# Modeling of pesticide fate in a luxembourgish catchment with the Soil and Water Assessment Tool (SWAT) - combining modeling and monitoring

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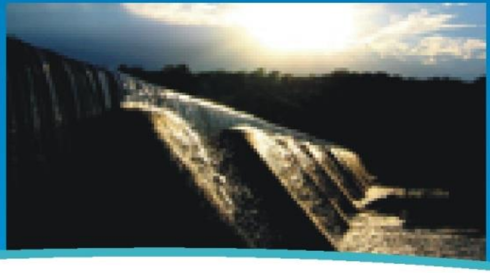
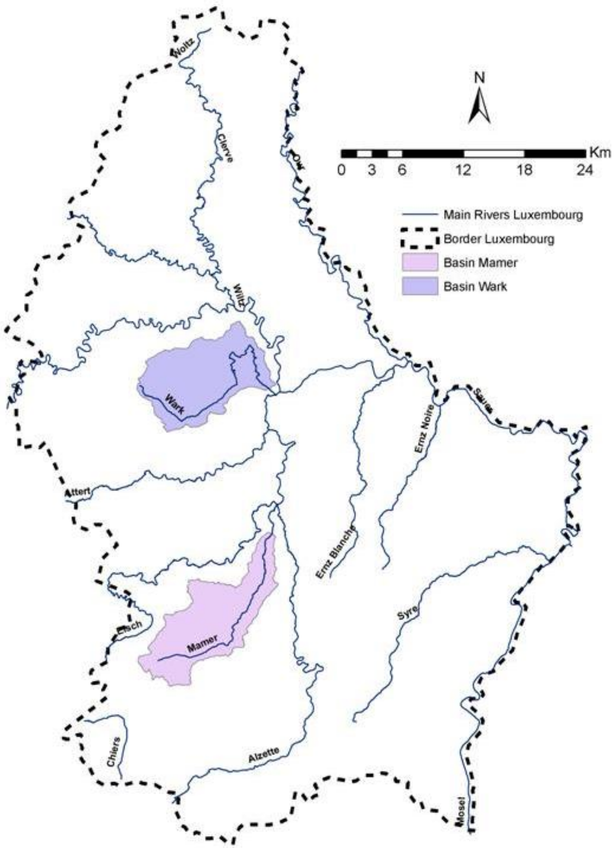


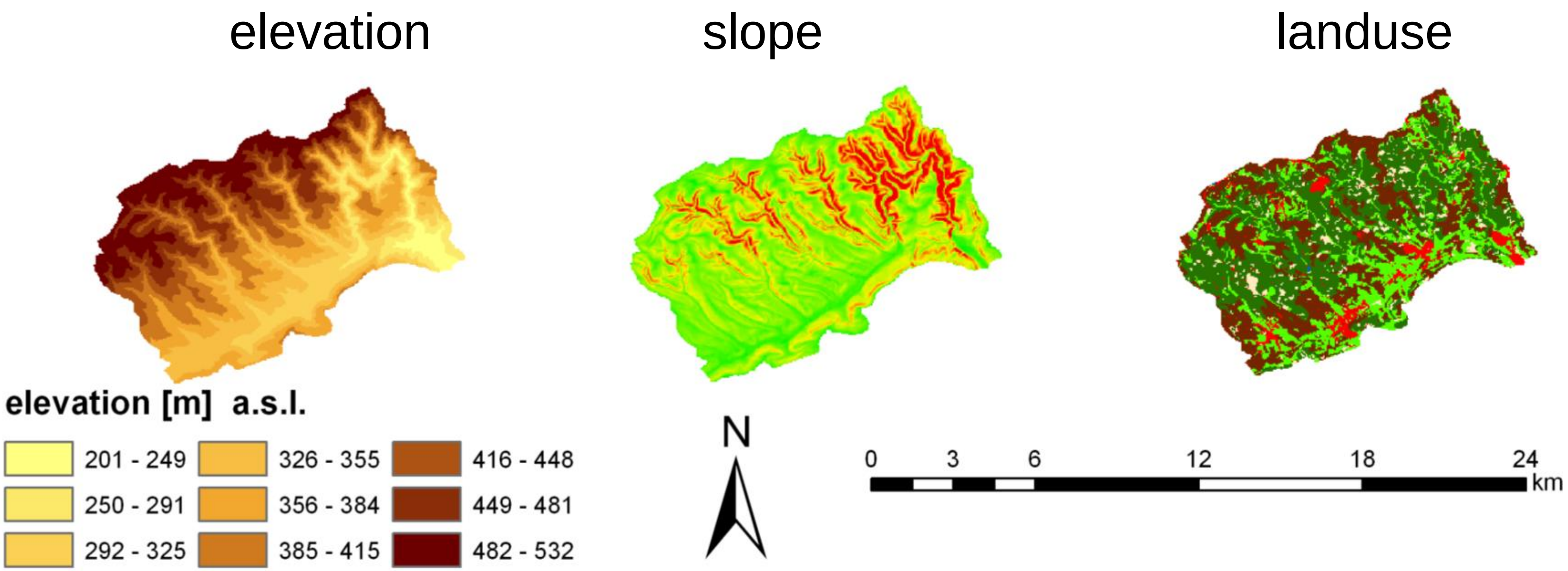
# $M^3$, WFD and POCIS

- $M^3$ is a demonstration project for WFD policy implementation of the LIFE+ programme
- $M^3$ tests state-of-the-art monitoring and modelling tools for programme of measures (POM) evaluation




