Session A3: Nutrients, Pesticides, Emerging Contaminants and Bacteria

10:30 - 10:50	**Hendrik Rathjens**	Advancing Pesticide Exposure Assessments with SWAT+: An Evaluation of Plant Uptake, Metabolites, and Landscape Dynamics
10:50 - 11:10	**Anne-Kathrin Wendell**	Comparison of different parameter settings on the transport of pesticides and their transformation products in a small-scale catchment
11:10 - 11:30	**Henrike T. Risch**	Evaluation of Sediment and Phosphorus Dynamics with SWAT+: Experiences from a German lowland catchment
11:30 - 11:50	**Mike Devin Fuchs**	Estimating high resolution exposure at landscape scale – on the implementation of the DAD-drift model into a SWAT+ model of an agriculturally dominated catchment

Advancing Pesticide Exposure Assessments with SWAT+: An Evaluation of Plant Uptake, Metabolites, and Landscape Dynamics

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Pesticide-Related Improvements of SWAT+

SWAT+ offers advantages over SWAT for pesticide risk assessments of flowing water bodies

1. Enhanced chemical fate processes
   - **Subsurface chemical transport** via tiles and groundwater
   - Directly **simulate pesticide metabolite formation**
   - Simulation of **chemical plant uptake**
2. Advanced **agricultural management** practices with probabilistic pesticide applications
   - Decision tables with if-conditions and actions
3. Spatial **representation of landscape features**, their connections and interactions
   - Hydrological response units (HRUs) within connected landscape units (LSUs)

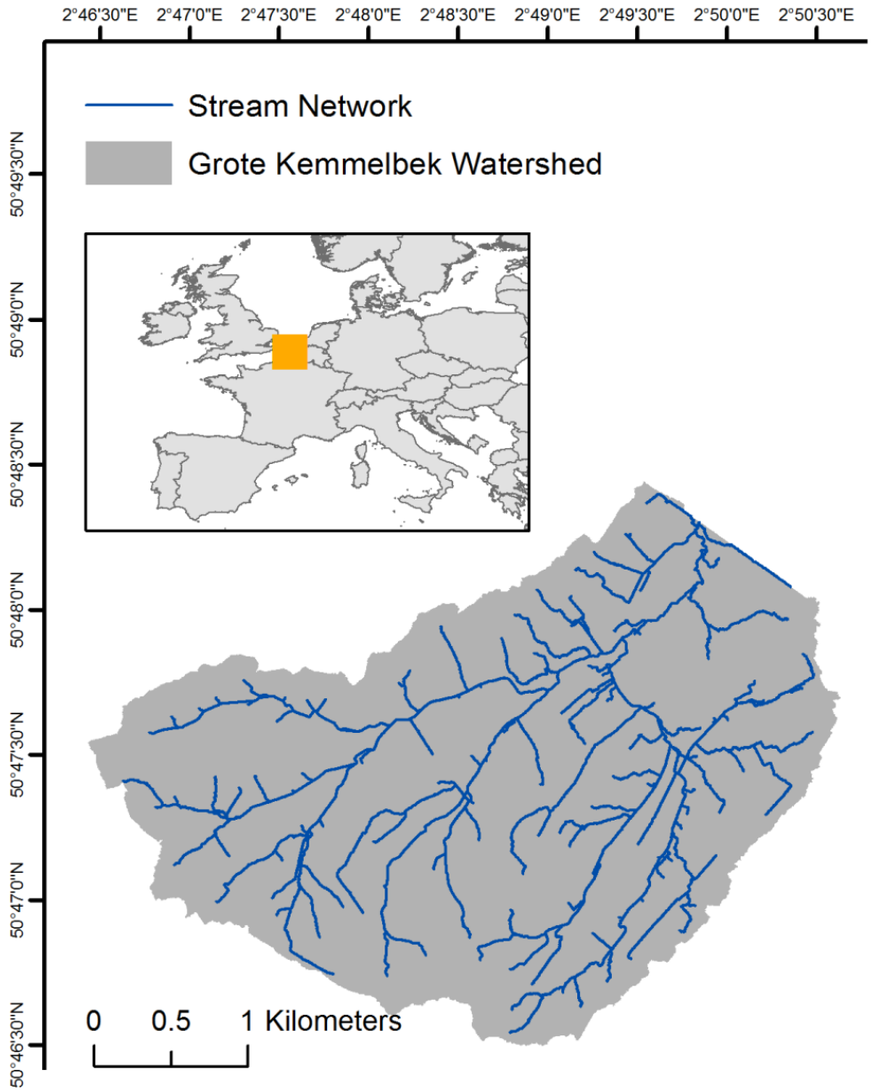
The GKb Watershed in the Flanders Region of Belgium

