Drift from Patch Spraying: an Approach to Regulatory Aquatic Exposure and Risk Assessment

Anastasiia Bolekhan, Andrew Chapple, Johannes Witt and Prakash Srinivasan

September.2024 / XVII Symposium in Pesticide Chemistry

Background

Precision farming is not far away…

- The use of precision technologies, such as patch spraying is of great interest and provides a number of benefits, *e.g.*, reduction of inputs, limiting crop phytotoxicity, decreasing boom weight (less soil compaction).
- Reducing inputs in crop protection is an important goal of the European Green Deal.
- Technical advances by machinery manufacturers make possible targeted, localized treatments, spraying patches as small as a 0.25 meter wide and long.

…but is regulatory science ready?

- Some EU regulatory authorities accept band application as a label recommendation for cases where broadcast application would not pass environmental hurdles, based on areal rate reduction, especially in the areas of leaching or drainage risk assessment.
- For drift entry from patch spraying exposure, assessment needs more consideration as it depends on the distance between the treated and non-target area. (This is also the case for run-off, but not so acutely.)
    - Current drift risk assessments are based on Rautmann drift values (percent of full field application rate), which are distance dependent (Rautmann, 2001) [1]

1 Rautmann, Dirk & Streloke, M. & Winkler, R. 2001. New basic drift values in the authorization procedure for plant protection products. Workshop on Risk Assessment and Risk Mitigation Measures (WORMM), vol. 13. 3-141.

Where do we stand..

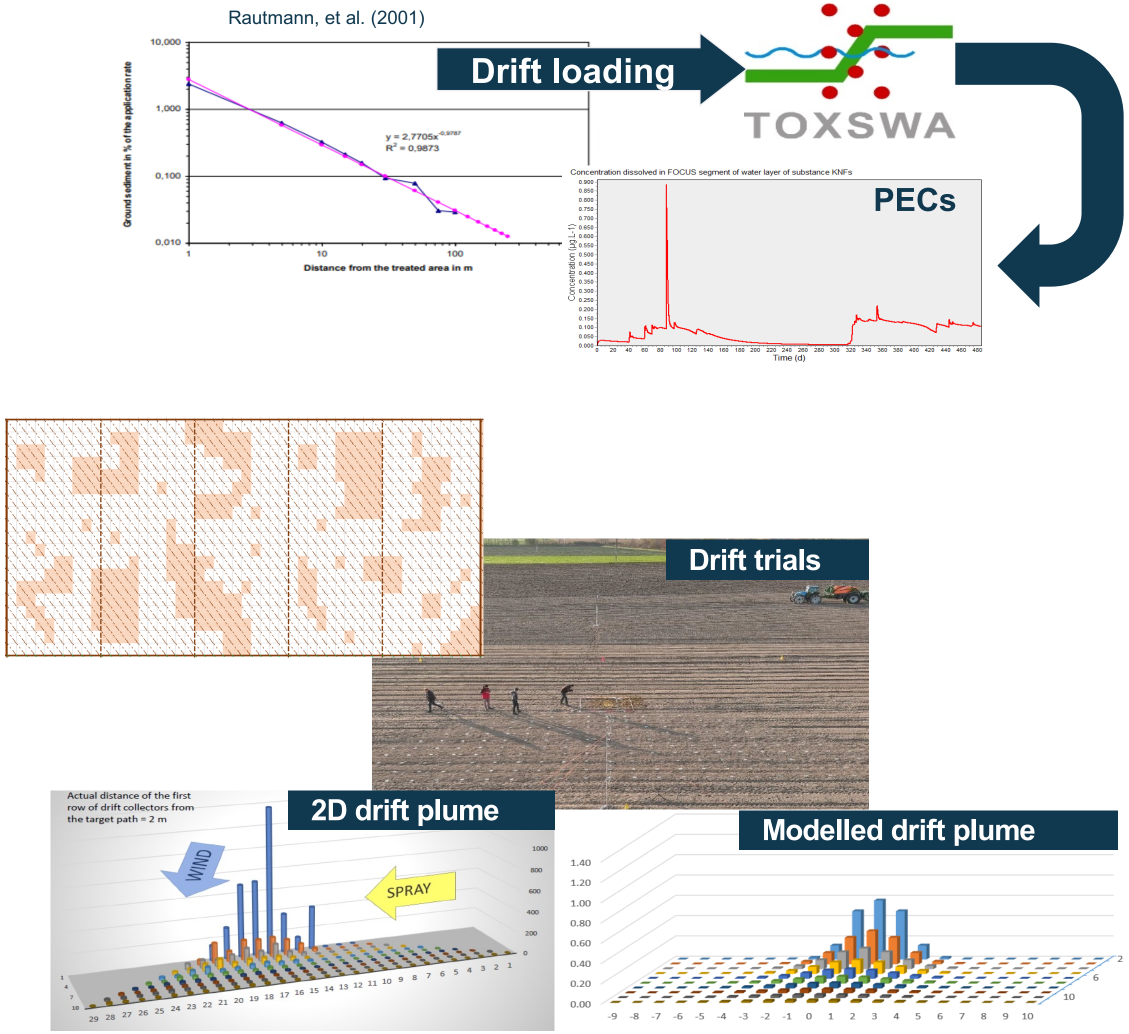
…in assessment of aquatic exposure *via* drift

Current assessment based on full field application

- Rautmann drift values (percent of full field application rate)
- TOXSWA model to simulate the aquatic fate of PPP and predict concentrations (PECs).

