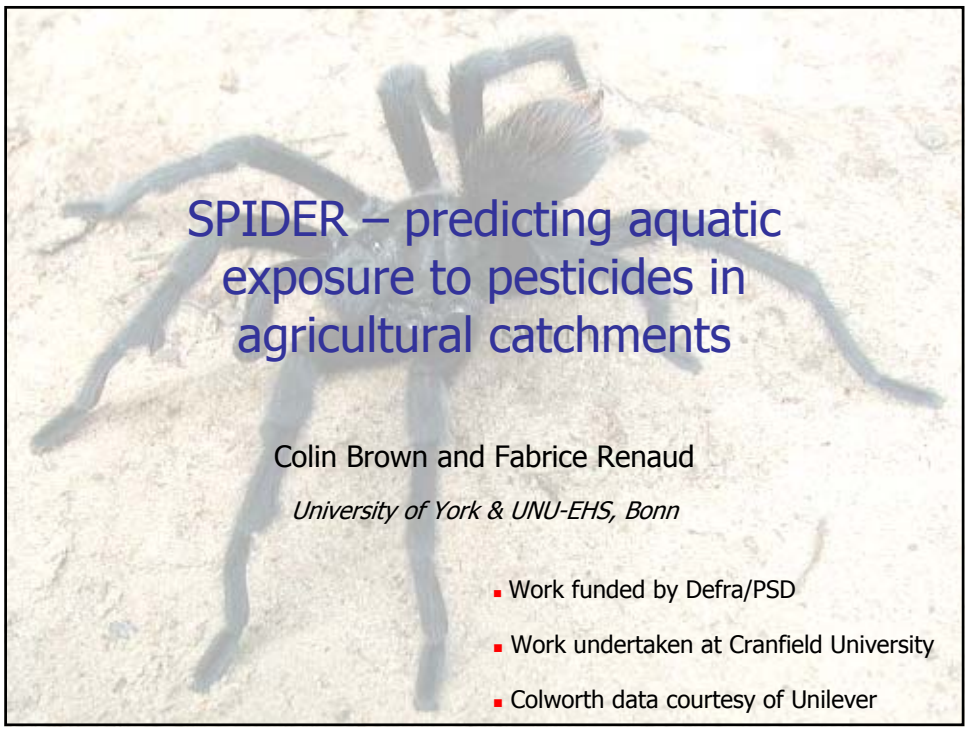


SPIDER – predicting aquatic exposure to pesticides in agricultural catchments

Colin Brown and Fabrice Renaud

University of York & UNU-EHS, Bonn

- Work funded by Defra/PSD
- Work undertaken at Cranfield University
- Colworth data courtesy of Unilever

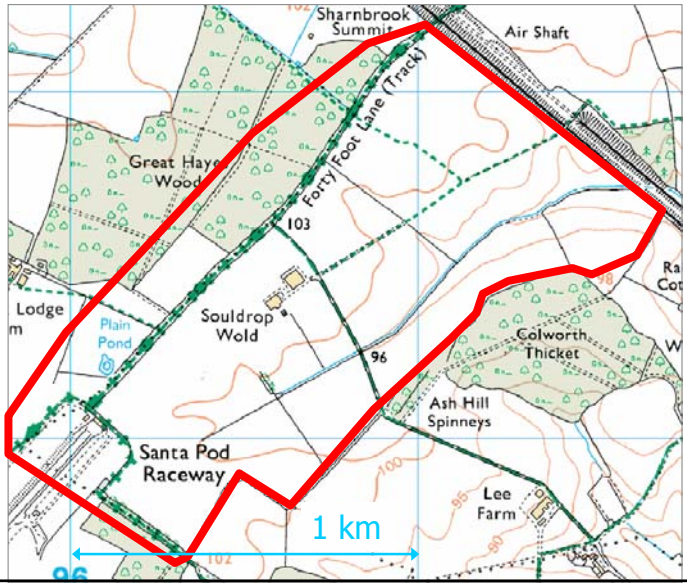
Gap in the fate modelling toolbox

- Field scale models (TOXSWA, MACRO, PRZM)
  - Parameter intensive
  - Restricted in scale of application
  - Normally account for one compartment or exposure route
- Catchment models
  - Large scale (10s to 100s of km^2), implemented in full GIS, large water bodies (POPPIE)
  - US runoff models (EPIC, SWAT)
  - Intensive, deterministic hydrological models (MIKE-SHE, ANSWERS-2000)