**Can passive samplers (POCIS) help to validate and improve simulations of pesticide fate ?**

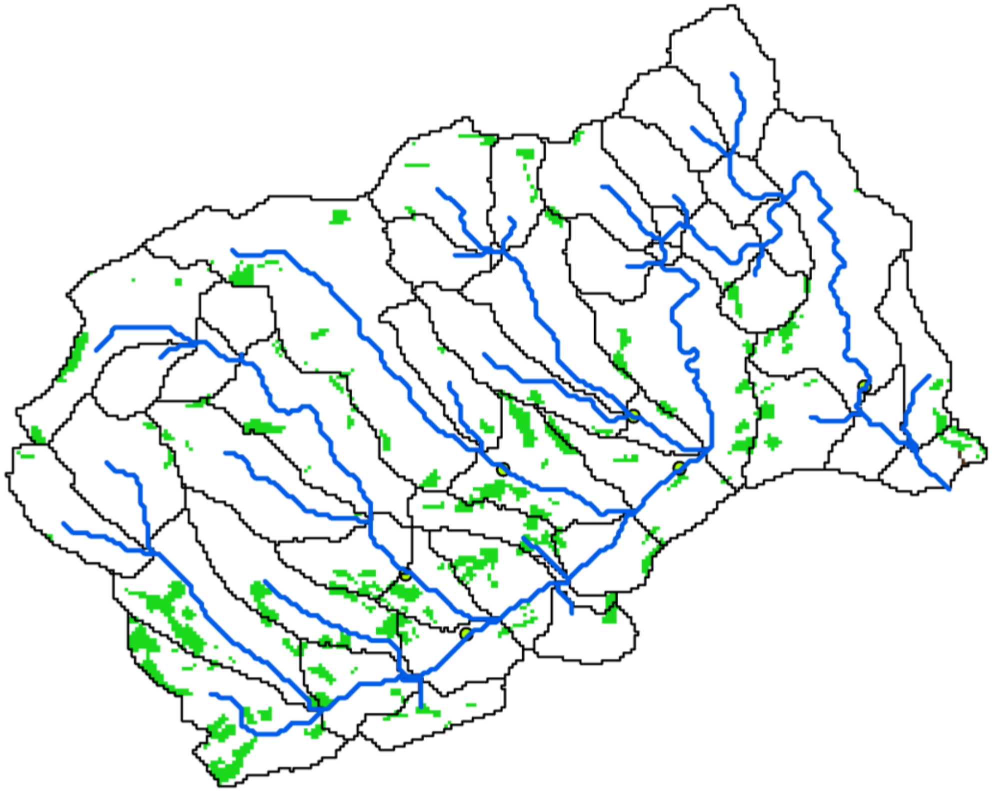
# The watershed




Land use: ~ 30% managed pasture
~ 30% agriculture (corn, winter cereals, summer cereals)
~ 6% urban area

# The watershed

- **Wark watershed → ca. 82km²**
- **First simulation concentrate on Terbuthylazine**
- **Applied on corn (~ 465 ha in 2011)**
- **Statistics indicate a application of 600 g/ha on average**



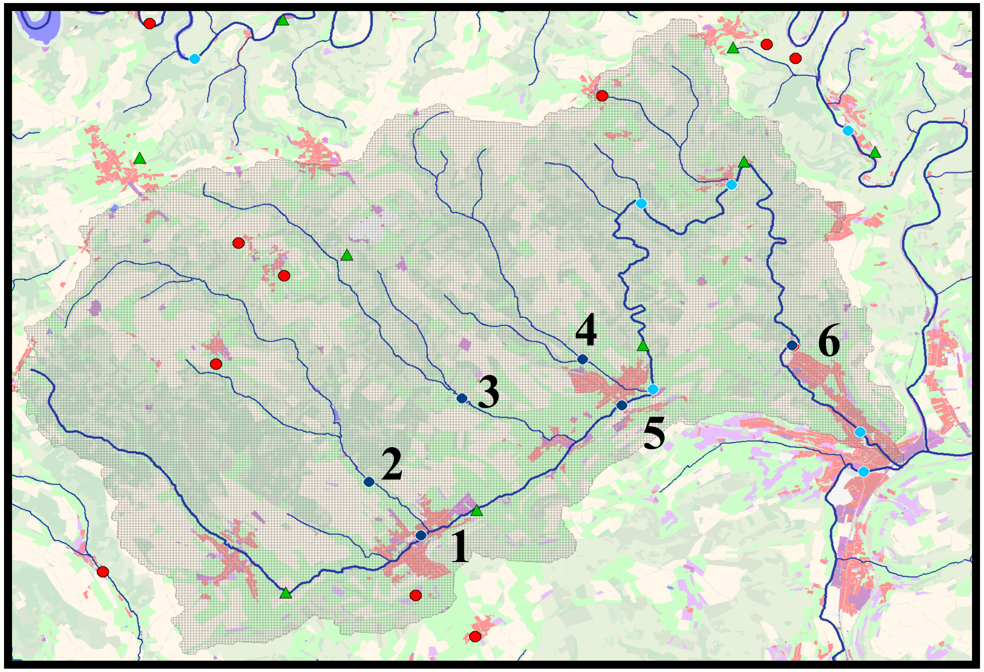
| SKOC | WOF | HLIFE_F | HLIFE_S | AP_EF | WSOL |
|---|---|---|---|---|---|
| 220 | 0.9 | 40 | 45 | 0.75 | 8.5 |

# Sources and dynamics of pesticide emissions

| Pesticide emission | Spatial property | Trigger/Period | Monitoring technique |
|---|---|---|---|
| Cleaning of equipment, spilling of leftovers | WWTP, runoff from sealed surfaces | During application period, random | Passive sampler |
| Surface runoff fields, interflow, drainage | Diffuse input | Floodwaves, following intensive or sustained rain events | Triggered Autosamplers; Passive sampler |
| Groundwater flow | Diffuse input | +/- constant | Passive sampler, grab samples |

# Case study Wark:Monitoring setup

| Campaign | Aim | Validation strategy | Location(s) | Parameters |
|---|---|---|---|---|
| Event-triggered autosampler | Capture pesticide runoff in flood waves | Verify pesticide use and runoff behaviour in the catchment on 12 events | Catchment outlet | Pesticides, Anions, o-$PO_4$, $NH_4$, POC, DOC, part. P |
| Passive Samplers (POCIS) River | Continuous monitoring of pesticide immission concentration | Two-week exposure of POCIS provide mean concentrations to verify mass balances | 6 sampling locations in the Wark and tributaries | Pesticides |
| Passive Samplers (POCIS) WWTPs | Continuous monitoring of pesticide emissions | Mean emission concentrations provide base-flow contribution of WWTPs | 5 WWTPs in agricultural settings | Pesticides |