Drift from patch application

- Random pattern of application around the field needs to be mapped out in advance to see if the risk is acceptable.
  - Future prerequisites for this are **digital label infrastructure**, digital recording of PPP application, and regulatory acceptance of **in-situ RA**.
- Drift from a patch is not strictly 1D: there is a plume perpendicular to the wind direction.
  - First field **drift trials** were performed in cooperation with the Polish Inhort Institute. This data was used for modelling combining **plume dispersion and mechanistic models** (ADMS, SiMod: CLE project with Silsoe Spray Application Unit)



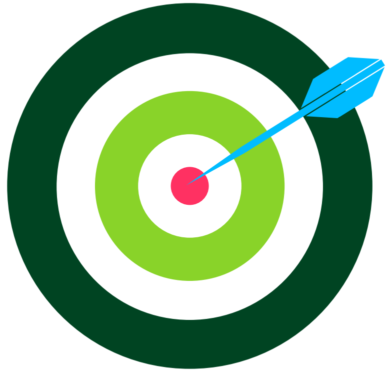
Chapple, et all, presentation at 11th European Modelling Workshop at Montpellier, 2023

Motivation

for the current work

Objective

► ***Investigate how spray drift from patch spraying can be fitted into an aquatic risk assessment using existing regulatory accepted concepts, approaches, and tools***



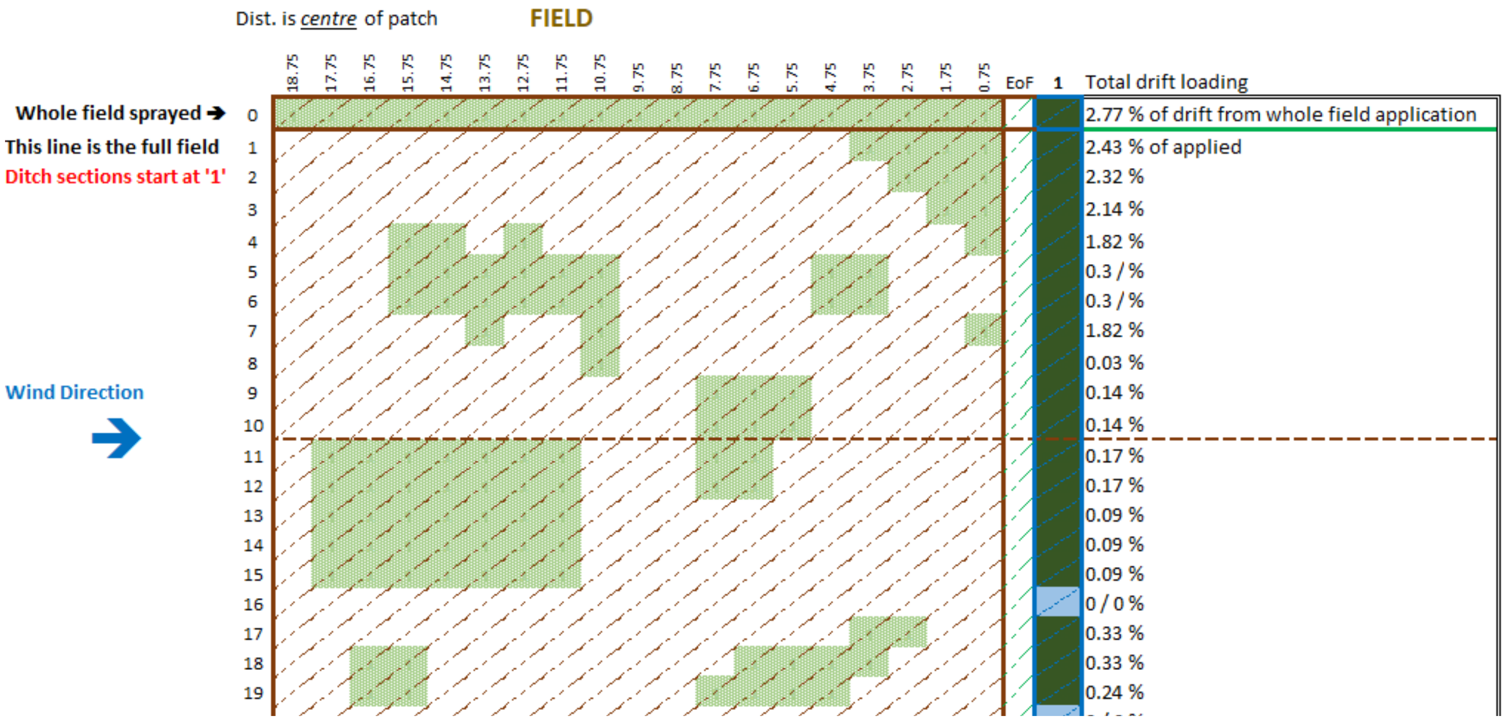
Caveats

- only aquatic assessment and cannot be translated one to one to other risk assessment areas (*e.g.*, off-crop, run-off).
- only for bare ground or arable crops application and does not cover other application techniques (*i.e.*, orchards, tree nurseries etc.)
- proof of concept and not a fully developed regulatory approach

Overview of procedure

Step 1
Derive drift loading to water body

- Drift curves for a 1 x 1 m patch were derived using SiMoD:
- These 1 x 1 m patches can be summed (upwind) to give a drift loading into the adjacent water body
- Drift curves from a 20 m wide application then normalized to give equivalent of Rautmann values



Overview of procedure

Step 2
Model pesticide behavior in the water body

- Downwind drift deposition converted to a point entry (1 m wide) in an extended Toxswa file (100 segments).
- Each patch has to be modelled separately and the output (distribution of concentrations over the ditch length with time) is combined afterwards.
- Different hydrological conditions were simulated.
- Different patch spraying scenarios (single and multiple patches, random patch applications patterns) were tested.
- A generic substance with Koc of 10 mL/g and DT50 water of 1000 d was chosen to investigate the distribution of the substance in water after the drift event (no sediment concentration).
- Application on winter cereals with a 100 g/ha application rate was used for calculations.