Objective

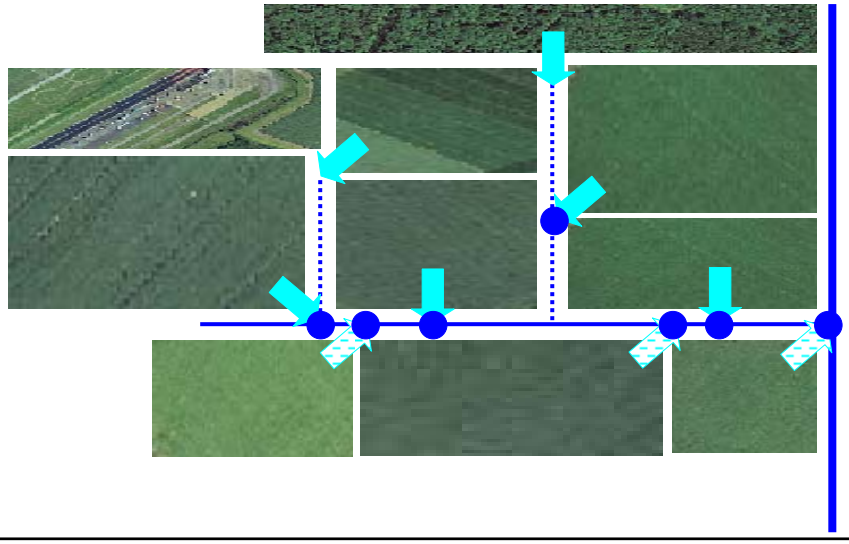
- Develop a new model to simulate pesticide exposure within small surface water bodies
  - Simulate sub-catchments up to a few km^2
  - Linked model describing major routes of entry to water and fate/transport in surface waters
  - Hourly timestep
  - Particular emphasis on pesticide transport in drainflow