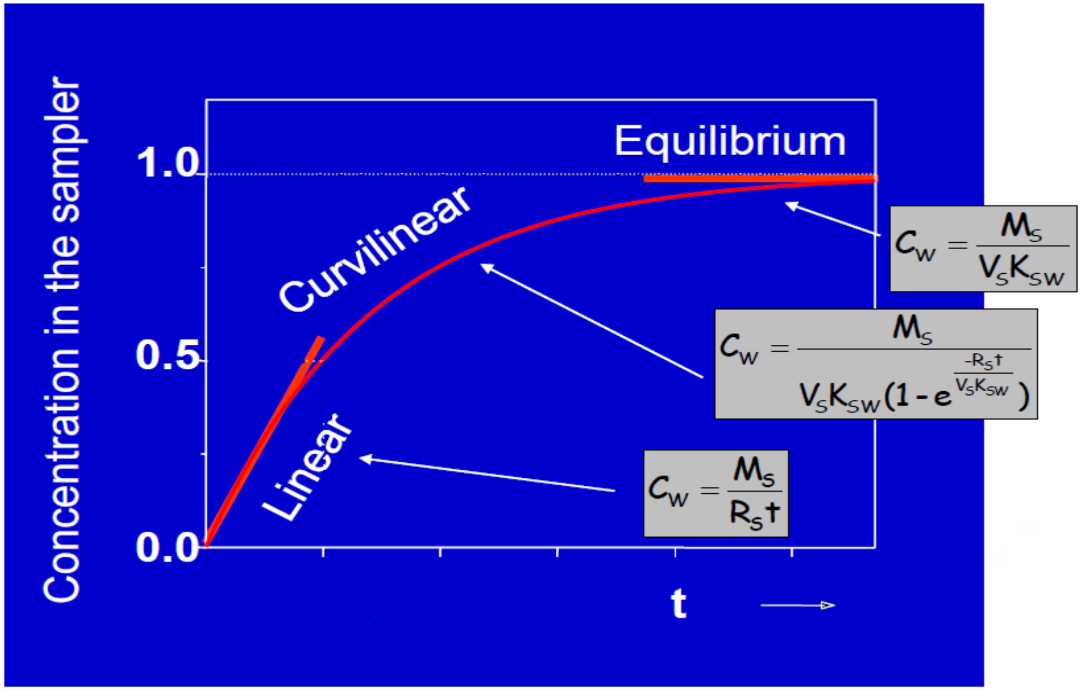



## POCIS theory

### Main factors that influence adsorbed xenobiotic concentration (Cs):

- Adsorption rate: ku
- Desorption rate : ke
- Time of exposure: t
- Xenobiotic concentration in water: Cw

