Effectiveness of vegetated filter strips based on modeling with VFSMOD or fixed reduction percentages from the European regulatory framework

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Introduction

Vegetative filter strips (VFS) are the most widely implemented mitigation measures to reduce the transfer of pesticides to surface water via runoff and erosion. The mechanistic model VFSMOD (Muñoz-Carpena and Parsons, 2014) calculates the retention of water and sediment dynamically for each event based on actual environmental conditions. On the other hand, the European FOCUS Landscape & Mitigation framework (FOCUS, 2007) relies on fixed percentages for the reduction of water, eroded sediment and pesticide for two different filter strip widths (10 or 20 m). The software tool SWAN (ECPA, 2015), which was developed for higher-tier simulations of pesticide exposure in surface water, offers both a fixed efficiency option (FOCUS LM) and a dynamic, event based option (SWAN-VFSMOD) for modelling the effect of VFS on pesticide inputs into surface water via runoff and erosion.

The objective of this study was to evaluate the impact of the choice of SWAN-VFSMOD vs. FOCUS LM on the predicted reduction of pesticide inputs into surface water.

Materials and Methods

- SWAN-VFSMOD (v. 4.0.1) was run for 27 combinations of crop (corn/winter cereals), scenario (FOCUS (2001) scenarios R1-R4), water body (stream/pond) and application season → 1031 runoff events in total
- VFS length in flow direction (VL): 10 m
- Reduction of pesticide load in runoff/erosion (ΔP) by the VFS was calculated from the SWAN hydrological output for a range of K_{oc} values (10 to 10^7 L/kg), using three pesticide trapping equations:
  (1) the empirical multiple regression equation by Sabbagh et al. (2009)
  (2) the revised Sabbagh equation (Reichenberger et al., 2019)
  (3) a mechanistic mass balance approach (Reichenberger et al., 2019).
- Alternative calculation of ΔP according to FOCUS LM from the fixed reduction efficiencies (60% for runoff, 85% for eroded sediment) and the phase distribution of the pesticide
  → ΔP between 60% and 85%

Results and Discussion

- In the vast majority of cases SWAN-VFSMOD yielded higher pesticide reduction efficiencies (ΔP) than the FOCUS LM approach. However, sometimes the dynamically modelled ΔP were lower than the fixed ones, notably for events with high precipitation or dominated by snowmelt (Fig. 1).
- The three trapping equations showed different behaviour with regard to the fraction of events for which ΔP calculated with SWAN-VFSMOD is lower than than ΔP given by FOCUS LM (Fig. 2):
  - mass balance approach: fraction decreased with increasing Koc:
  - revised Sabbagh equation: fraction increased with K_{oc}
  - original Sabbagh eq.: non-monotonous behavior
- Due to the SWAN-VFSMOD scenario settings, ΔP for a given runoff event is almost equal to the relative change of the resulting pesticide concentration in surface water (ΔPECsw or ΔEEC).
- However, it can occur that with SWAN-VFSMOD the PECsw,max (EECmax) is caused by a different event than without VFS simulation. Hence, the change of the PECsw,max over the total simulation period (ΔPECsw,max) can be smaller than proportional.