Scale of application

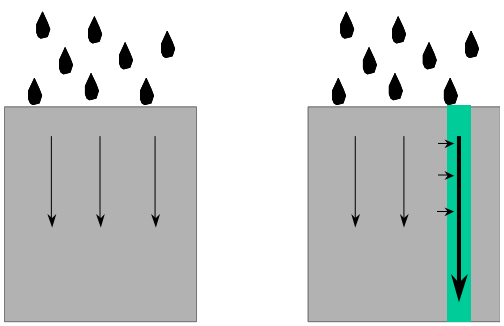


The Colworth catchment

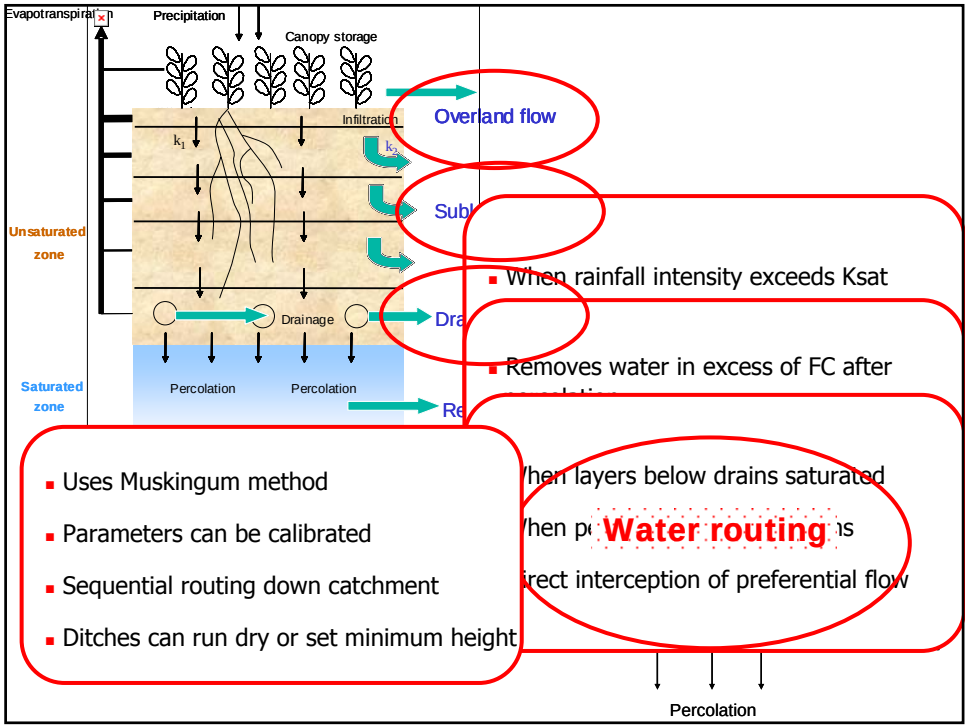
Conceptualisation of the catchment



Capacitance-based water movement



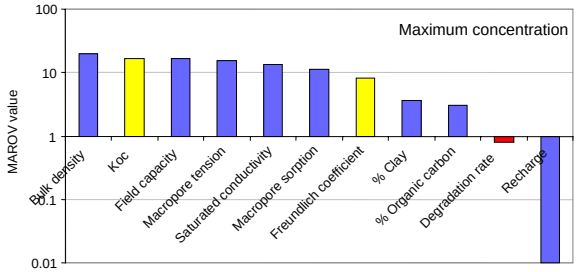
- Matrix flow
  - Layer water content exceeds field capacity
  - Limited by K_unsat (recalculated six times during 1-hr timestep)
- Preferential flow
  - Layer water content exceeds micropore capacity
  - Rate is K_sat



Model evaluation

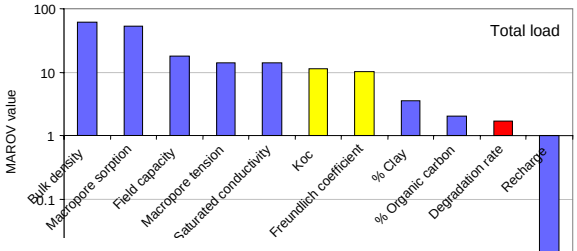
- Sensitivity analysis for leaching model
- Isoproturon transport via drains at Cockle Park
- Sulfosulfuron transport via drains at Maidwell
- Surface water concentrations in the Colworth catchment

Sensitivity analysis for field level transport



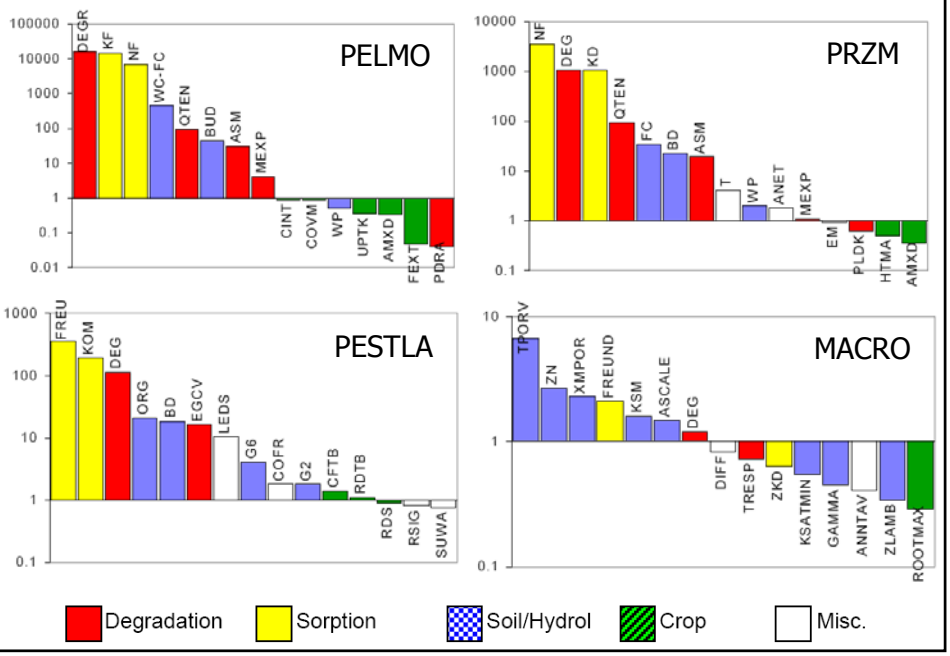
Leaching of IPU to drains at Cockle Park