$$\frac{dCs}{dt} = ku\ Cw - keCs$$




$$\boxed{Cw = \frac{Ms(t)}{Rs * t}}$$

**With Rs= ku $V_T$**

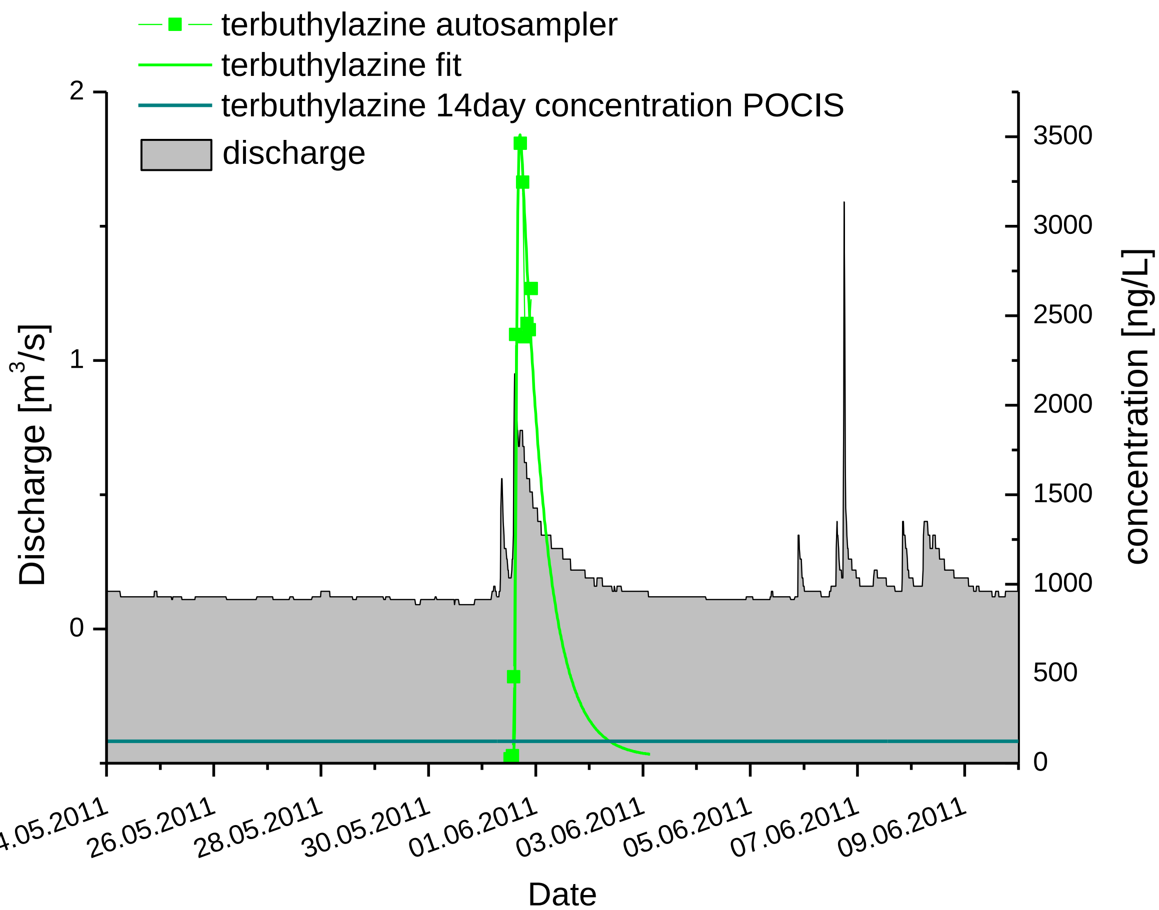
**(lab determination)**

**$R_S$: sampling rate [L/d]**
**$k_u$: uptake rate constant**
**$V_T$: volume of water tank**

## Combination of POCIS and autosampler:

## Possibility of xenobiotic load calculations during not-monitored period

**Wark river at Warken**

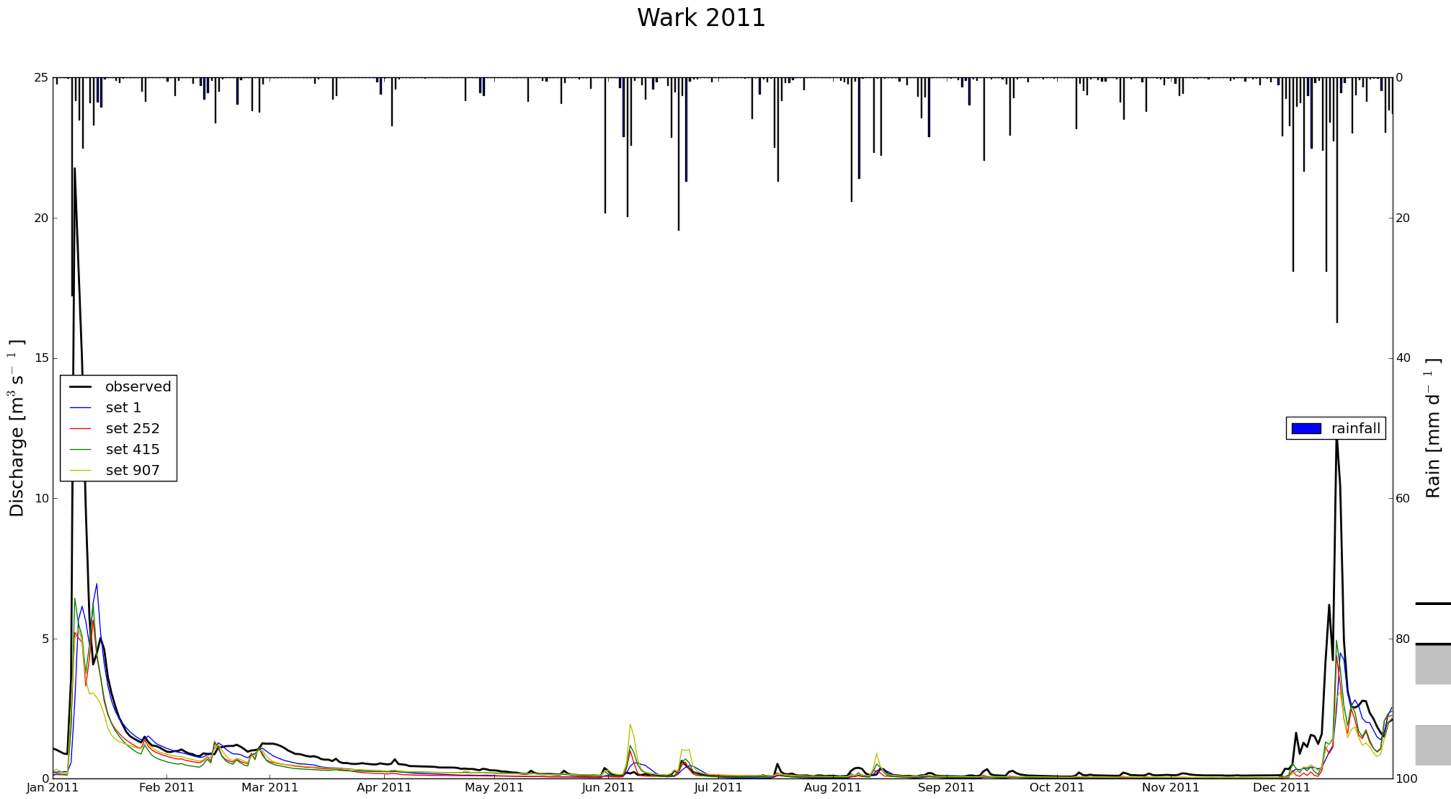


## Calculation of terbuthylazine balance

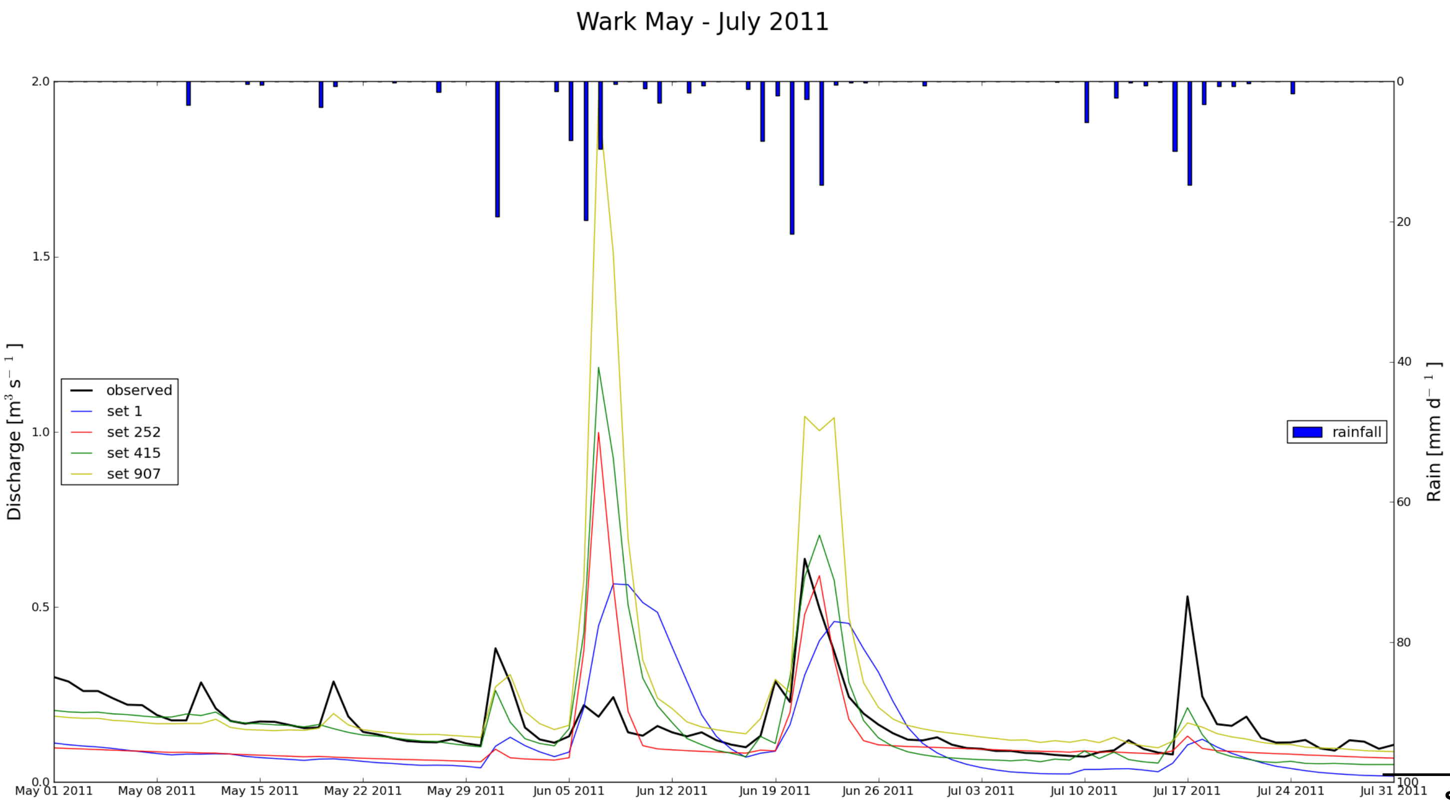
| | Duration | Mean concentration (ng/L) | Rs (L/d) | Mass POCIS (ng) |
|---|---|---|---|---|
| POCIS | 14.0 days | 127 | 0.57 | 1013.5 |
| Autosampler – floodwave | 2.1 days | 750 | 0.57 | 897.8 |
| Difference for other days | 11.9 days | | | 115.7 |