Overview of procedure

Step 3
Link exposure and effect
for risk assessment

- Aquatic guidance document was used as a basis for risk assessment of drift from patch spraying
- PECmax, TWA7, refined exposure pattern and effect modelling of patch spraying scenarios were compared to those of full field applications.
- Effect modelling with *Lemna* model is run separately for each segment using a moving time window approach, where a 7 day time window (corresponding to the length of a standard *Lemna* study) was moved over the exposure profile.
- A generic herbicide with a virtual EC50 (50% effect for 7 days constant exposure) of 0.56 µg/L was used.
- A multiplication factor to the profile to obtain 50% (EP50) effect is used to identify the segment with worst case exposure pattern.
- The factor is calculated by which effect modelling refines risk assessment ("refinement factor", EP50 * PECmax / EC50).

Patch spraying scenarios

Theoretical single patches scenarios:

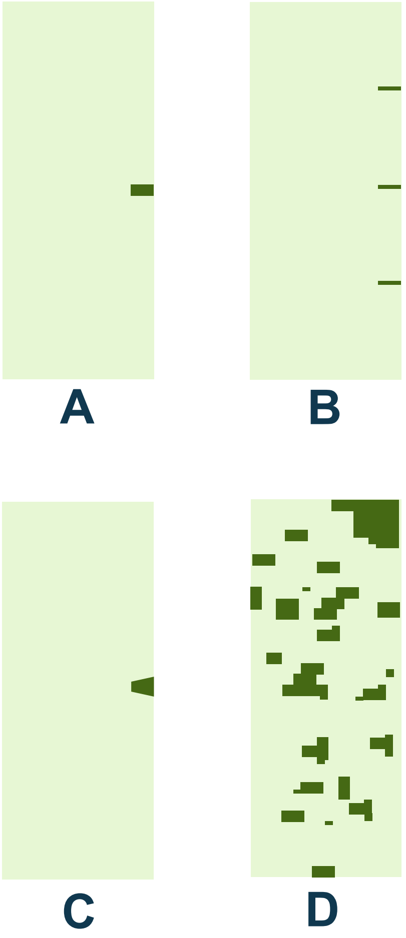
A Single 3x3m patch

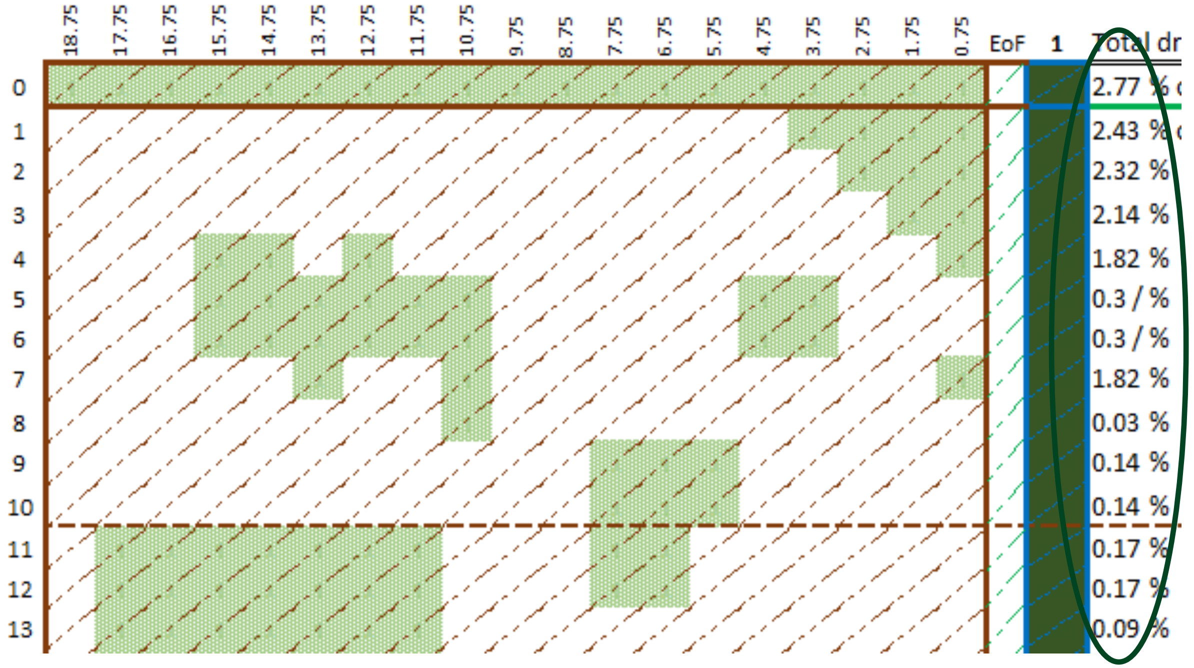
B Three 1x3m patch

C Single patch using the plume dispersion data from patch application drift trial (Inhort, PO)

