Identification of Transport Processes, Herbicide Source Area Variability, and VFS Effectiveness in a High Agricultural Intensity Catchment

Hendrik Rathjens[1], Michael Winchell[1], Robin Sur[2], Dirk Baets[2], Florian Krebs[3], David Lembrich[2]

[1]Stone Environmental, [2]Bayer Crop Science Division, [3]Dr. Knoell Consult

NC STATE UNIVERSITY

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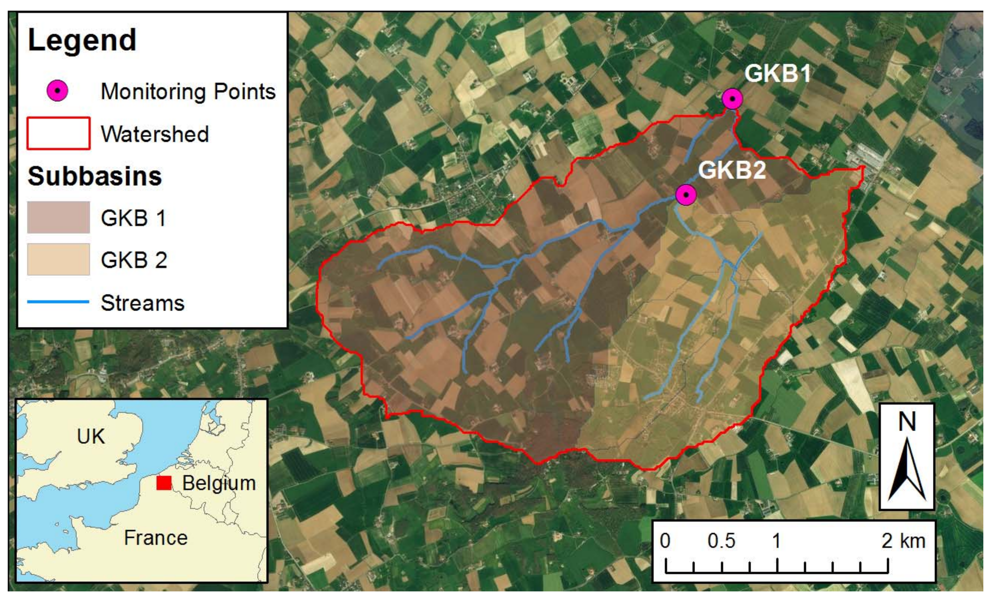
Objectives

The occurrence of herbicides in surface waters of intensively cultivated catchments can originate from a variety of sources. The objective of this study was to evaluate herbicide transport processes and estimate source areas.

The evaluation combined modeling, monitoring, and pesticide application data:

- Surface water monitoring of agricultural use pesticides with frequent detections over 3.5 years
- Detailed application data
- Application of a physically-based water quality model (SWAT)