**$C_W$ (base flow average)= 17 ng/L on the 12 days outside of floodwave**

- **Green-Ampt infiltration with 10 min rainfall**
- **Monte-Carlo Simulation with latin hypercube sampling**
- **Soil hydrology, groundwater, routing parameters**
- **2500 runs**




| set | NSE | NSE-log |
|---|---|---|
| 1 | 0.4626 | 0.4559 |
| 252 | 0.4785 | 0.614 |
| 415 | 0.5343 | 0.7185 |
| 907 | 0.4556 | 0.7992 |

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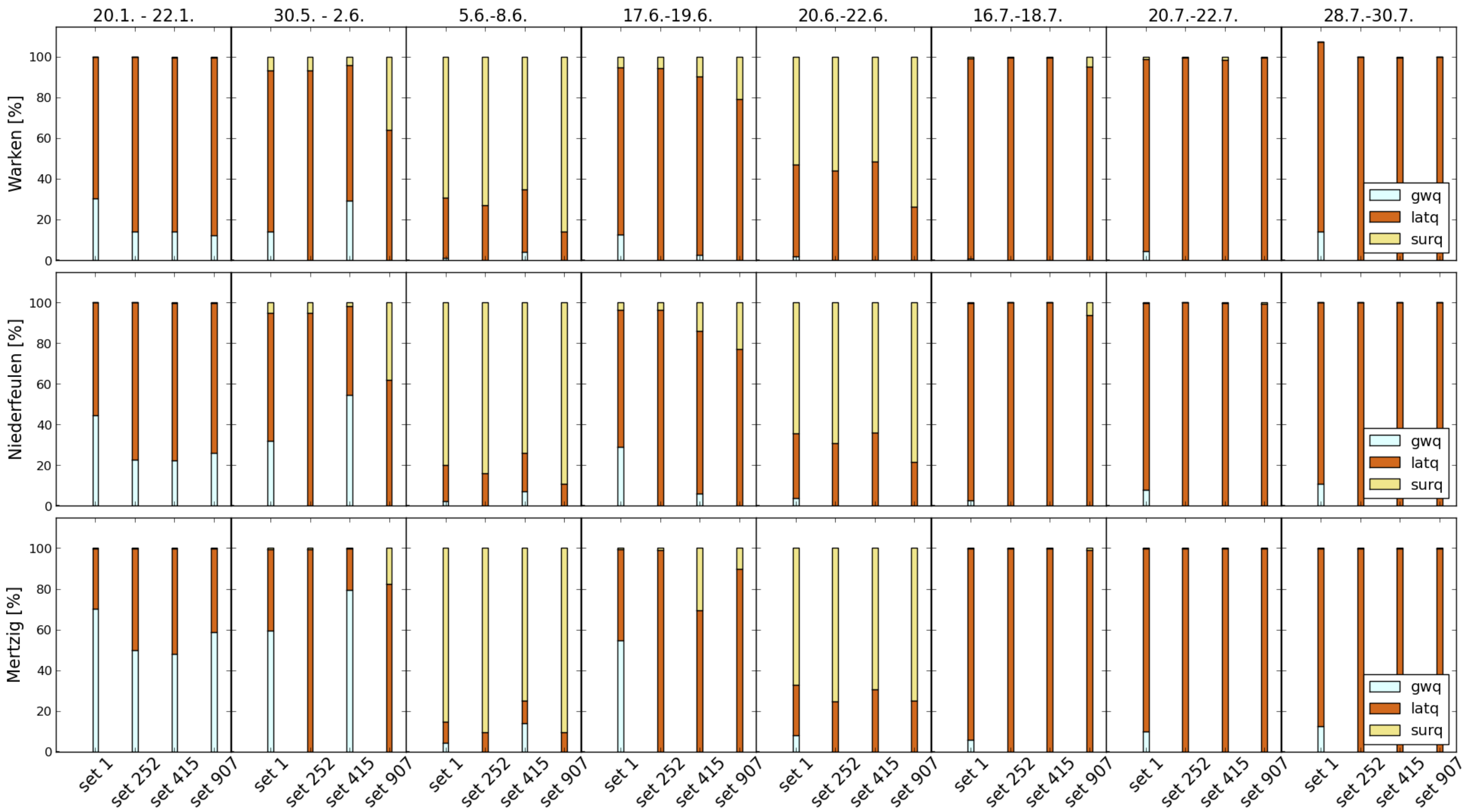
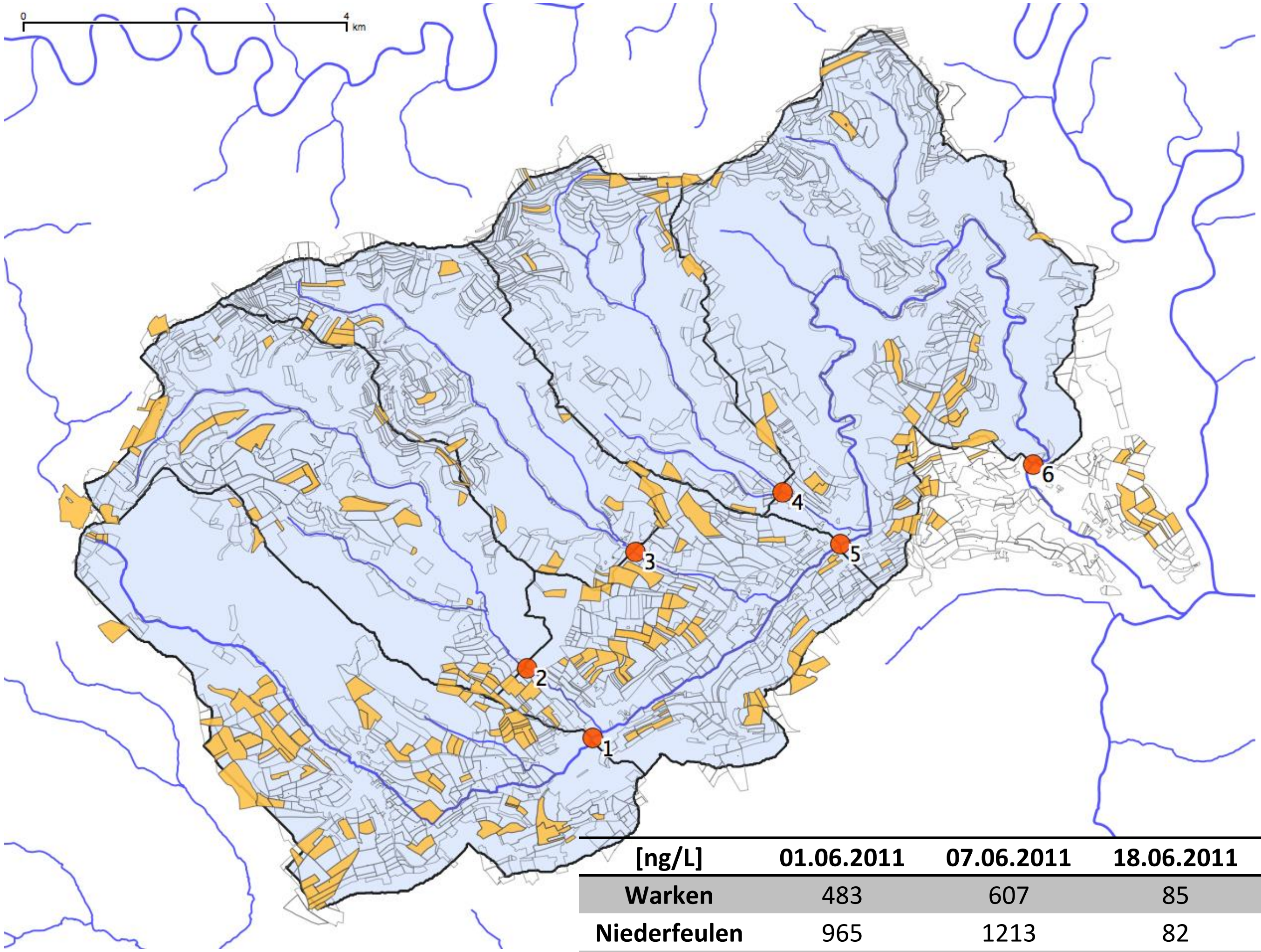