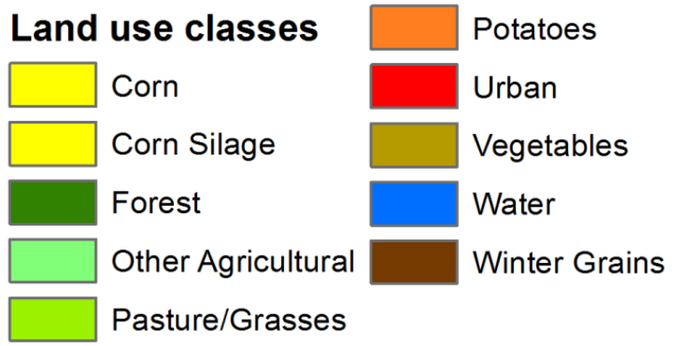
Watershed Characteristics

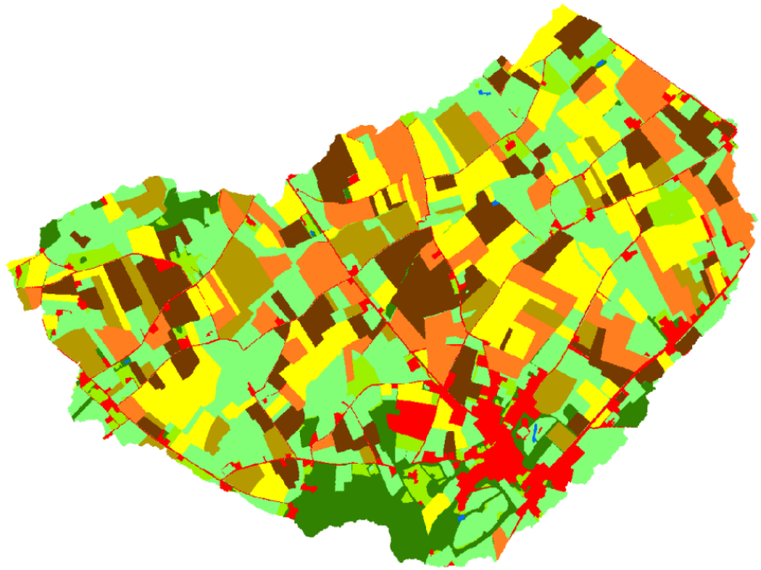
- 1,030 ha area
- 50% tile- drained
- 85% agricultural use (mainly corn, potatoes and winter wheat)
- Mostly poorly drained soils (loams, silts, and silt loams)

Pesticide Data

- Field level data on FFA applications
- Daily FFA and FFA-SA concentrations (3 years)







Study Design

Evaluating the improvements of SWAT+

1. **Enhanced fate processes**
   Simulate pesticide metabolite formation
   Parent pesticide application (FFA) with simulation of transformation to metabolite (FFA-SA)
   Evaluation of chemical plant uptake

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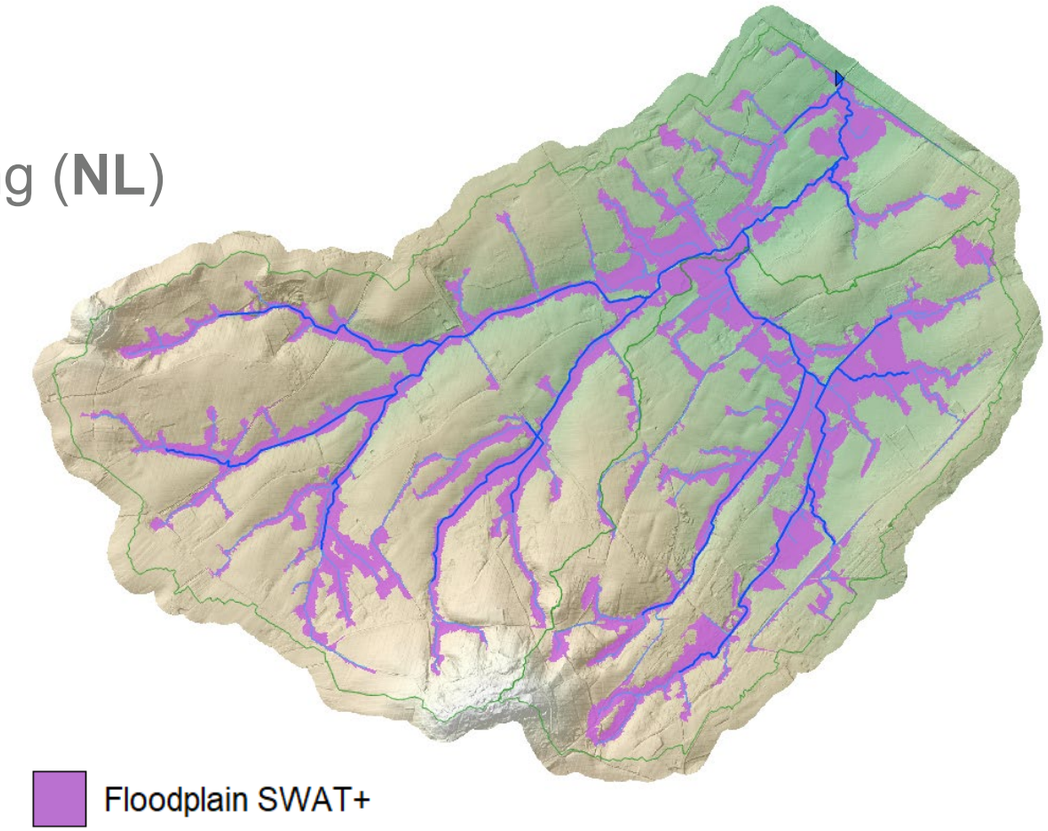
2. **Representation of landscape features**
   Landscape Routing (**LR**) vs No Landscape Routing (**NL**)

   Topographic delineation of floodplains and hydrological connection of uphill and downhill landscape units



Study Design

Simulations for evaluating the improvements to SWAT+

1. **Enhanced fate processes**
   Simulate pesticide metabolite formation
   Parent pesticide application (FFA) with simulation of transformation to metabolite (FFA-SA)
   Evaluation of chemical plant uptake
2. **Representation of landscape features**
   Landscape Routing (**LR**) vs No Landscape Routing (**NL**)
3. **Agricultural management** scenarios
   Farmer Survey-based (**FS**) vs conditional pesticide application data