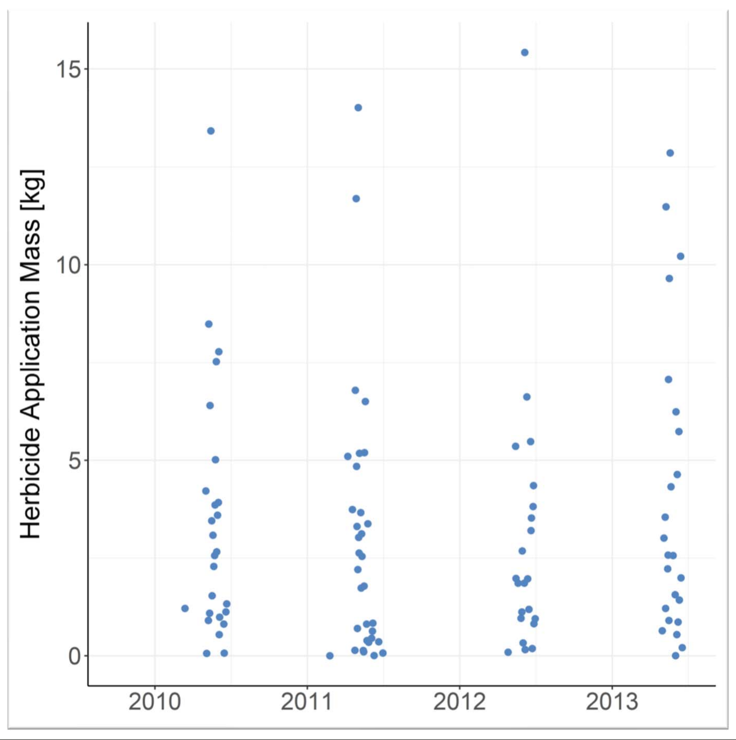
Study Area – Grote Kemmelbeek Catchment



The occurrence of herbicides in surface waters of intensively cultivated catchments can originate from a variety of sources. These include transport via runoff and erosion during storm events, subsurface transport through lateral flow and through subsurface tile drains, baseflow, from spray drift during applications, and from point sources.

Study area: 992 ha
Main landuse: Agriculture (> 90 %)
Elevation: 159 m to 24 m
Precipitation: 816 mm per year

Monitoring Data



Surface water monitoring

- Two sampling points (GKB1 and GKB2)
- May 17th, 2010 to December 31st, 2013
- Flow velocity and water level measurement every 5 minutes
- Water sampling every 0.5 to 2 hour (1–4 composite samples per day)

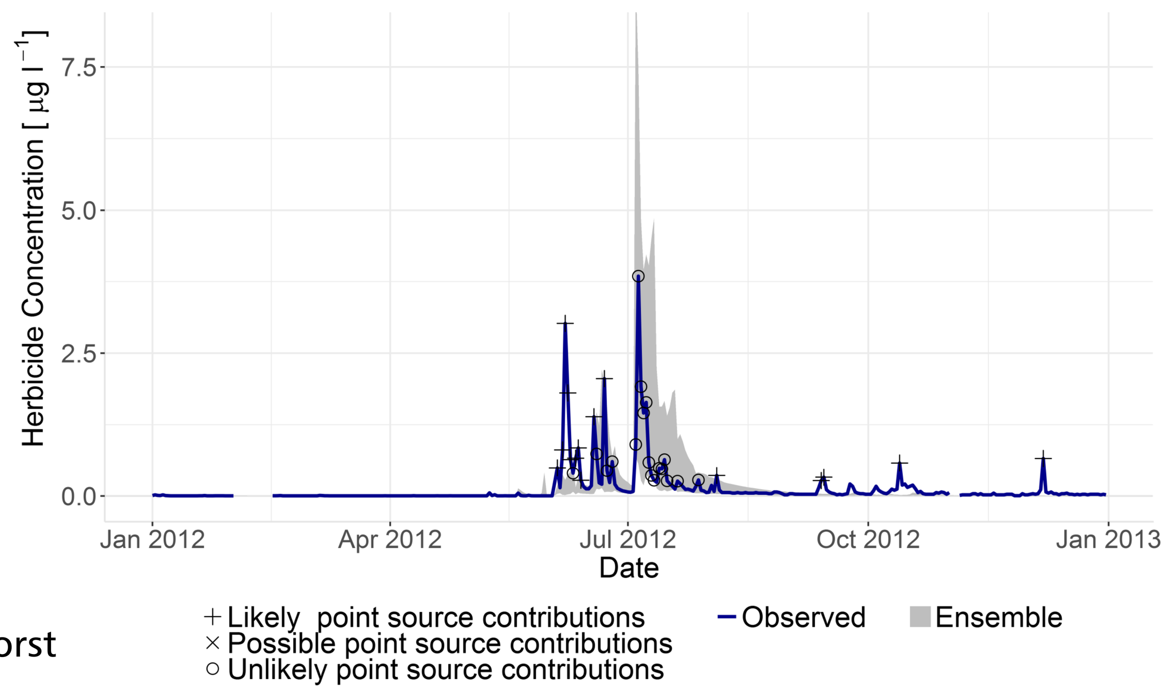
Farmer's survey field-based application data

