DOES THE INCLUSION OF MASS BALANCE AND DEGRADATION PROCESSES TO VEGETATIVE FILTER STRIPS IMPACT LONG-TERM PESTICIDE ENVIRONMENTAL EXPOSURE ASSESSMENTS?

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INTRODUCTION

Vegetative filter strips (VFS) are a widely adopted for reducing pesticide transport from adjacent fields to receiving water bodies. The long-term VFS efficacy is dependent on site-specific factors related to soils, weather, land use, vegetation and maintenance. The previous version of the well-tested process-based model for VFS (VFSMOD), assumed that pesticide mass stored in the VFS was not available for transport in subsequent storm events. This research study uses an updated PRZM/VFSMOD/EXAMS modeling framework, by considering the effect of the addition of surface mass balance and degradation processes on acute (peak) and chronic (60-d) aquatic environmental exposure concentrations (EECs) and percent reductions across three distinct 30-yr US EPA scenarios.

EPA REGULATORY FRAMEWORK

- Estimated Environmental Concentration (EEC) are calculated based on a Farm-Pond model
- EPA's standard Farm-Pond scenario estimates the upper 90th percentile EEC over a period of 30 years based on conservative considerations
- Higher tier refinements may include vegetative filter strip (VFS), drift buffer, etc. (see Figure 1).

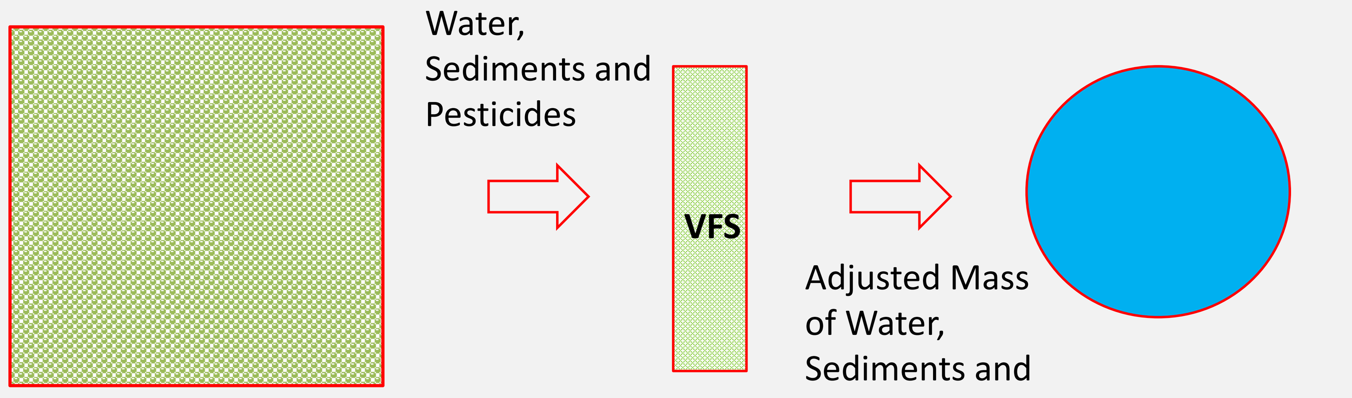

Figure 1. EPA Standard Pond Conceptual Model and VFS

VFSMOD: A MECHANISTIC DESIGN TOOL

- VFSmod [Muñoz-Carpena, et al., 1993b; 1999, 2004] is a field scale, mechanistic, and storm-based model that describes the overland water flow, particle and contaminant filtration in dense vegetation.
- Successfully field-tested[1] for infiltration, flow, particles, bromide, pesticides, phosphorus (particulate and dissolved).

NEW PESTICIDE RESIDUE AND DEGRADATION

- Evaluation of the VFS effects on the 30-year pesticide assessment simulations require realistic initial conditions at the beginning of each runoff event in the time series (initial soil water, pesticide residue and vegetation status).
- A new simplified VFS pesticide mass balance is proposed to estimate surface pesticide residue for inclusion in VFSMOD's buffer efficiency calculations (Fig. 2).