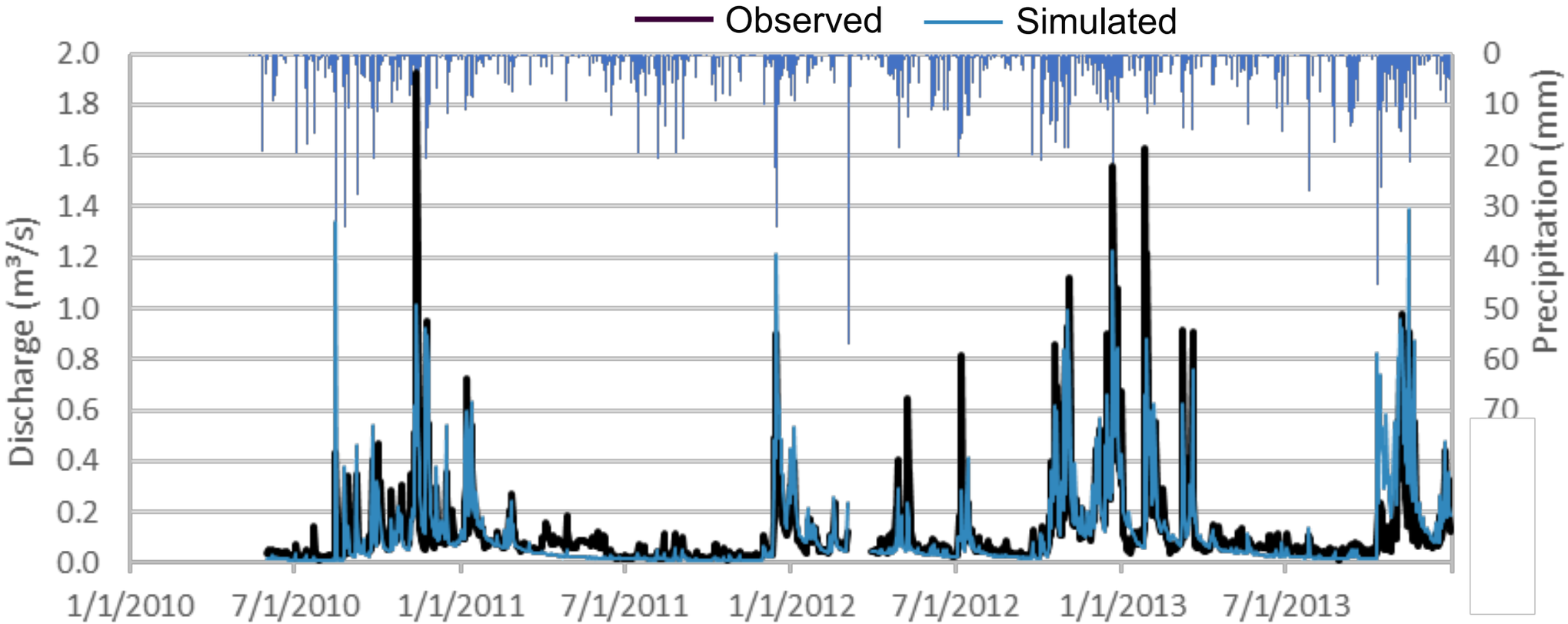
Scenario	Percent Crop Treated (PCT)	Pesticide Application Timing (TIM)	Pesticide Application Mass (kg)
Farmer Survey (FS)	Actual	Actual	1,891
PCT-100 TIM-single	100%	Single day (mid window)	3,003
PCT-act TIM-single	Actual	Single day (mid window)	1,904
PCT-act TIM-rand	Actual	Random (within window)	1,894

- Calibration scenario: LR-FS

Flow Simulation: Results

Performance (daily)

- NSE 0.63
- Pbias 3.26
- KGE 0.81



Variable weather conditions for the dry year 2011 and the wet years 2012/2013

- Simulating the weather conditions is challenging

Good to very good performance statistics according to Moriasi et al. (2007, ASABE)

- Model tends to underestimate peaks

1. Subsurface Transport and Metabolite Formation

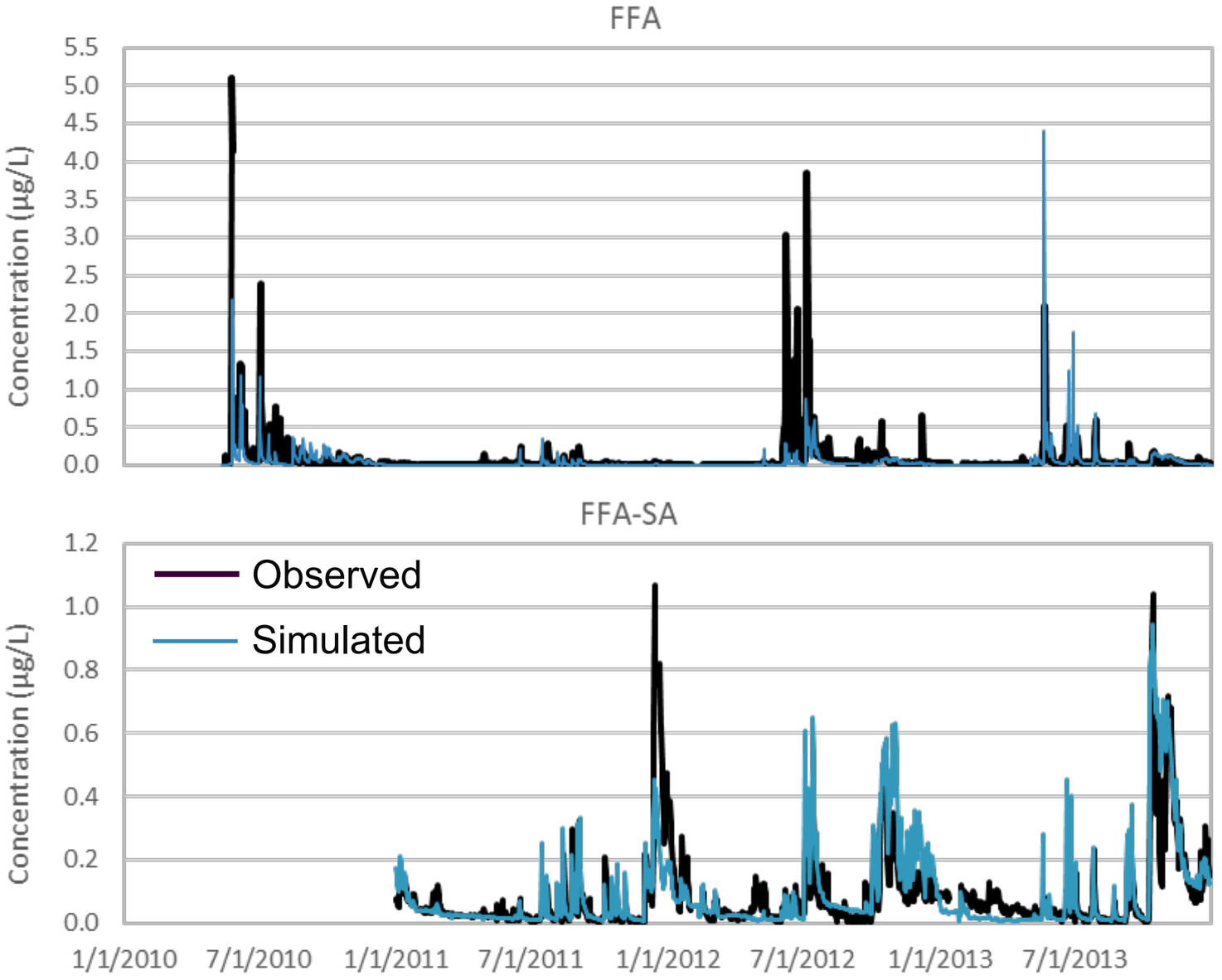
Model configuration: Landscape routing and Farmer Survey (LR-FS)

FFA: dynamics and timing well predicted

- Underestimation of peaks, likely caused by point sources
- Sur et al. 2018, Comm. Appl. Biol. Sci.