MAROV = max [$\Delta_{output}/\Delta_{input}$]



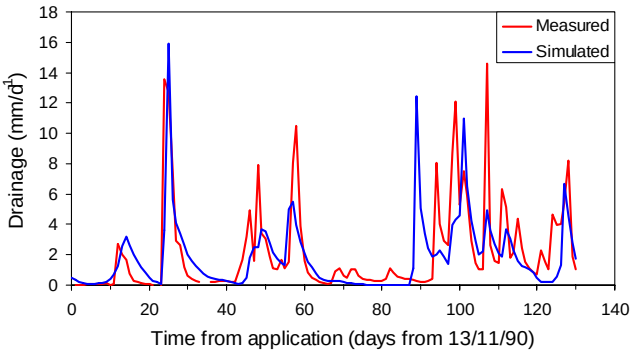
Degradation | Sorption | Soil/Hydrol | Crop | Misc.

Sensitivity analysis for four leaching models



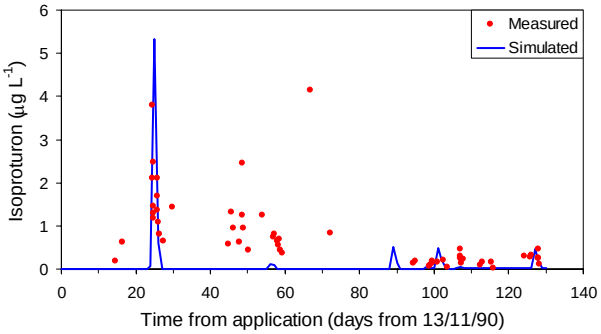
Isoproturon at Cockle Park

- Compound applied in November to clay loam soil
- Transport to drains followed over drainage season
- No calibration



Flow over a winter season

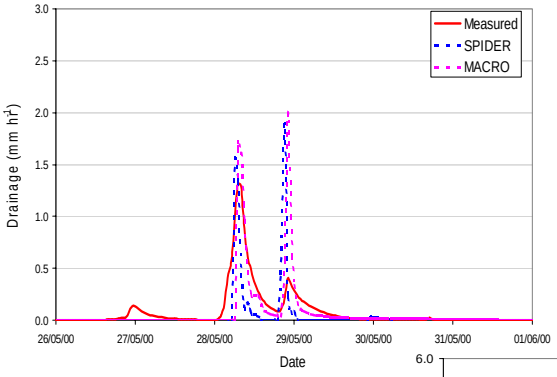
Pesticide concentrations



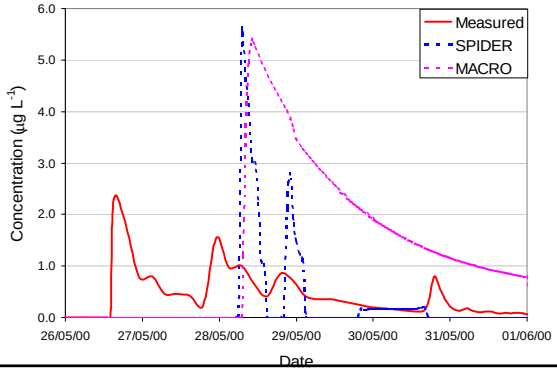
Sulfosulfuron at Maidwell

- Compound applied in May to a clay soil
- Transport to drains followed for the next 9 months
- Uncalibrated then calibrated simulations
  - Water release curve
  - Groundwater recharge
  - Percentage of macropores
- Comparison with MACRO simulations