D Random spraying pattern corresponding to 75% rate reduction

E Full field application for comparison

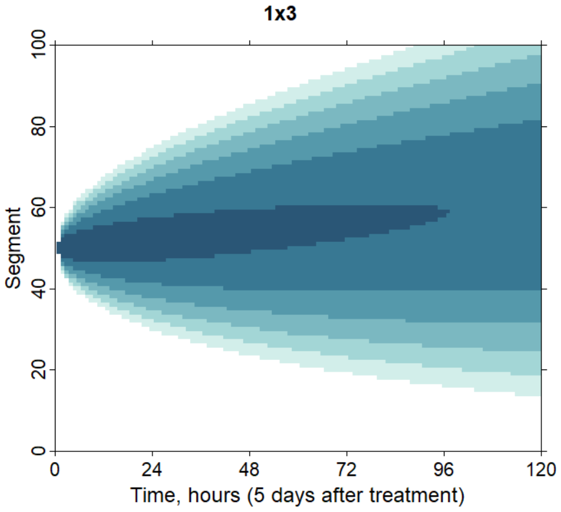


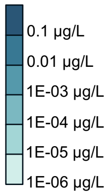


Exposure modelling results

Ditch constant flow stagnant conditions [1]

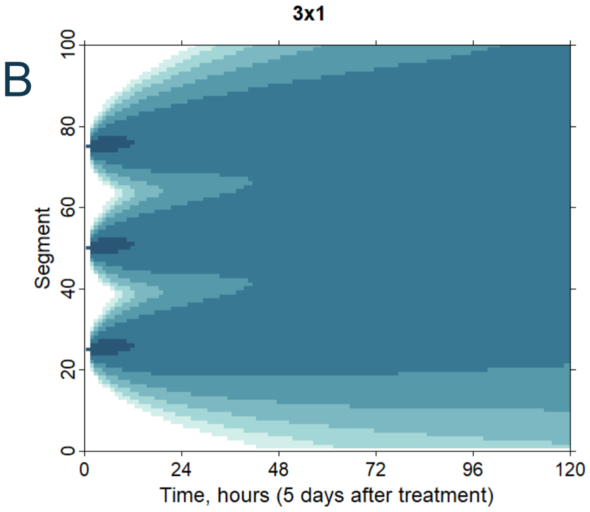
A

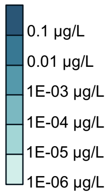




PECmax 0.773 µg/L
TWA7 0.547 µg/L

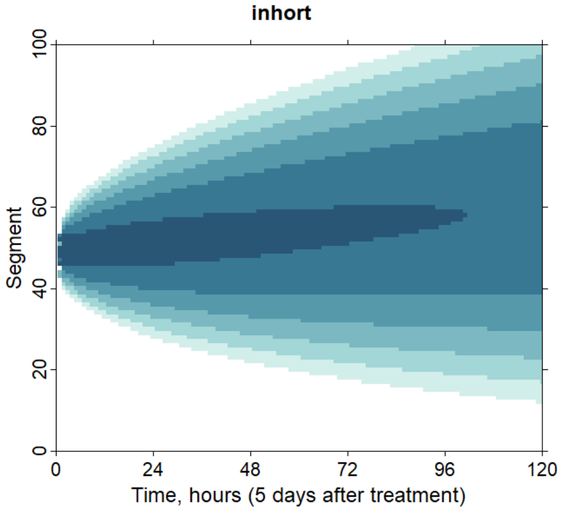
B

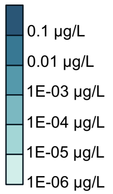




PECmax 0.773 µg/L
TWA7 0.293 µg/L

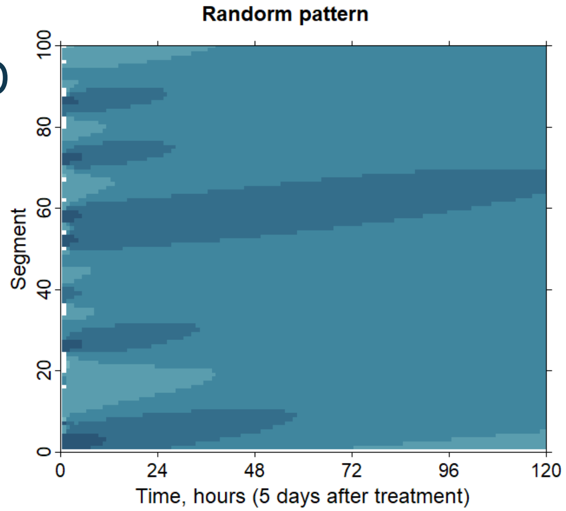
C

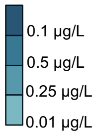




PECmax 0.964 µg/L
TWA7 0.514 µg/L

D



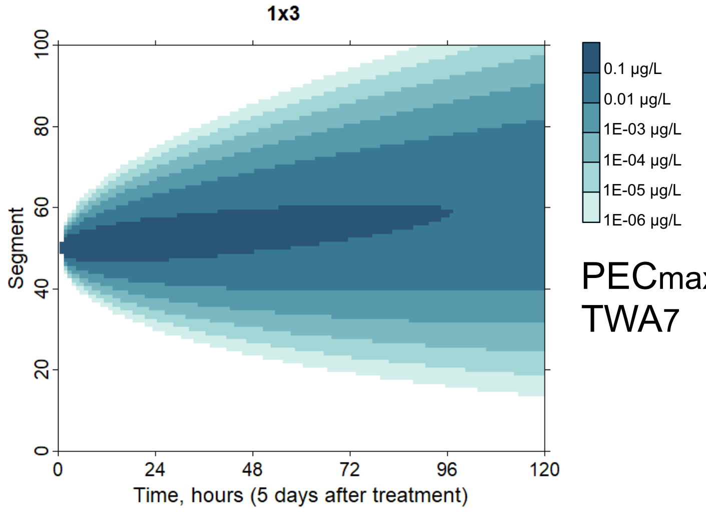


PECmax 0.890 µg/L
TWA7 0.678 µg/L

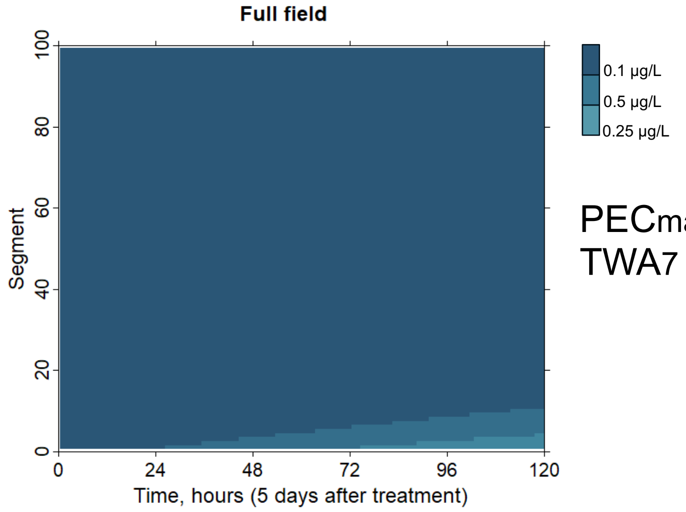
1 FOCUS D1 ditch scenario with a baseflow of 0.66 m^3/d (flow velocity of 2.2 m/d) and dispersion coefficient of 10 m^2/d was used for calculations