20.1. - 22.1.
30.5. - 2.6.
5.6.-8.6.
17.6.-19.6.
20.6.-22.6.
16.7.-18.7.
20.7.-22.7.
28.7.-30.7.
Warken [%]
Niederfeulen [%]
Mertzig [%]
gwq
latq
surq
set 1
set 252
set 415
set 907

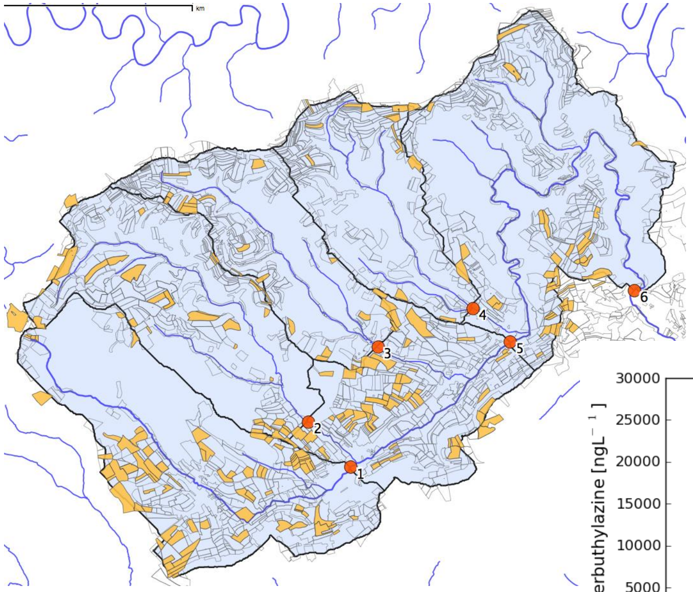


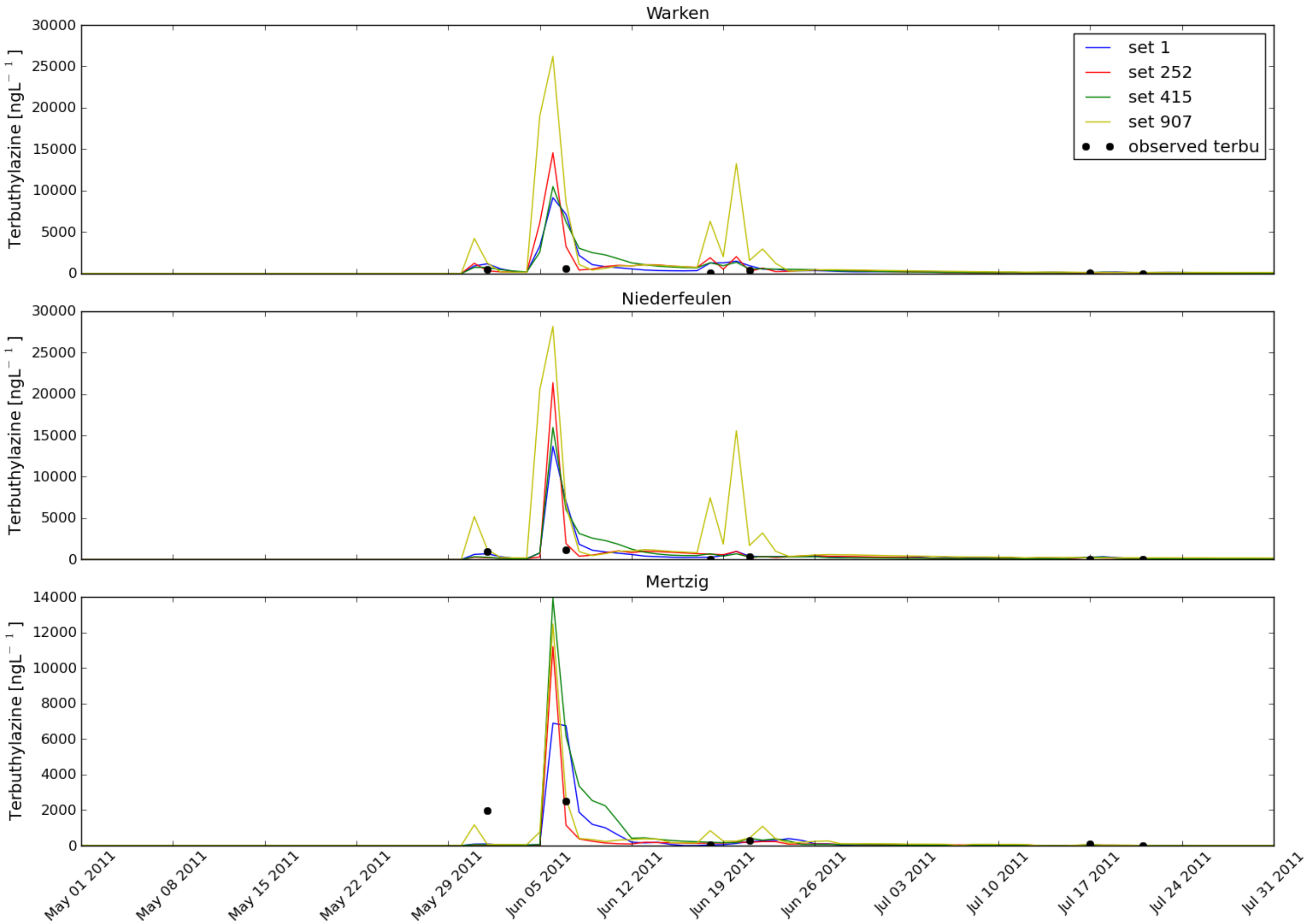

| [ng/L] | 01.06.2011 | 07.06.2011 | 18.06.2011 | 21.06.2011 | 17.07.2011 | 21.07.2011 |
|---|---|---|---|---|---|---|
| **Warken** | 483 | 607 | 85 | 366 | 89 | 26 |
| **Niederfeulen** | 965 | 1213 | 82 | 354 | 59 | 17 |
| **Fel** | 12 | 15 | 2 | 10 | 10 | 3 |
| **Mechelbaach** | 8 | 10 | 3 | 12 | 14 | 4 |
| **Turel** | 15 | 19 | 144 | 617 | 105 | 30 |