FFA-SA: very good agreement

- Primary FFA-SA transport path is via subsurface flow



1. Plant Uptake

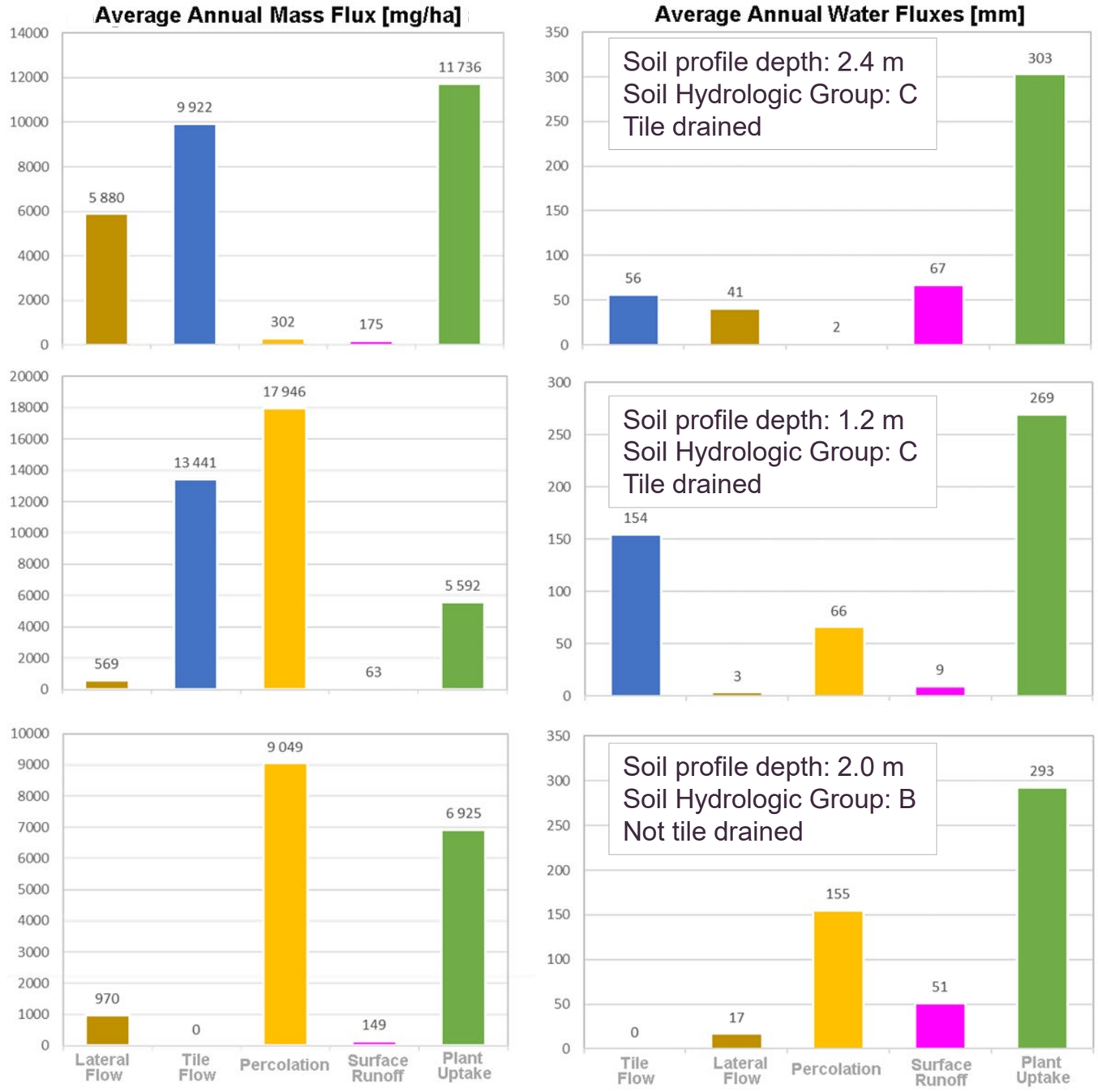
Model configuration: Landscape routing and Farmer Survey (LR-FS)

Chemical plant uptake

- Compound and plant specific
- Single plant uptake factor is used
- Complex temporal dynamics