Exposure modelling results

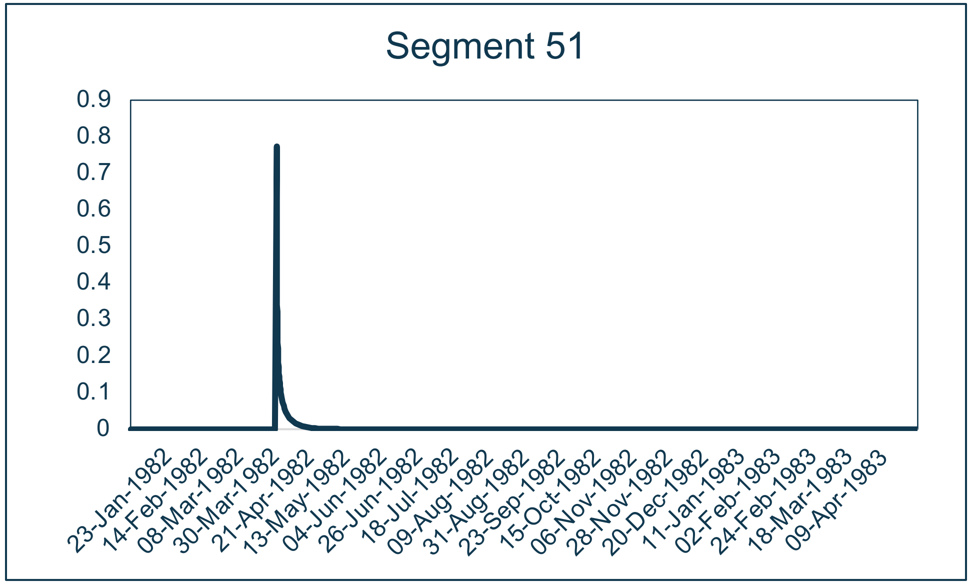
Ditch constant flow stagnant conditions

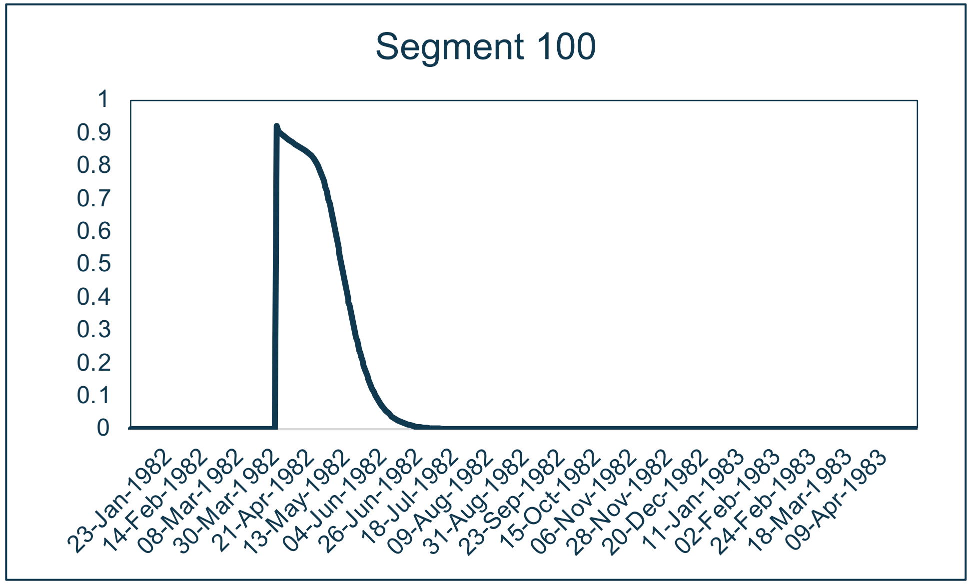


PECmax 0.773 µg/L
TWA7 0.547 µg/L



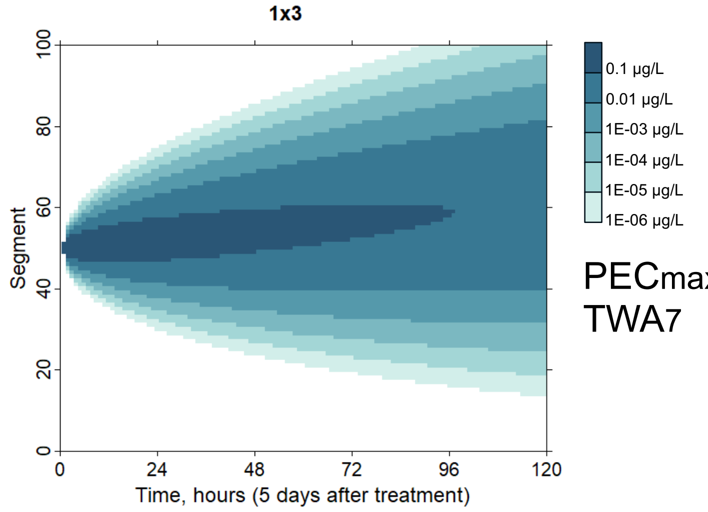
PECmax 0.923 µg/L
TWA7 0.919 µg/L



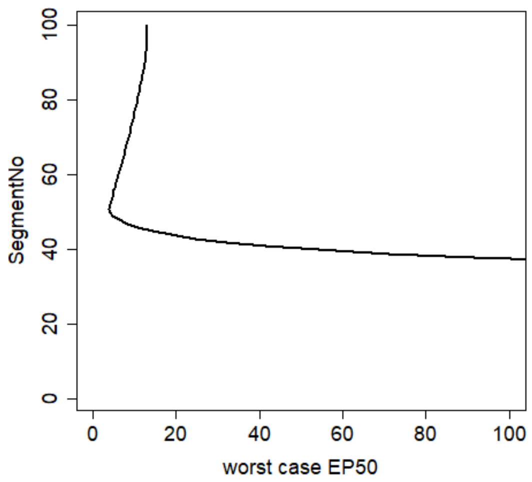


Effect modelling results

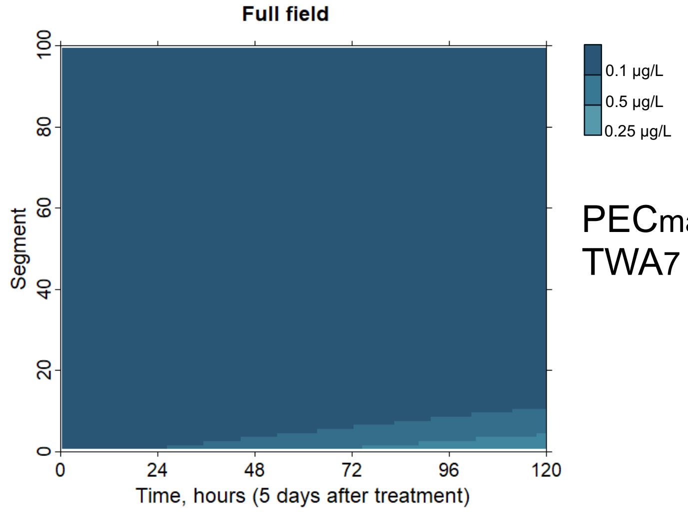
Ditch constant flow stagnant conditions



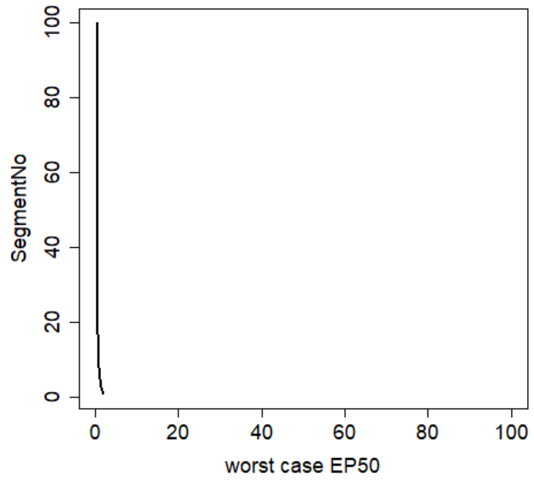