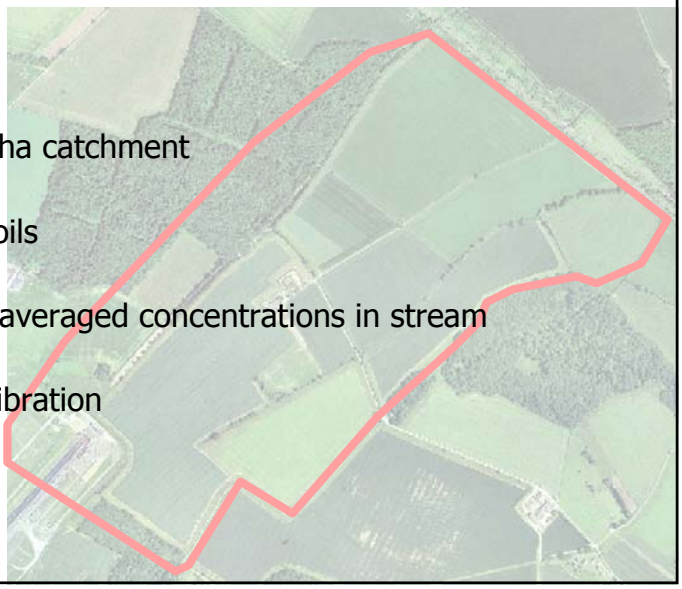
Flow over main loss event



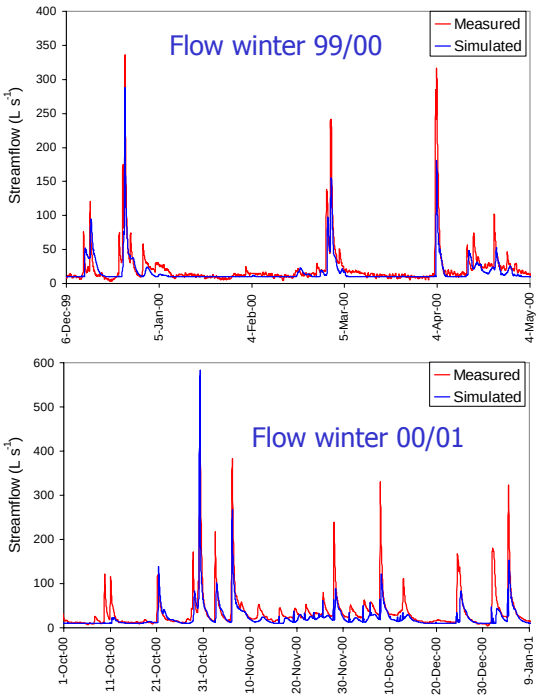
Pesticide concentration



Colworth catchment



- 141.5 ha catchment
- Clay soils
- Event-averaged concentrations in stream
- No calibration



- Pesticide transport
  - Timing of pulses well simulated
  - Good simulation of event average for IPU
  - Under-estimation for more strongly sorbed compounds

Summary of model evaluation

Calibration status	Cockle Park No calibration	Maidwell Hydraulic params calibrated	Colworth No calibration
Flow			
Observed	274 mm	296 mm	1.16 Mm
Simulated	240 mm	274 mm	0.88 Mm
NSME	0.32	0.34	0.51
Max pesticide conc (µg L^{-1})			
Observed	3.8	2.3	0.26
Simulated	5.3	5.6	0.31
Pesticide load (mg)			
Observed	352	0.76	-
Simulated	216	5.57 (2.00)	-

Conclusions from initial evaluation

- Working model that simulates concentrations across catchment
- Soil leaching model emulates MACRO very closely
- Two-year simulation for catchment with 17 fields takes 15 minutes
- Hydrology and pesticide outputs from the leaching model look promising

New 3-year project

- Evaluation against catchment data
  - Rosemaund
  - Cherwell
  - Lillabæk , Odderbæk
- Evaluation of the drift model
- Improvements to the code
  - Groundwater routing
  - More refined fate in ditches
- External distribution and testing