Results

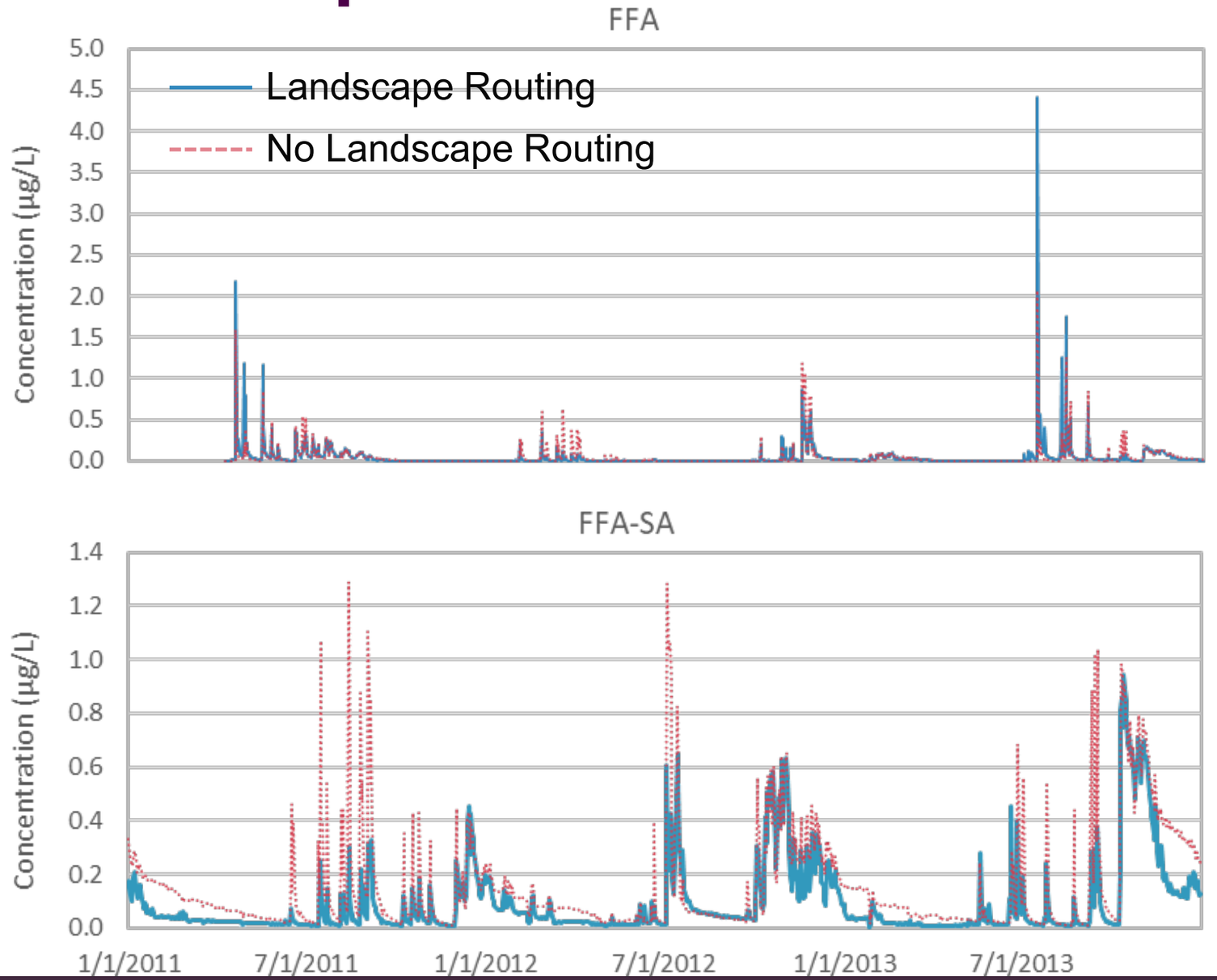
- Average streamflow concentration reduction by 10 to 20% (average 12%) for a soil metabolite with a plant uptake factor of 0.3



2. Representation of Landscape Features

Landscape Routing vs. No Landscape Routing

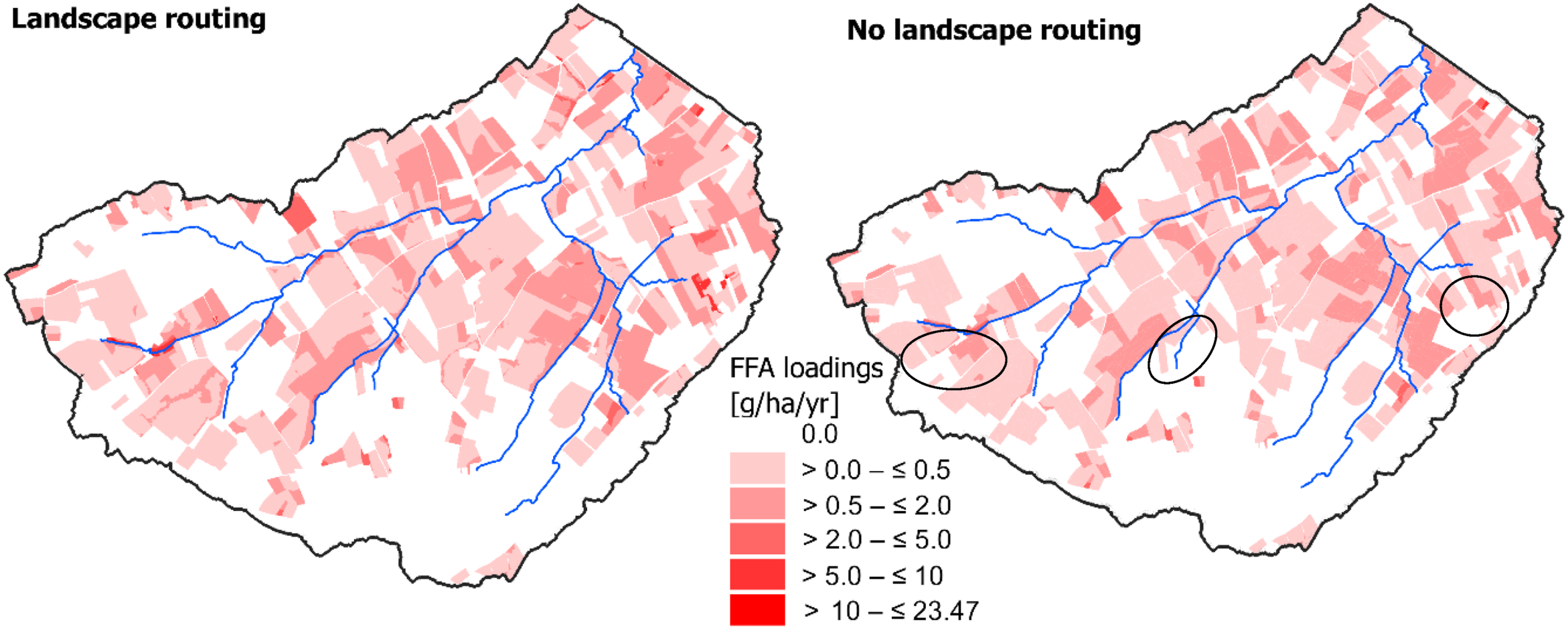
- FFA: Landscape routing changes the peak concentrations
  - Increase due to higher saturation and surface runoff in the lowland
  - Decrease due to buffer effect
- FFA-SA: Landscape routing buffers (reduces) concentrations