PECmax 0.773 µg/L
TWA7 0.547 µg/L



Worst-case segment 51



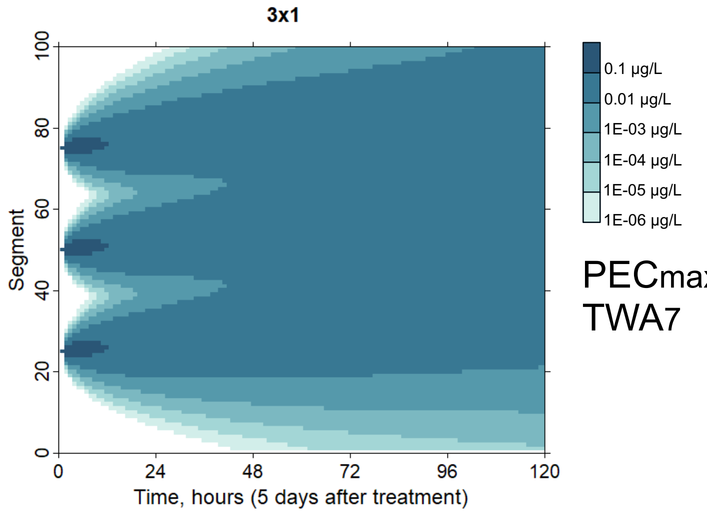
PECmax 0.923 µg/L
TWA7 0.919 µg/L



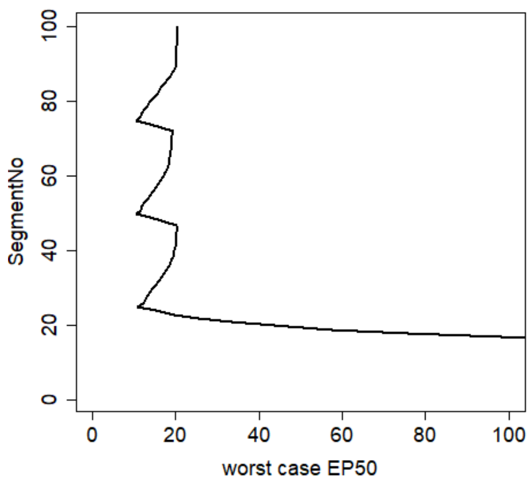
Worst-case segment 41-100

Effect modelling results

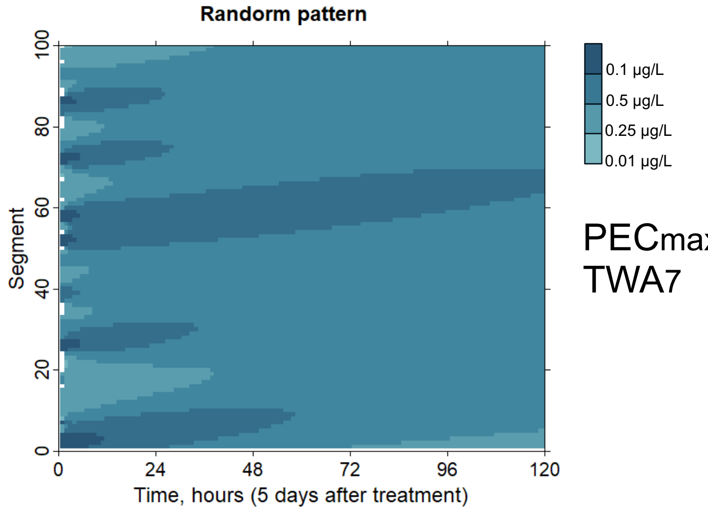
Ditch constant flow stagnant conditions



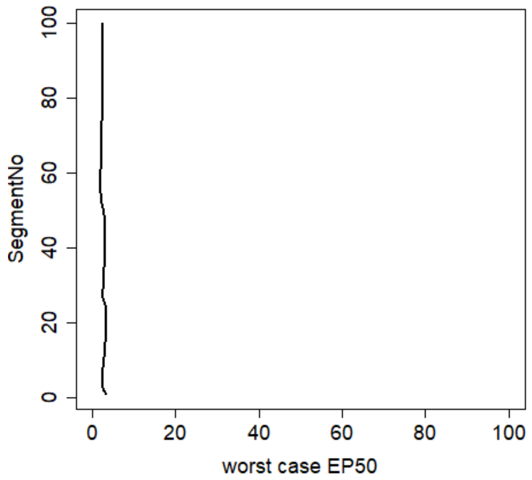
PECmax 0.773 µg/L
TWA7 0.293 µg/L



Worst-case segment
50, 75