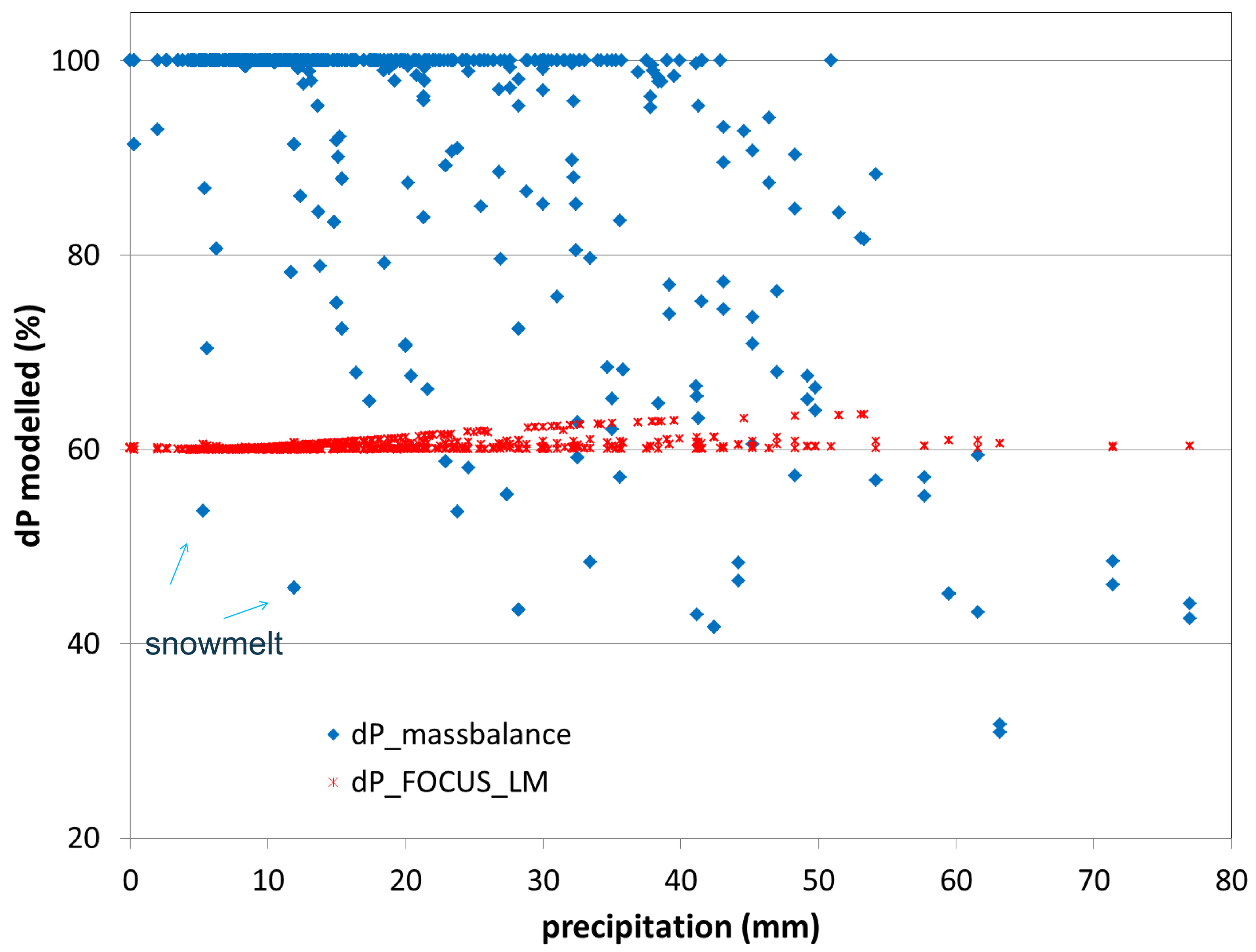

Fig. 1: Predicted pesticide reduction efficiency (ΔP) by a 10m-VFS for a dummy compound with K_{oc} = 1000 L/kg. dP_FOCUS_LM: fixed efficiencies according to FOCUS (2007). dP_massbalance: SWAN-VFSMOD simulation with a mechanistic mass balance trapping equation (Reichenberger et al., 2019)