2. Landscape Features: Spatial FFA Differences

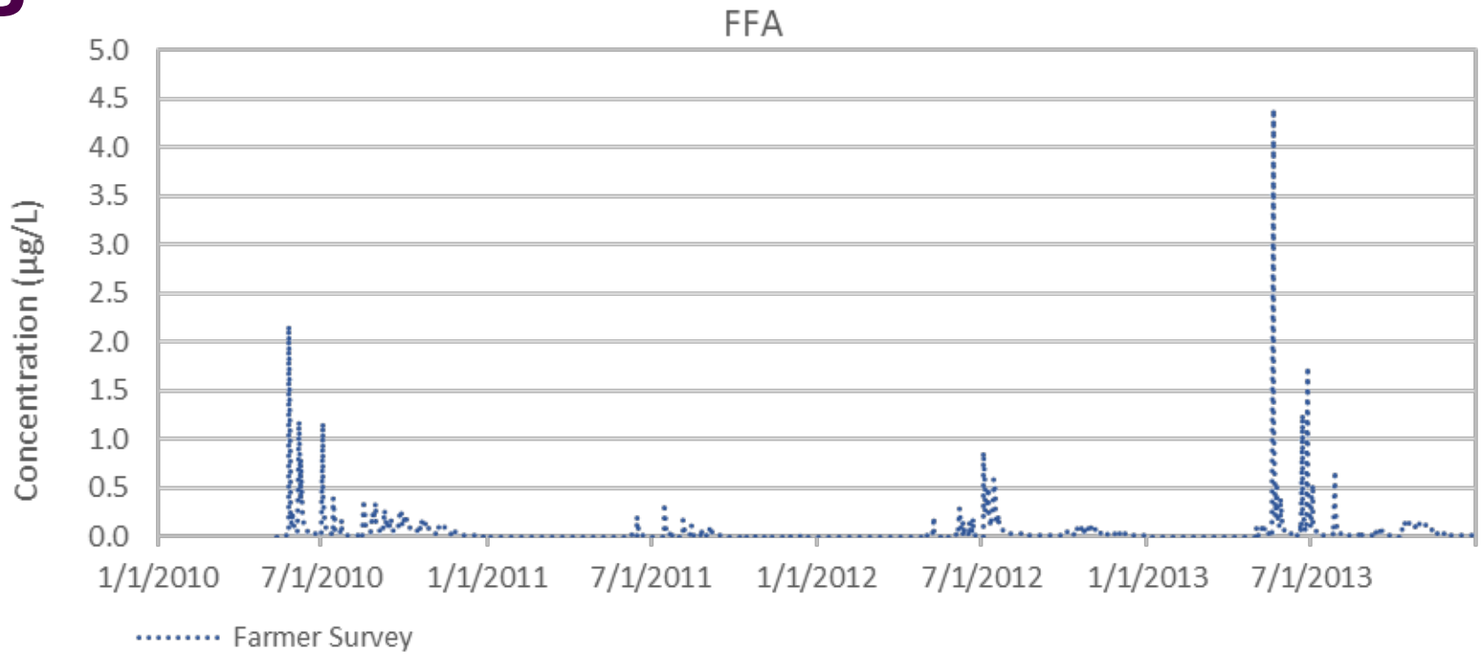
Landscape routing (LR-FS) vs no landscape routing (NL-FS)

- Reduction in contribution of upland areas, increasing vulnerability of floodplains



3. Agricultural Management

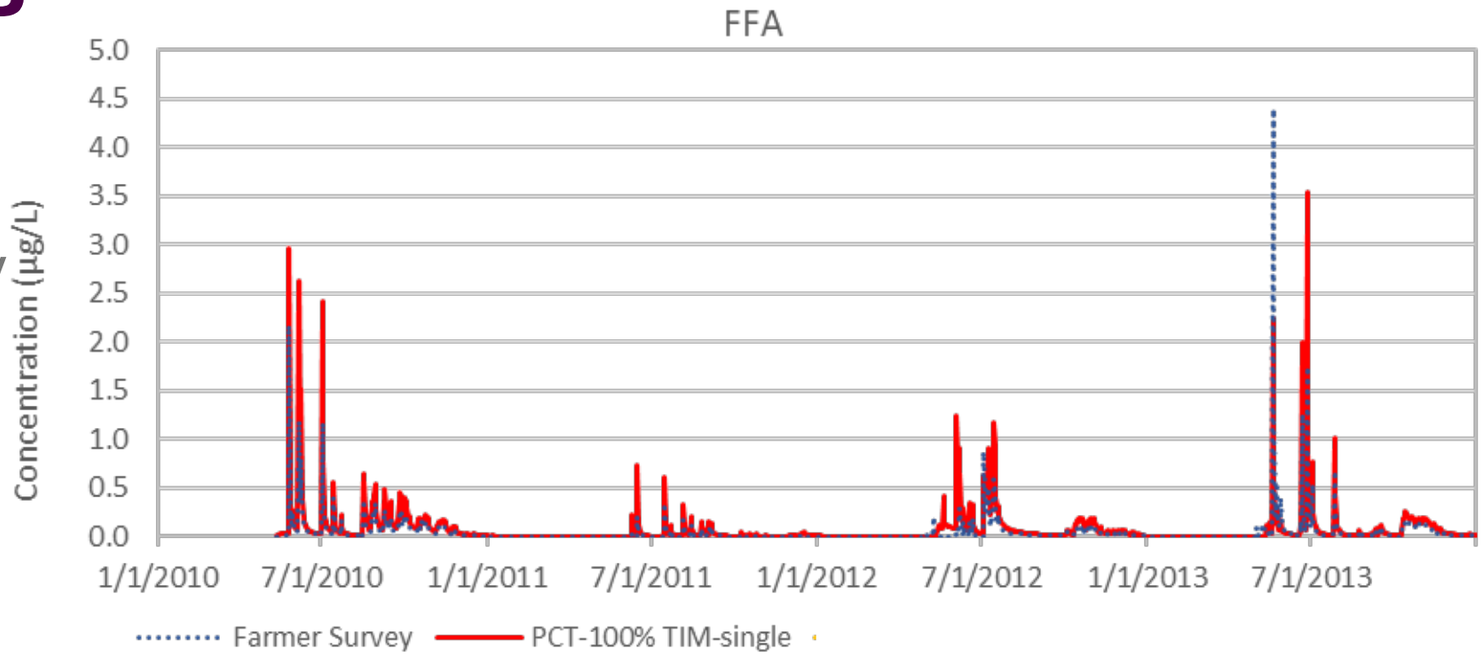
Farmer Survey (FS) vs. conditional management