- 115 farmers participated
- Field specific pesticide application data was collected (product used, field treated, and application rate)
- Collected from October 10, 2009 to June 6, 2013

Point Source Identification

Possible Causes for Point Sources

- Washing of sprayer equipment on impervious surfaces directly connected to drains
- Filling area directly adjacent to stream
- Improper disposal of empty containers
- Runoff via furrows installed by farmers to drain water from fields
- Undocumented agricultural/non-agricultural uses
- Misuse of the product



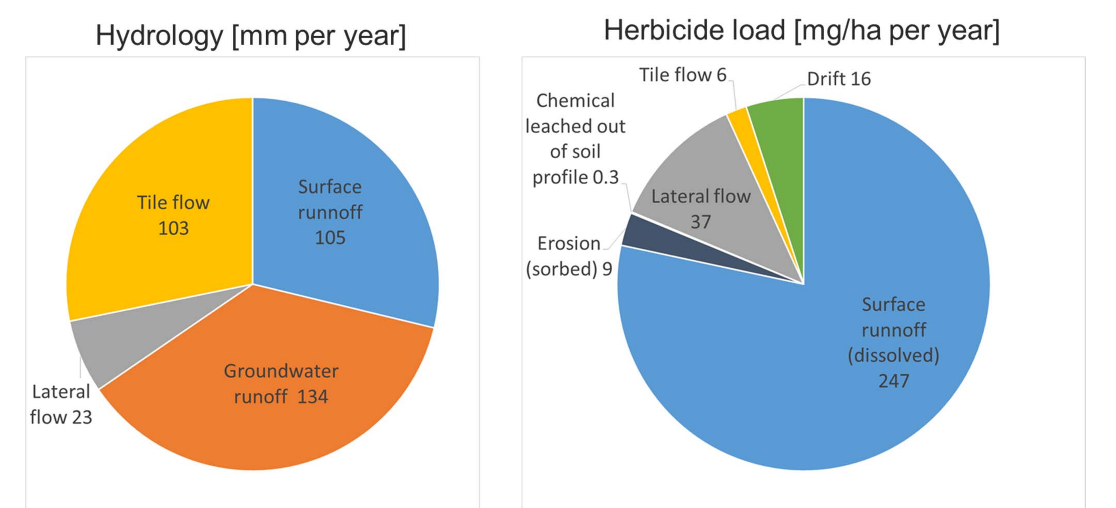
A Monte Carlo simulation and classification approach that accounts for worst case conditions and uncertainty in hydrology, surface flow (curve number), subsurface flow (aquifer parameters), pesticide percolation, drift and application timing was used to estimate point source contribution.

Likely point source contributions: 46% (34)
Possible point source contributions : 3 % (2)
Unlikely point source contributions : 51 % (38)

Classification Approach of Concentration Peaks (above 0.25 µg/l)

- Likely diffuse source (unlikely point source contributions)
  - If the observed peak is less than the maximum of the model ensemble
- Possible diffuse source (possible point source contributions),
  - If the observed peak is greater than the maximum of the model ensemble but less than the 3 day rolling average of the ensemble maximum
- Unlikely diffuse source (likely point source contributions),
  - If the observed peak is greater than the maximum of the model ensemble and greater than the 3 day rolling average of the ensemble maximum