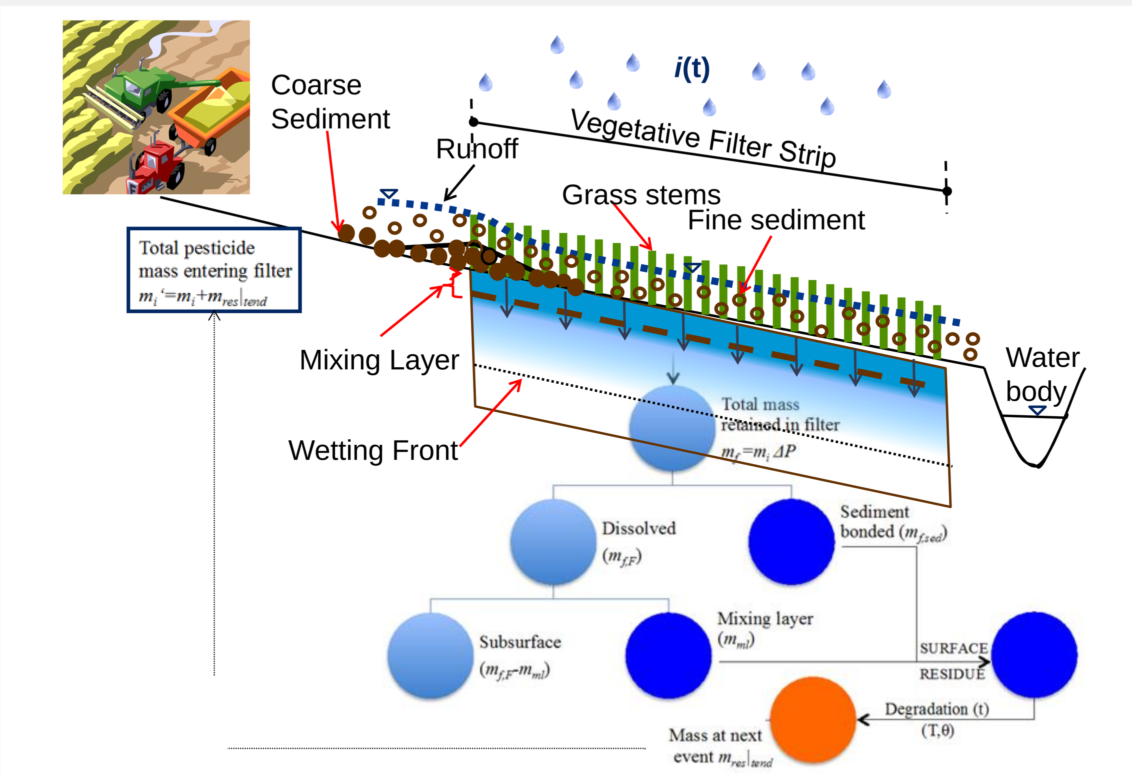

Figure 2. Conceptual pesticide mass balance/degradation.

EVALUATION: 30-YEAR EXPOSURE ASSESSMENTS

- 3 distinct EPA scenarios for 30 yr. assessments: IL-Corn, OR-Wheat, CA-Tomato.
- Soils, land-use and climate from USEPA prescribed scenarios.
- VFS grass mixture, good stand, filter lengths VL=0 (no filter), 1, 5 and 9 m.
- Pesticides compared: Koc (20, 200, and 2000 L/kg) , ts (aerobic soil metabolism half-life,10, 100, 1000 d), tw (half-life in water and sediment,10, 100, 1000 d)
- 2-5 applications at typical insecticide timings and rates for each crop.
- Without pesticide residue calculations (IDG0) and with calculations (IDG1).
- Total of 648 long-term (30-yr) simulations for all scenarios .
- Evaluation methods shown in Figure 4 (box plots and Morris method).