3. Agricultural Management

Farmer Survey (FS) vs. conditional management

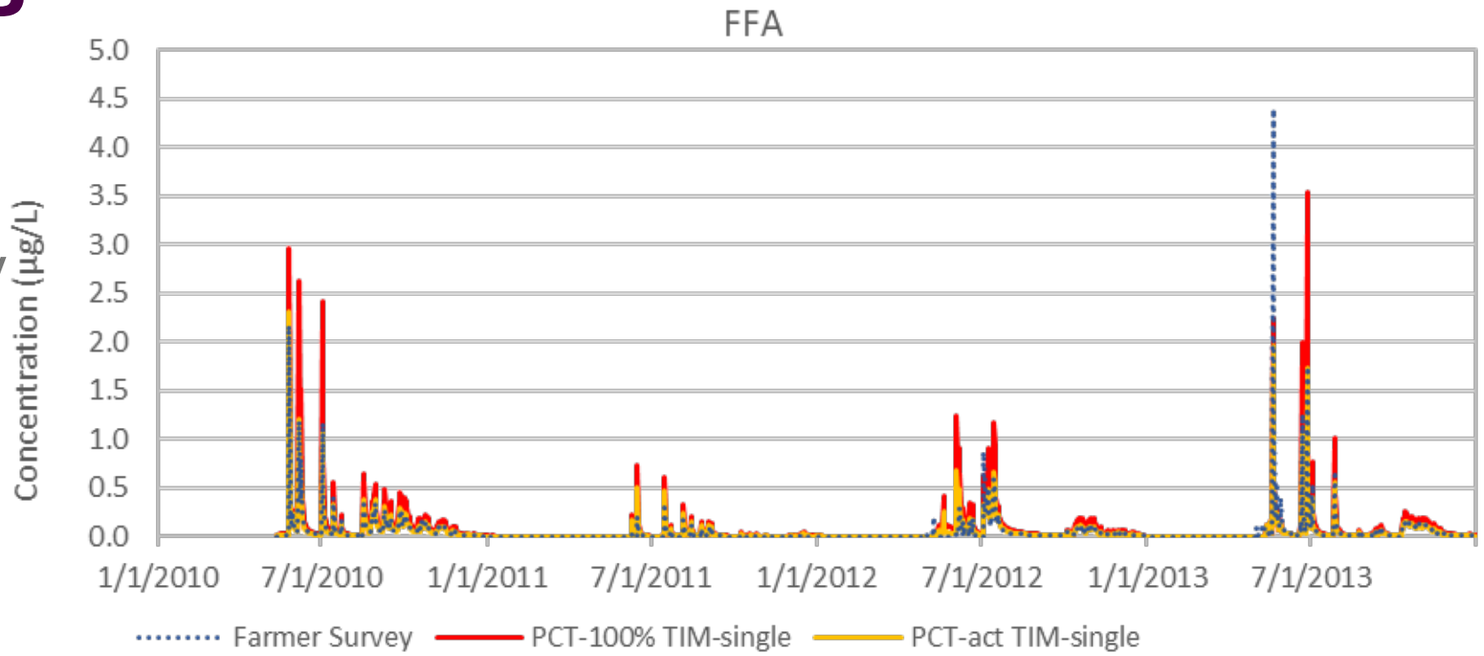
- 100% crops treated + single day appl.: High concentrations (red)



3. Agricultural Management

Farmer Survey (FS) vs. conditional management

- 100% crops treated + single day appl.: High concentrations (red)
- Accounting for actual crops treated: Reduction of concentrations (yellow)



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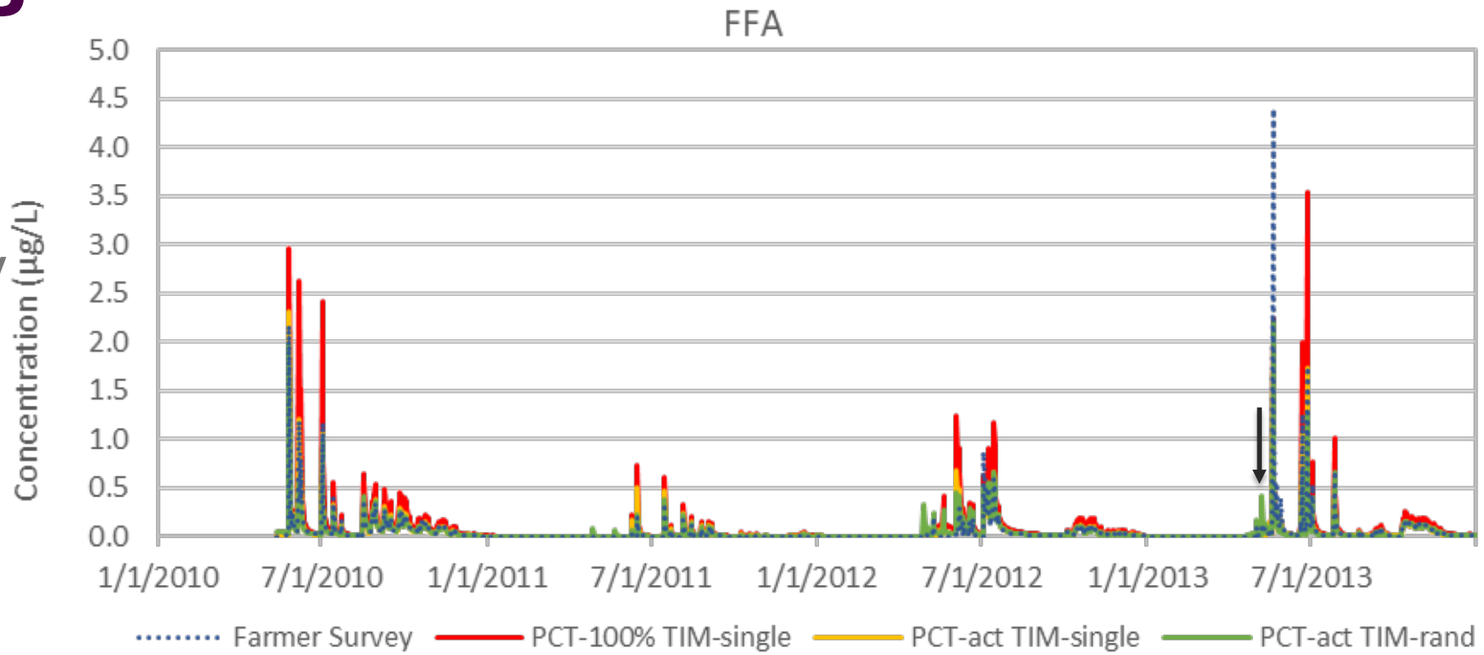
- 100% crops treated + single day appl.: High concentrations (red)
- Accounting for actual crops treated: Reduction of concentrations (yellow)
- Randomization of application dates: Further reduction of concentrations, closest to farmers survey, but timing impacted (green, arrow)