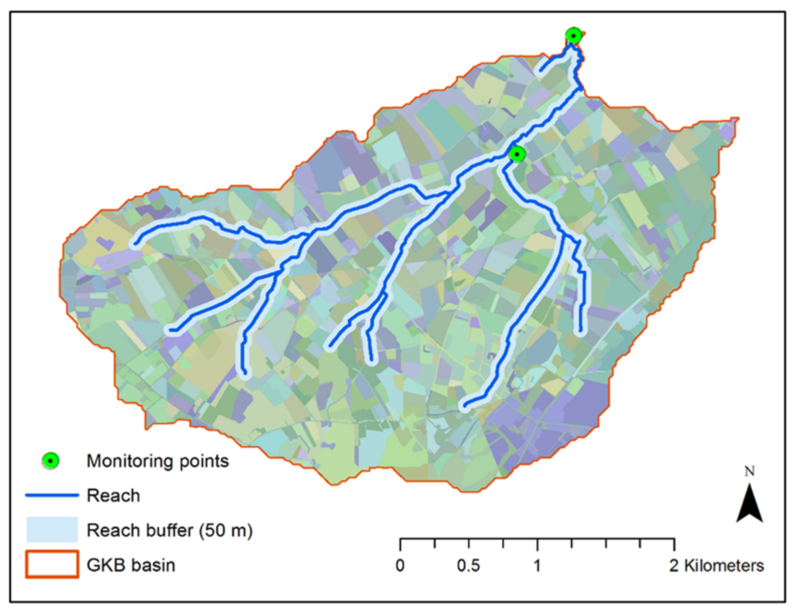
Long-Term Source Analysis of Diffuse Source Events (Watershed Scale)

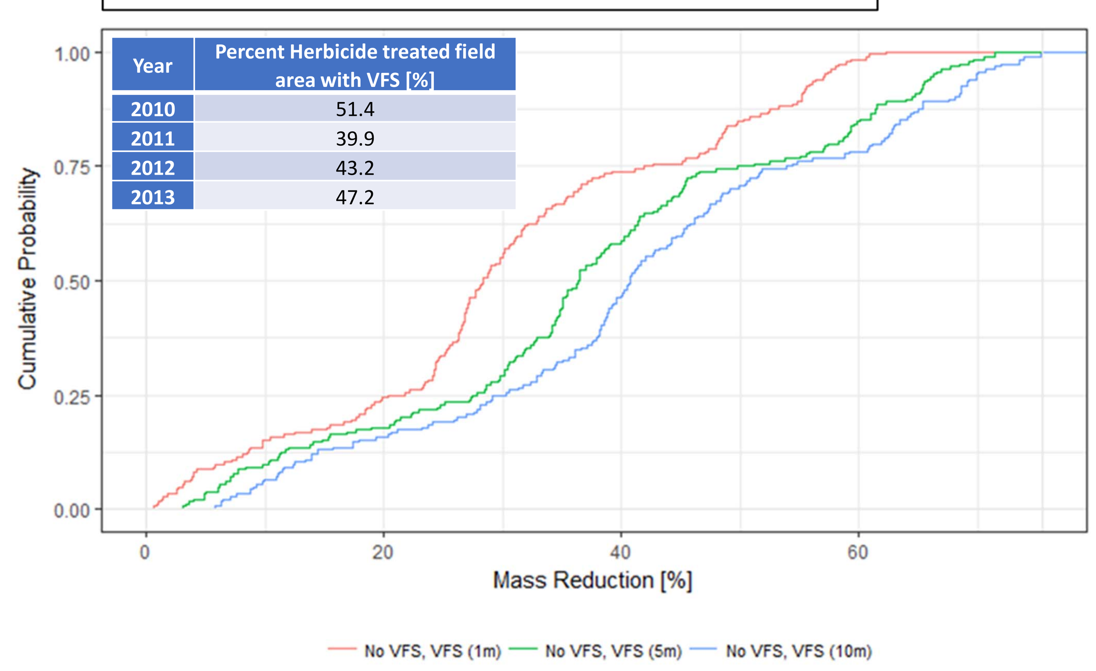


Runoff flow of soluble pesticide is the major contributor

Vegetative Buffer Strip Simulation

- VFSs were simulated on all field within 50 m of streams
  - 40% to 51% of pesticide-treated fields had VFSs
- Three buffer widths were simulated: 1 m, 5 m, and 10 m
  - Median long-term effectiveness in total mass reduction ranged from 28% (1 m buffer) to 41% (10 m buffer)
  - Maximum effectiveness was as high as 75%