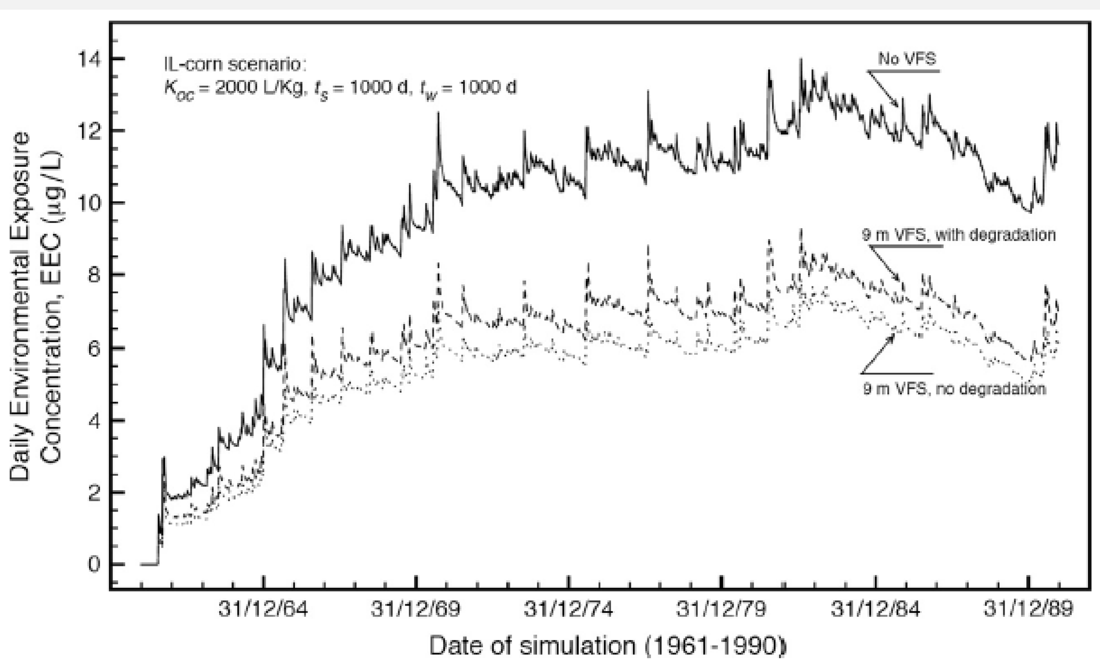

Figure 3. Daily EECs in water for IL Corn scenario example for 30 years

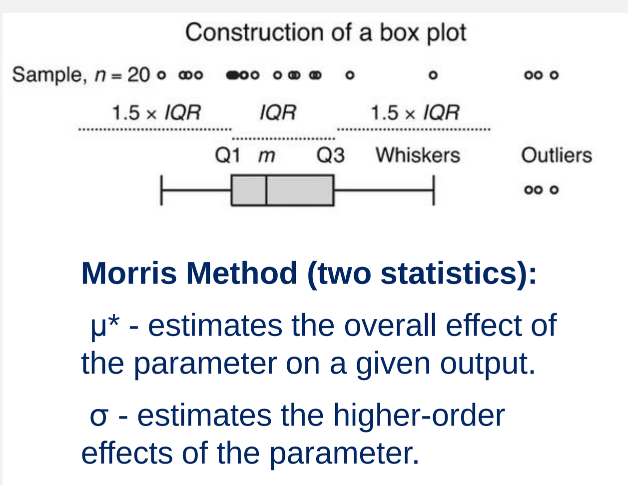

Figure 4. Evaluation methods: Box plots and global sensitivity analysis

RESULTS:

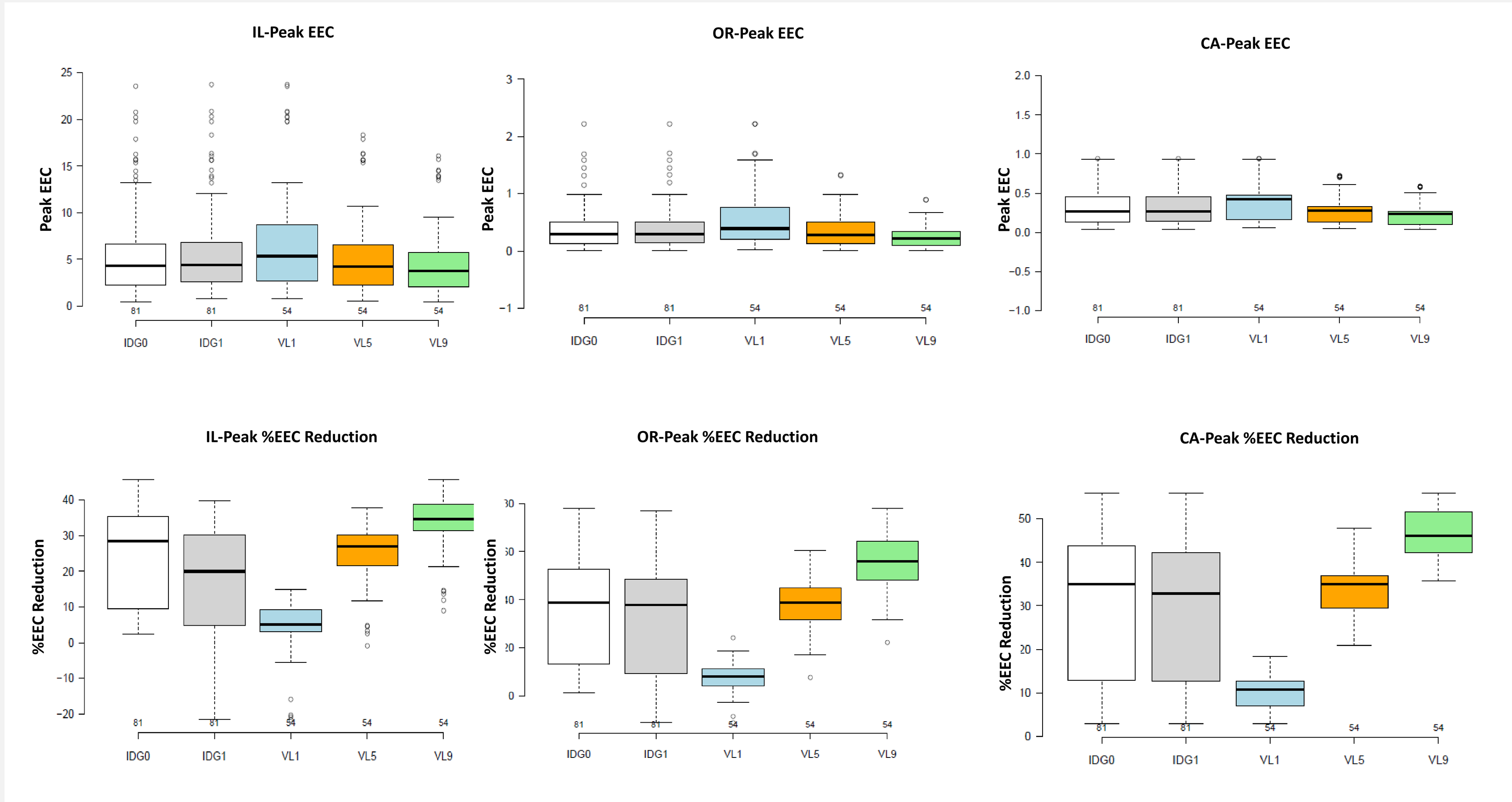

Figure 5. Box plots of acute (peak) absolute and % reduction in EEC