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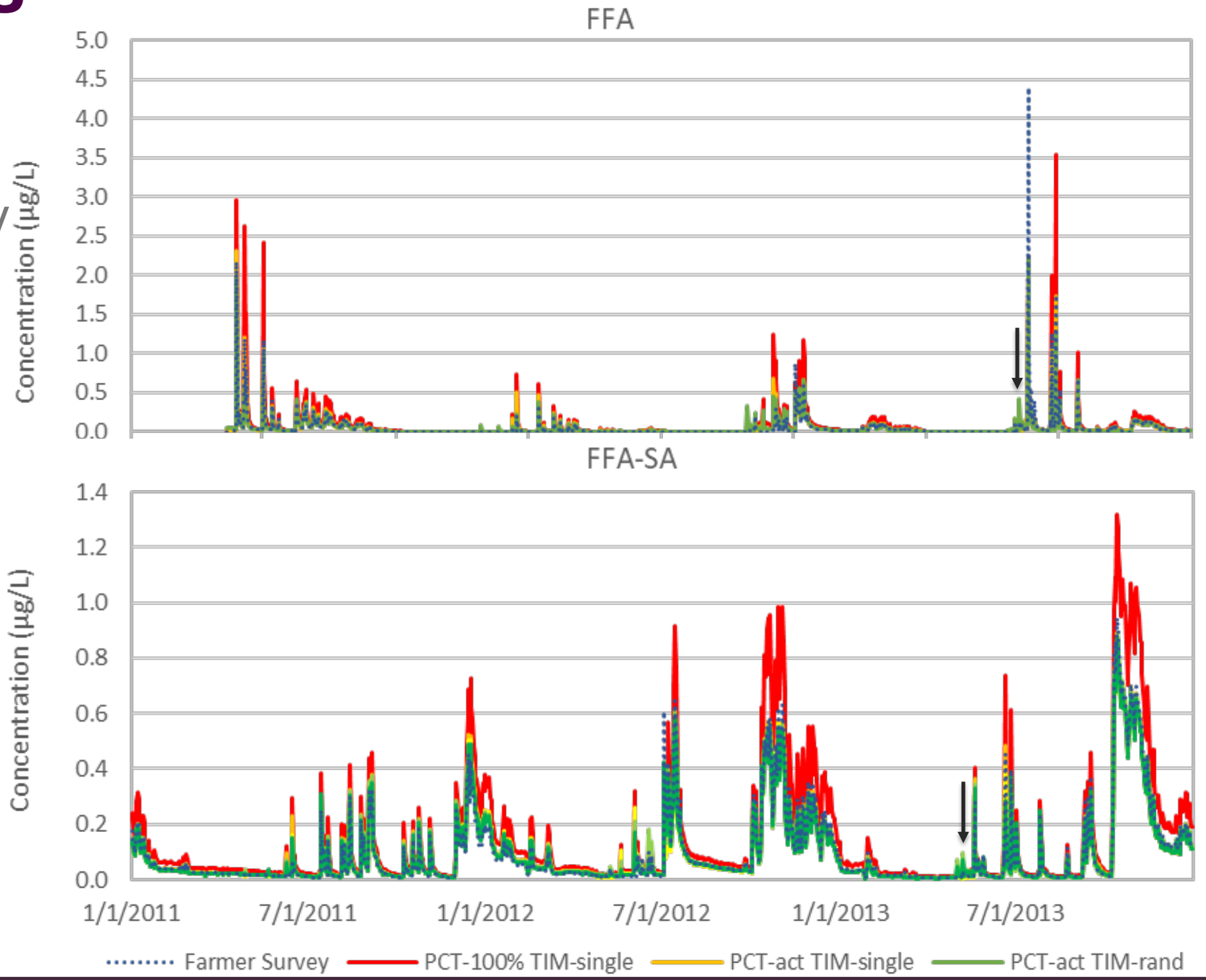
- 100% crops treated + single day appl.: High concentrations (red)
- Accounting for actual crops treated: Reduction of concentrations (yellow)
- Randomization of application dates: Further reduction of concentrations, closest to farmers survey, but timing impacted (green, arrow)
- FFA-SA dynamics not impacted by the management scenario



Conclusions

1. Subsurface chemical transport, formation decline, and plant uptake modeling
   - Successful implementation of subsurface transport, chemical transformation, and plant uptake process.
   - Very good agreement between observation and simulated FFA-SA concentrations

2. Representation of landscape features
   - Reveals complex spatio-temporal relationship of leaching and transport processes
   - Different impacts for FFA (surface runoff) and FFA-SA (lateral flow, groundwater)
   - More realistic simulation with landscape routing

3. Agricultural management
   - Results from detailed Farmer Survey can be approximated by ‘simpler’ conditional management with SWAT+
   - Accounting for percent cropped treated (or total pesticide mass applied) is crucial
   - Additional randomization of application dates leads to more realistic simulations

Questions?

Rathjens H, Kiesel J, Miguez MB, Winchell M, Arnold JG, Sur R. 2022. **Simulation of Pesticide and Metabolite Concentrations Using SWAT+ Landscape Routing and Conditional Management Applications**. Water 2022, 14, 1332.

Rathjens H, Kiesel, J Winchell, M, Arnold JG, Sur R. 2023. **Technical Note: Extending the SWAT Model to Transport Chemicals Through Tile and Groundwater Flow**. HESS 2023, 27, 159-167

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