PECmax 0.890 µg/L
TWA7 0.678 µg/L



Worst-case segment
58

Effect modelling results

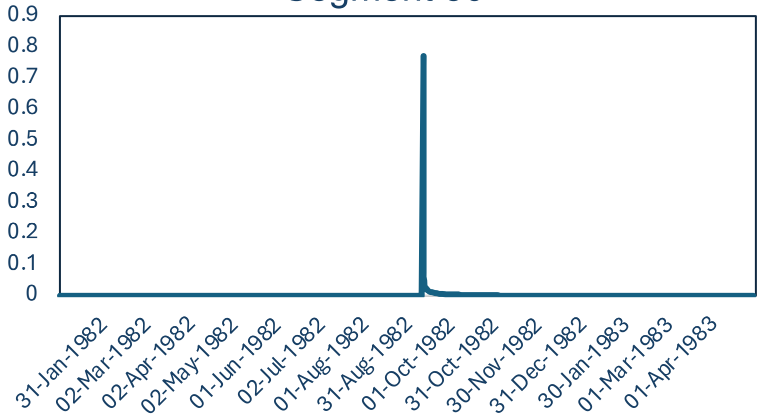
Ditch constant flow stagnant conditions

Scenario	PECmax	TWA7	At Segment	Minimum EP50	Refinement factor
	µg/L	µg/L			
One 3x3 patches	0.773	0.547	51	3.97	5.44
Three 3x1 patches	0.773	0.293	50 = 75	10.37	14.22
Plume dispersion patch	0.964	0.514	50	4.17	7.13
Random 25%	0.890	0.678	58	1.90	2.99
Full field	0.923	0.919	41	0.63	1.02