Year	Percent Herbicide treated field area with VFS [%]
2010	51.4
2011	39.9
2012	43.2
2013	47.2

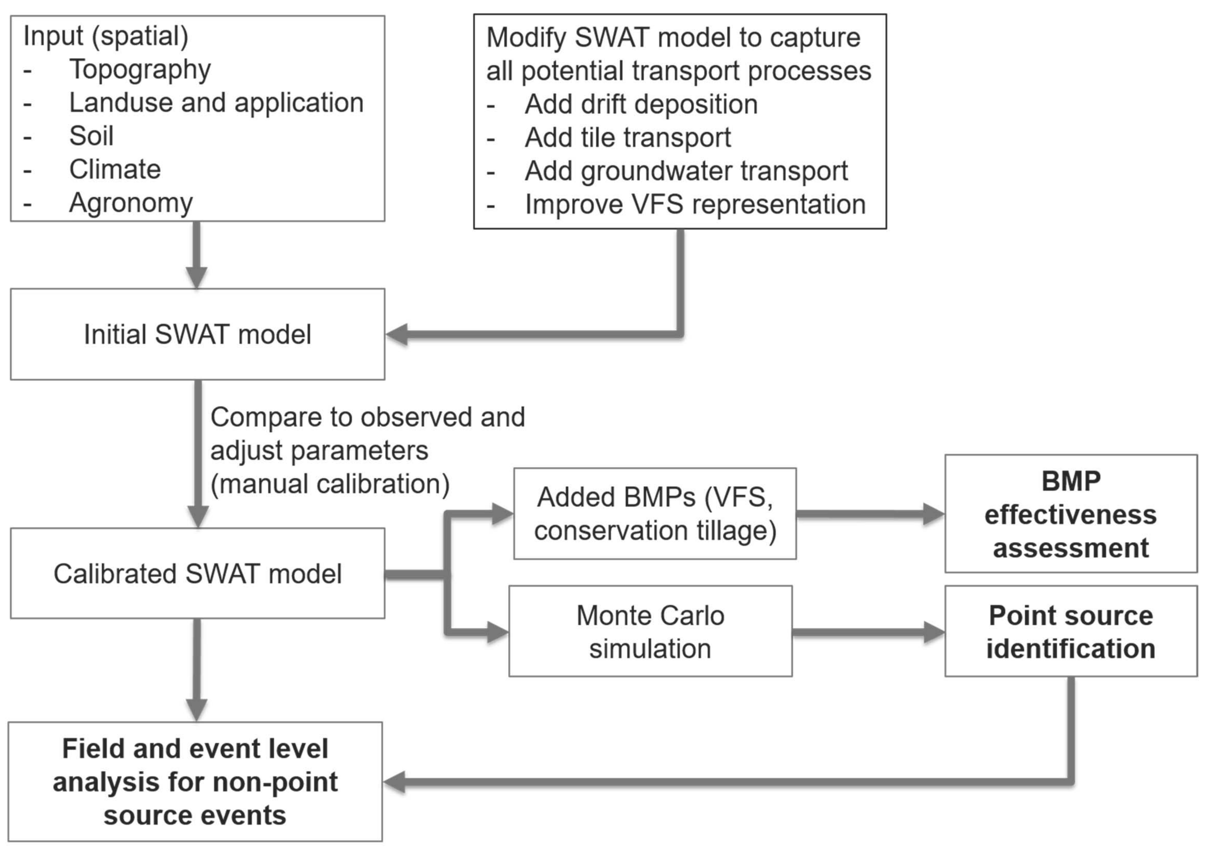
Modeling Approach

Soil and Water Assessment Tool (SWAT)