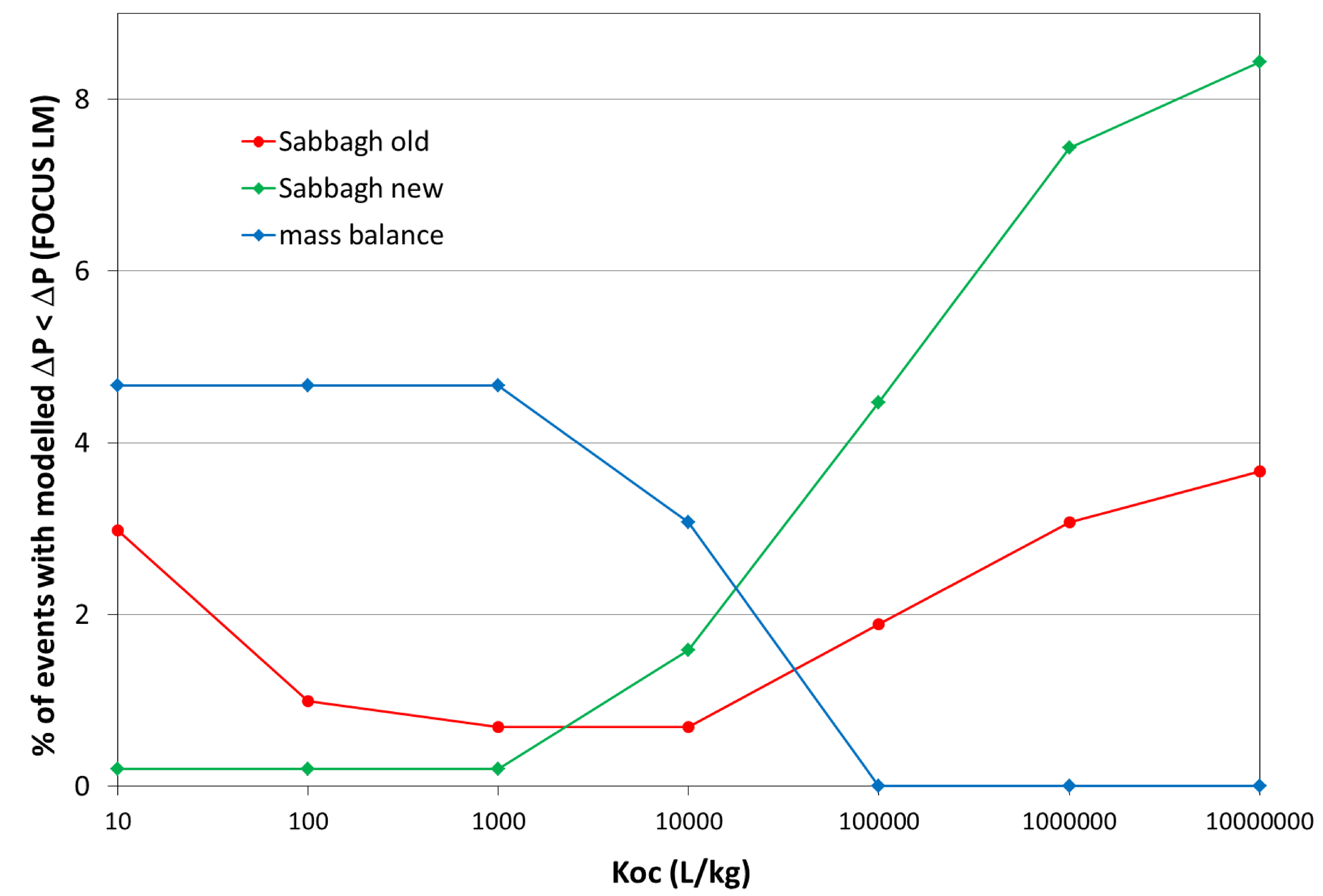

Fig. 2: Percentage of surface runoff events for which the pesticide reduction efficiency (ΔP) calculated with SWAN-VFSMOD for a 10-m VFS is lower than ΔP according to FOCUS LM, as a function of K_{oc}.

Conclusions

SWAN-VFSMOD can describe the performance of VFS (in terms of reducing surface runoff volume, eroded sediment yield and pesticide load) more realistically than a fixed efficiency approach such as FOCUS LM because it accounts for environmental conditions. In contrast to FOCUS LM, SWAN-VFSMOD can predict low VFS efficiency for large rainfall/runoff events and events dominated by snowmelt. Nevertheless, the LM approach is well suited as a lower tier approach.

References

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