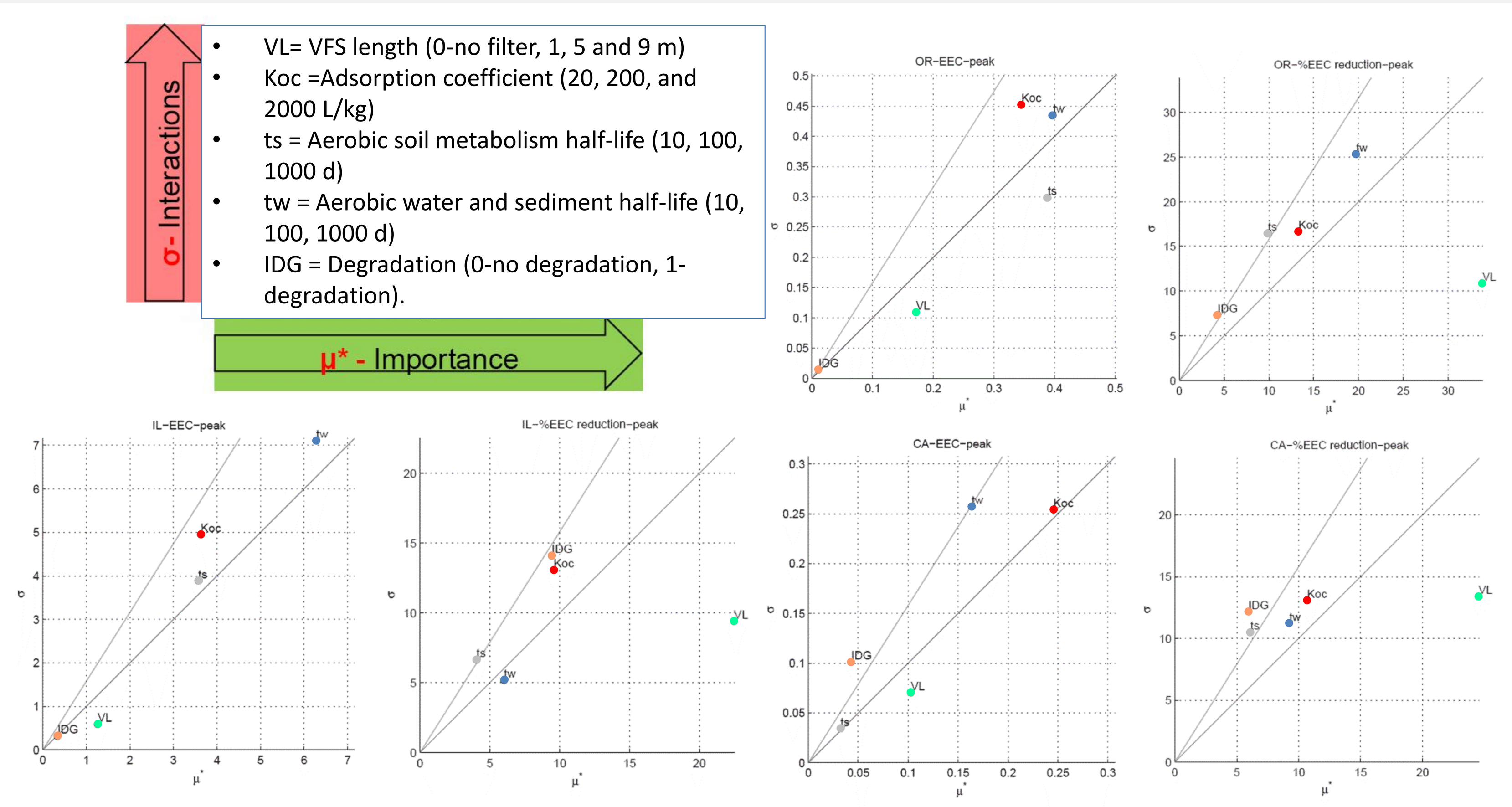

Figure 6. Global sensitivity analysis on acute (peak) absolute (left) and % reduction (right) in EECs