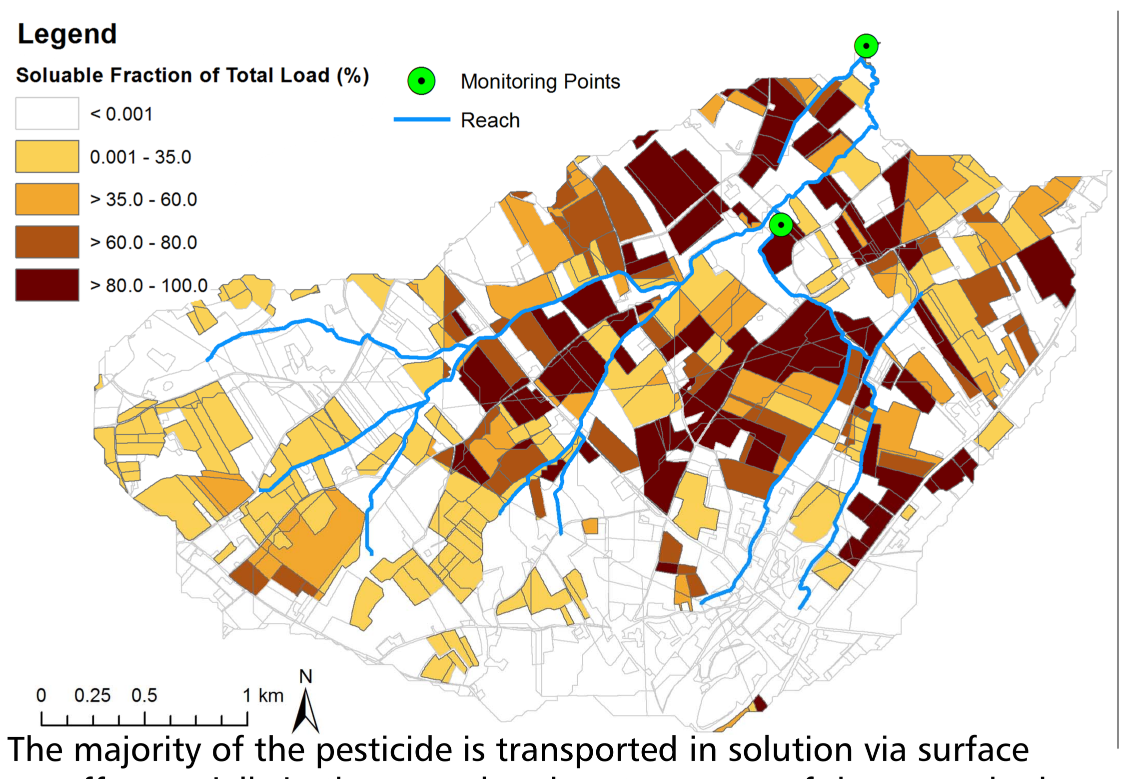
- Used to model pesticide transport in watersheds around the world
- Developed and maintained by USDA, Agricultural Research Service (ARS)
- Semi-distributed model (Hydrologic Response Unit concept)
  - Represent individual fields and account for heterogeneity in soils
- Pesticide fate is based on GLEAMS
  - Surface and subsurface pesticide transport processes from field to stream
  - In-stream transport processes
- VFS reduction efficiency component developed from VFSMOD (Muñoz-Carpena et al., 1999; White et al, 2009)

Model Modifications

- Added chemical transport through subsurface tile drains and groundwater recharge
- Drift deposition
- Improved VFS implementation (developed by Cibin et al., 2018)



Long-Term Source Analysis of Diffuse Source Events (Field Scale)



The majority of the pesticide is transported in solution via surface runoff, especially in the central and eastern parts of the watershed.

Identifying long-term dominant field processes helps to develop mitigation measures for diffuse sources

Conclusions

Combining model simulations, monitoring data, and application data provided a new perspective to interpret monitoring data

- SWAT identified the spatial variability in all dominant transport processes
- Runoff (and lateral) flow of soluble pesticide is the major contributor
- Spray drift is likely the least significant contributor at the catchment scale
- Around 50 % of the higher herbicide residues detected had point source contributions
- Reducing herbicide concentrations can be accomplished by mitigating
  - Point sources
  - Diffuse sources (BMPs such as VFS and reduced tillage)