pathways Module

- Gives vulnerability estimates

Basic concept of FOOT-NES

> Modelling

- Groundwater (GW): leaching beyond bottom boundary of the soil profile (2 m)
- SW: hypothetical edge-of-field surface water bodies (FOCUS ditch, stream, pond; with FOCUS upstream catchment)
- PEC are calculated for each combination of agro-environmental scenario (NUTS2/climate/SMU/CLC), STU and crop afterwards spatial aggregation to maps and Cumulative Distribution Functions (CDFs)

> FOOT-NES output

- Maps and spatial CDFs of pesticide leaching concentrations (PECgw)
- Maps and spatial CDFs of
  - pesticide losses from fields and pesticide inputs into surface water
  - Predicted Environmental Concentrations and Time Weighted Average Concentrations in surface water and sediment (PECsw/sed and TWACsw/sed)

The FOOT-NES tool

> To be used at the large scale by EU and MS policy- and decision-makers, ministries, potentially pesticide registration authorities

> Prospective exposure / risk assessment

> Emphasis on:

1. Identifying the areas most at risk from pesticide contamination (maps)
2. Assess the probability of pesticide concentrations exceeding legal or ecotoxicologically-based thresholds (spatial CDFs)

> Add-on (toolbar) in ArcGIS

The FOOT-FS tool

> To be used at the farm level by extension advisers and farmers

> Mitigation and Best Management Practices (BMP)

> Emphasis on:

1. Identifying the pathways and areas most contributing to contamination of water resources by pesticides
2. Providing site-specific recommendations to limit transfers of pesticides in the local agricultural landscape

> Stand-alone application