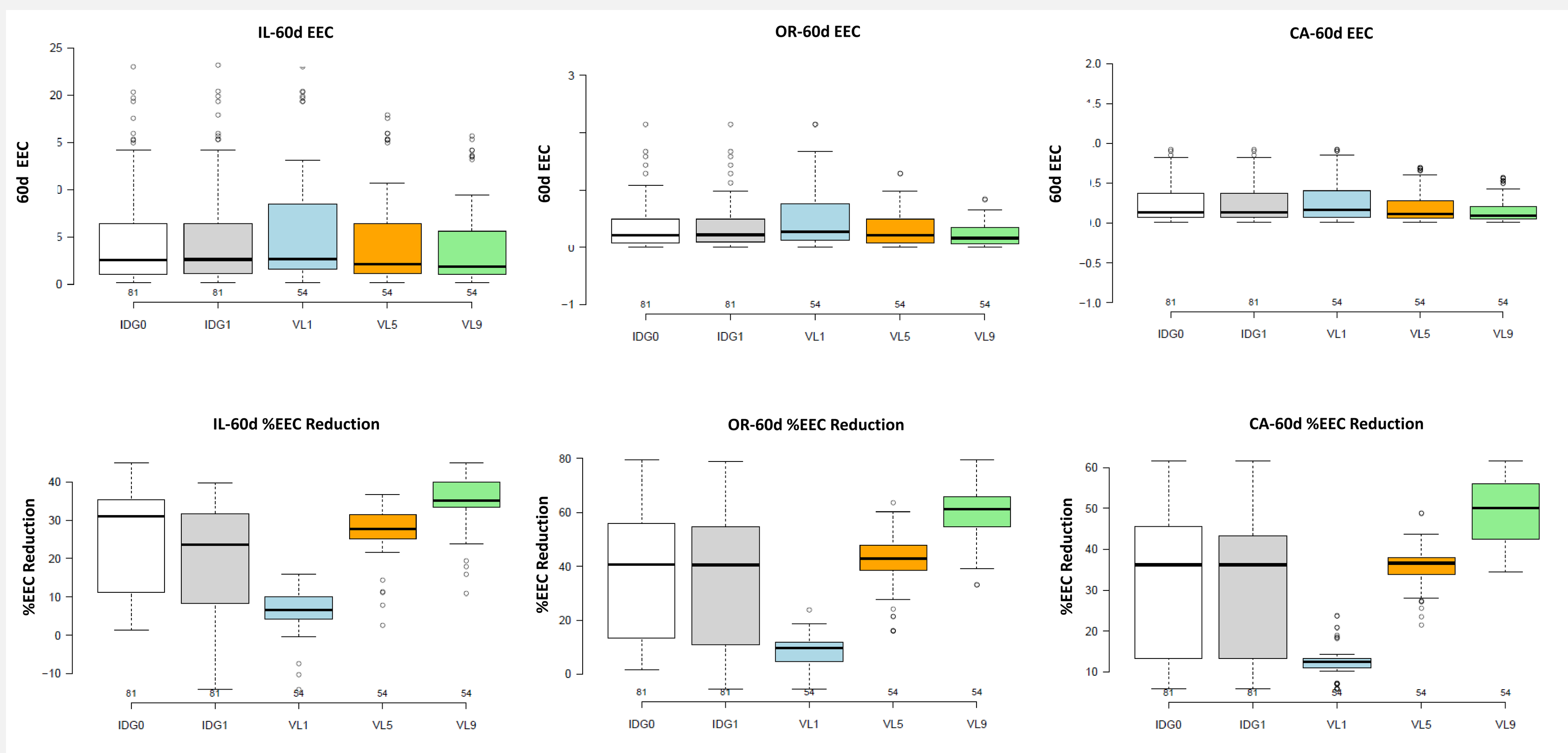

Figure 7. Box plots of chronic (60d) absolute and % reduction in EEC

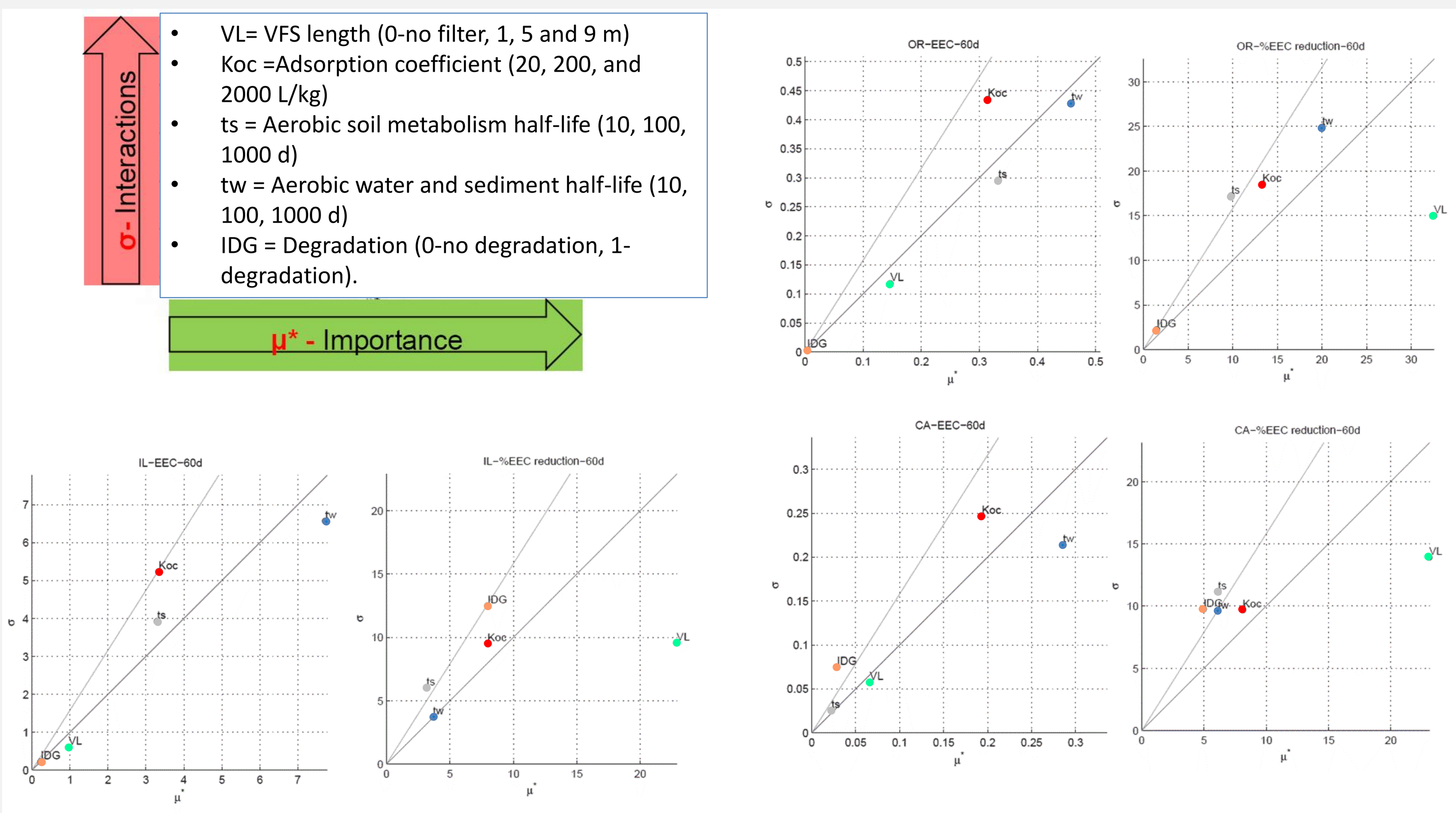

Figure 8. Global sensitivity analysis on chronic (60d) absolute (left) and % reduction (right) in EECs

CONCLUSIONS

- Significantly updated modeling framework for pesticide environmental exposure assessment with pesticide mass balance and degradation process in VFS.
- Based on the three distinct U.S. EPA scenarios in this research, considering degradation was not important if single, large events controlled pesticide transport through the vegetative filter strip.
- Including the mass balance and degradation was important when considering percent reduction in exposure concentrations.
- Revised framework allows for mechanistic analysis on the internal dynamics of the pesticide trapping process for all transport events, beyond the limited information contained in the upper percentiles of the EEC assessment process.

REFERENCES

1. Abu-Zreig, 2001; Fox, et al., 2005; Muñoz-Carpena et al., 1993b; 1999, Kuo et al., 2009; Sabbagh et al., 2009; Poletika et al., 2009; Perez-Ovilla, 2010; Winchell et al., 2011; Yu et al., 2011, 2012, etc.