| **Mertzig** | 1987 | 2498 | 72 | 308 | 81 | 23 |



# Results Pesticides

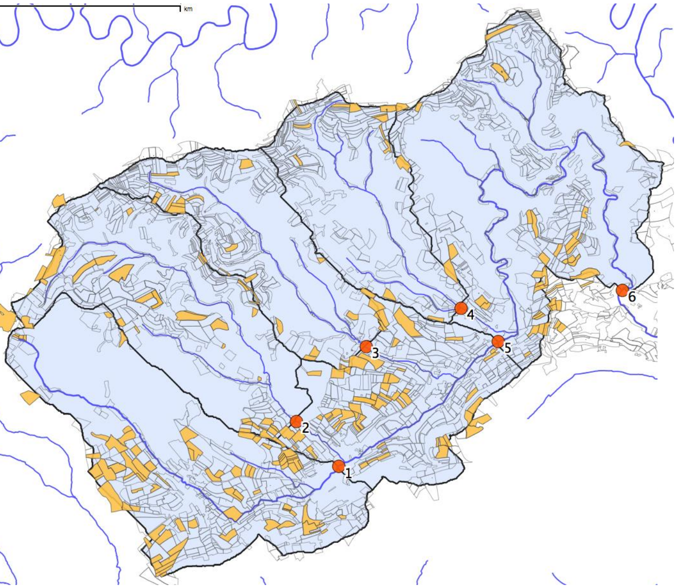
# results



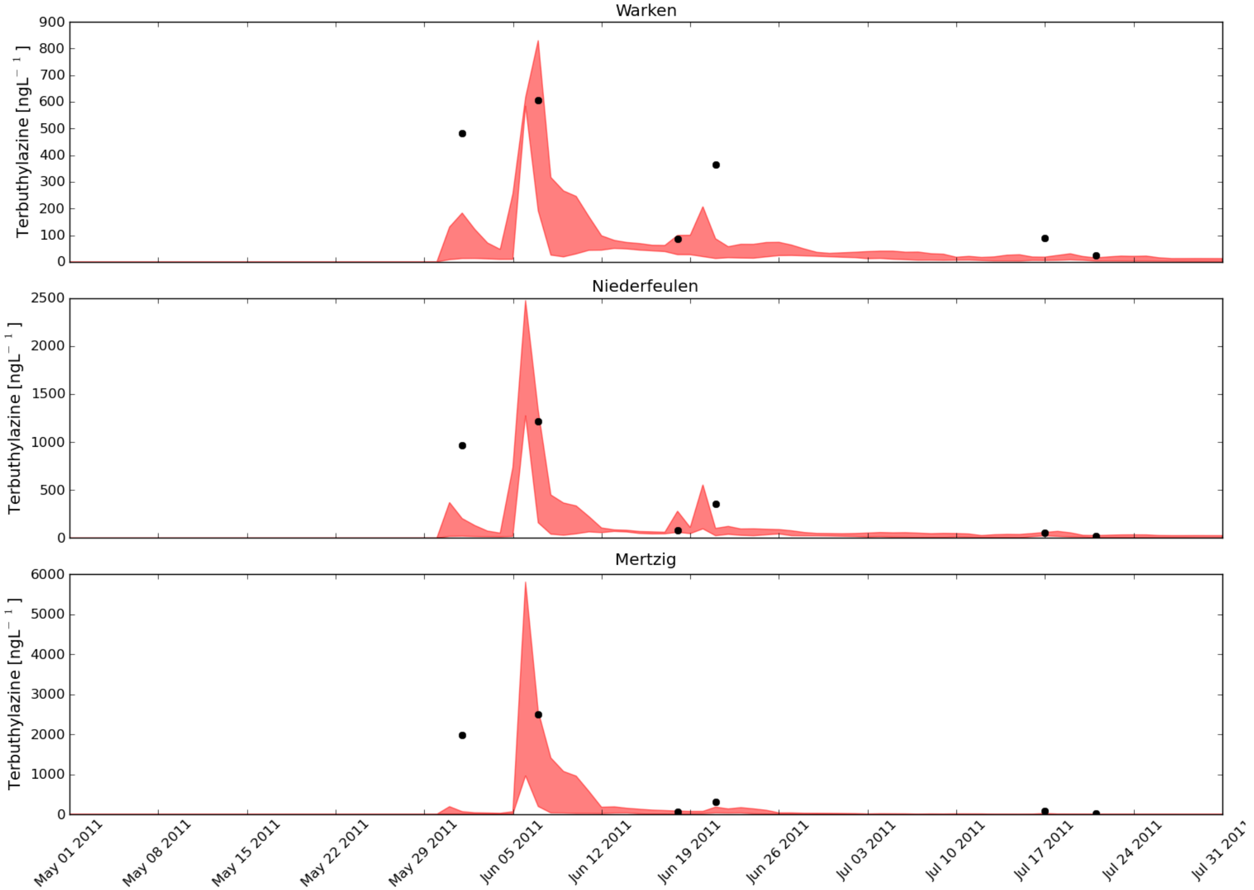




| | Experiment 1 | |
|---|---|---|
| **POCIS catchment** | **First application** | **Second application** |
| **Mertzig** | May 23rd<br>0.37 | June 3rd<br>0.295 |
| **Niederfeulen** | May 23rd<br>0.37 | June 3rd<br>0.295 |
| **Turelbach** | May 23rd<br>0.37 | June 3rd<br>0.295 |
| **Mechelbach** | May 23rd<br>0.37 | June 3rd<br>0.295 |
| **Fel** | May 23rd<br>0.37 | June 3rd<br>0.295 |
| **Downstream Niederfeulen** | May 23rd<br>0.37 | June 3rd<br>0.295 |

