Modelling real vegetative filter strip (VFS) experiments with a new VFSMOD version – calibration and uncertainty analysis with DREAM-ZS

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Introduction
- Vegetative filter strips (VFS) are the most widely implemented mitigation measure to reduce transfer of pesticides and other pollutants to surface waters via surface runoff and erosion.
- To reliably model VFS effectiveness in a risk assessment context, an event-based model is needed. The most commonly used dynamic, event-based model for this purpose is VFSMOD (Muñoz-Carpentas and Parsons, 2014; Muñoz-Carpentas et al., 1999).
- VFSMOD simulates reduction of total inflow (ΔQ) and reduction of incoming eroded sediment load (ΔE), the mechanistic reduction of pesticide load by the VFS (ΔP) is calculated with alternative process-based equations, including empirical regressions and a mechanistic mass balance approach.

Preliminary study
- Reichenberger et al. (2018) simulated 4 VFS studies (cf. Tab. 1) with 16 hydrological events.
- Conclusions:
  - The SWAN-VFSMOD (Brown et al., 2012) parametrization of saturated hydraulic conductivity seems too conservative (too little infiltration), while the parametrization of sediment filtration seems too optimistic (too much sediment trapping).
  - Biases in predicted ΔQ and ΔE propagate differently to ΔP predicted with the different trapping equations.

Objective
- The objectives of this follow-up study were to:
  1. Calibrate hydrology and sediment trapping in VFSMOD for the 4 VFS studies
  2. Compare the performance of the three pesticide trapping equations applied predictively to the calibrated VFSMOD runs
  3. Elucidate which trapping equation performs better in which situation (e.g. soil type, Kd characteristics of run-off/erosion events).
  4. Help improve parameterization methodologies for the infiltration and sediment filtration modules for regulatory VFS applications.

Materials and Methods
- For each VFS study, a calibration and uncertainty analysis was performed with the DREAM-ZS algorithm (Vrugt, 2016).
- A Python tool for automated VFSMOD simulations was coupled with the DREAM-ZS implementation in MATLAB.
- Three scenarios: ΔQ, ΔE, ΔP VFS outflow graphs (where available)
- Hydrologic events of the same study were calibrated simultaneously
- Four different VFSMOD settings:
  - no water table (noWT, 14 parameters) / shallow water table (Muñoz-Carpentas et al., 2018) / sWT, 12 parameters
  - ICO switch (feedback on infiltration on runoff): 0 or 1
- Goodness-of-fit measure:
  - weighted Nash-Sutcliffe Efficiency (NSE, w = NSE of ΔQ + D * NSE of ΔE)
  - sum of squared inversely weighted residuals (SSRWP)
- To limit the effect of the parameters, the posterior distributions, flat, non-informative priors were used (cf. Table 2).
- After the calibration the three pesticide trapping equations were applied predictively to the best parameterized sets.

References
- Reichenberger S et al. (2016). 8th European Modelling Workshop, Copenhagen, DK; oral pres.
- Reichenberger S et al. (2019). STOTEN, 647, 534–550
- Areva K. et al. 1996. Trans. ASAE, 39, 2155–2162
- Boull PM et al. 2003. Trans. ASAE, 46, 675