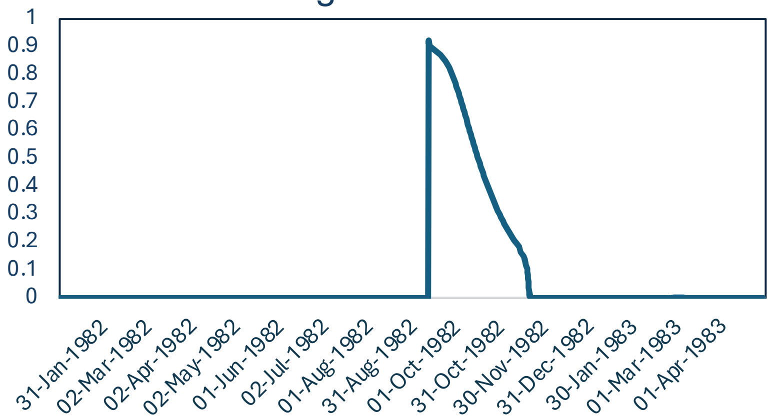
Exposure modelling results

FOCUS scenarios dynamic hydrologic conditions

D1 ditch 1 patch
Segment 50

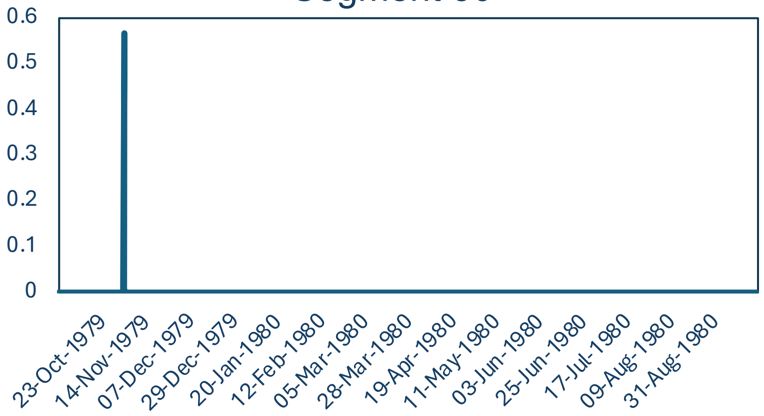


D1 ditch full field
Segment 100

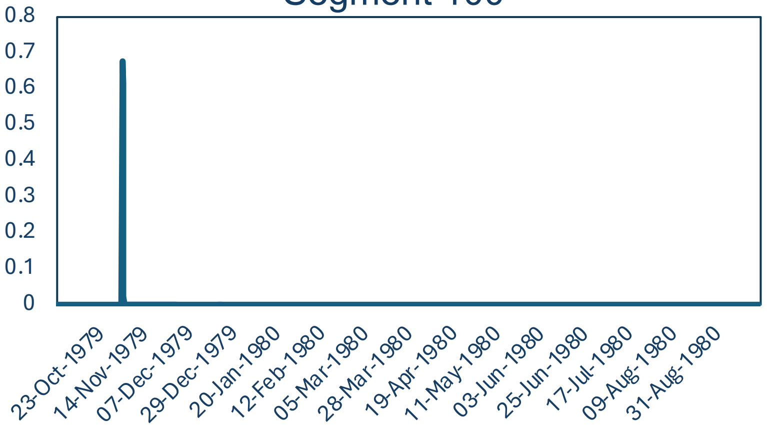


Slow flow conditions

R1 stream 1 patch
Segment 50



R1 stream full field
Segment 100



Fast flow conditions

Effect modelling results

FOCUS scenarios dynamic hydrologic conditions

FOCUS Scenario	PECmax	At Segment	Minimum EP50	Refinement factor	Contribution of patch application *	
	µg/L					
D1d	0.77	50	19.1	26.3	25.5	Slow flow conditions
D1s	0.76	50	99.2	134.7	22.1	
D2d	0.77	50	18.5	25.4	24.6	
D3d	0.76	50	97.9	132.9	20.1	
D4s	0.74	50	114.9	151.8	7.6	Fast flow conditions
D5s	0.8	50	104.4	148.0	9.9	
D6d	0.77	50	37.1	50.6	3.4	
R1s	0.56	50	154.5	154.3	4.8	
R4s	0.57	50	152.7	153.5	5.6	

* Contribution of patch application is calculated as the ratio between refinement factors from patch spraying scenarios and full field application scenarios

Conclusions and outlook

- Aquatic exposure *via* spray drift due to patch application can be assessed using existing regulatorily acceptable approaches and tools.
- The decrease of exposure due to lower pesticide input from patch application can be described consistently with existing guidance on tiered risk assessment for edge-of-field surface waters.
- Effect modelling demonstrates that patch applications can significantly reduce the real-world impact of pesticides on aquatic environments, especially for low flow conditions.
- Further aspects needing to be investigated include:
  - FOCUS TOXSWA dispersion of pollutants in water
  - Numerical stability when calculating different scenarios with a refined spatial scale
  - Linking exposure and effects for other aquatic species than *Lemna*

► ***Existing regulatory models can be adapted to describe spray drift exposure and risk from patch spraying***

Thank you for your attention!