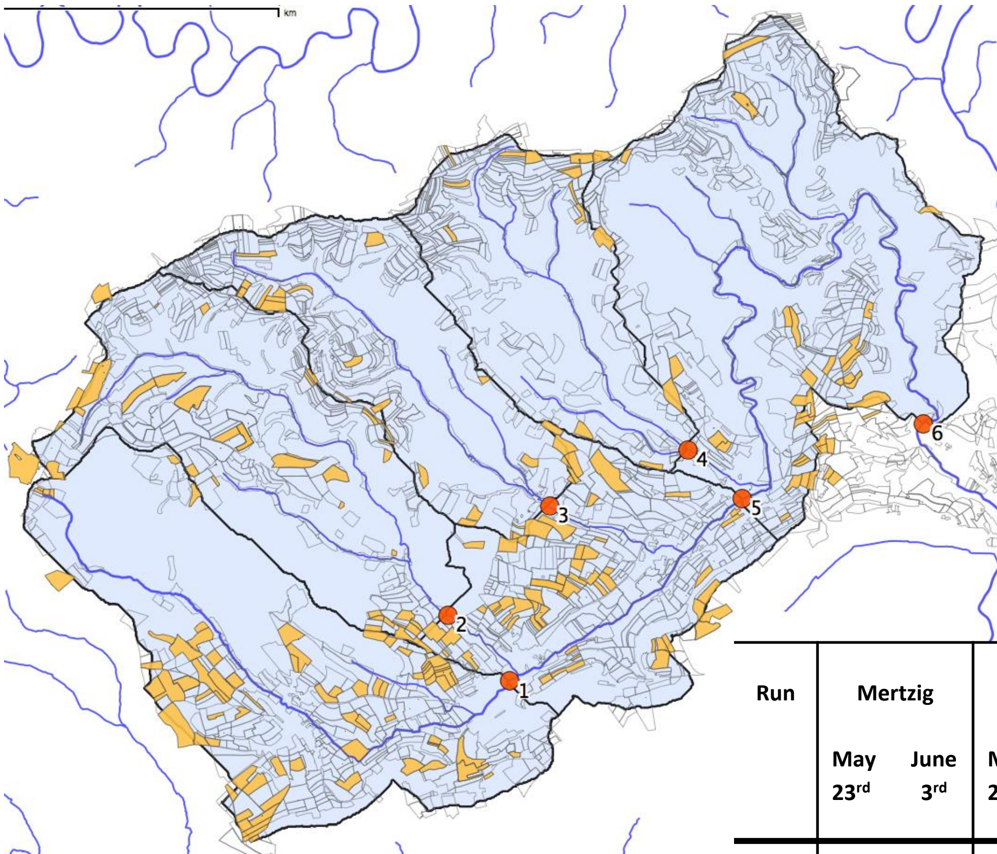
# results




| | Experiment 2 | |
|---|---|---|
| **POCIS catchment** | **First application** | **Second application** |
| **Mertzig** | May 23rd<br>0 - 0.35 | June 3rd<br>0 - 0.3 |
| **Niederfeulen** | May 23rd<br>0 - 0.35 | June 3rd<br>0 - 0.3 |
| **Turelbach** | May 23rd<br>0 - 0.3 | June 15th<br>0 - 0.2 |
| **Mechelbach** | May 23rd<br>0 - 0.1 | June 3rd<br>0 - 0.1 |
| **Fel** | May 23rd<br>0 - 0.1 | June 3rd<br>0 - 0.1 |
| **Downstream Niederfeulen** | May 23rd<br>0 - 0.35 | June 3rd<br>0 - 0.3 |



# results

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| Run | Mertzig | | Niederfeulen | | Turelbaach | | Mechelbaach | | Fel | | Downstream Niederfeulen | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | May 23rd | June 3rd | May 23rd | June 3rd | May 23rd | June 15th | May 23rd | June 3rd | May 23rd | June 3rd | May 23rd | June 3rd |
| 95 | 0.14 | 0.05 | 0.28 | 0.04 | 0.00 | 0.06 | 0.09 | 0.03 | 0.01 | 0.09 | 0.04 | 0.21 |
| 151 | 0.26 | 0.05 | 0.23 | 0.15 | 0.07 | 0.07 | 0.06 | 0.02 | 0.06 | 0.07 | 0.04 | 0.03 |
| 487 | 0.13 | 0.15 | 0.11 | 0.03 | 0.00 | 0.03 | 0.09 | 0.04 | 0.06 | 0.09 | 0.00 | 0.26 |
| 573 | 0.07 | 0.14 | 0.12 | 0.26 | 0.04 | 0.11 | 0.00 | 0.06 | 0.07 | 0.06 | 0.03 | 0.26 |
| 576 | 0.33 | 0.28 | 0.00 | 0.08 | 0.00 | 0.14 | 0.08 | 0.00 | 0.00 | 0.05 | 0.03 | 0.17 |
| 896 | 0.06 | 0.20 | 0.22 | 0.14 | 0.01 | 0.00 | 0.05 | 0.08 | 0.01 | 0.01 | 0.00 | 0.17 |

# to conclude:

- For the simulation of pesticide exports the model has to be able to predict the driving hydrological processes to a satisfactory degree. This includes the ability of the model to simulate rainfall-runoff events at a similar temporal and spatial scale as they occur in reality.
- The use of models is connected with a minimum requirement of monitoring data e.g. measured discharge and rain fall to drive the model correctly and to assess the model ability to correctly predict all relevant rainfall runoff processes
- Devices like POCIS are useful tools to spatially validate the simulated pesticide exports from agricultural areas. Although their informational value rises and falls with additional data like spatially discrete discharge and rain fall to correctly interpret the results of the POCIS measurements.
- For the simulation of pesticide exports from agricultural fields detailed information on application dates and amounts on regional scale are necessary.