Supporting Information A (SI-A) to:

Are spray drift losses to agricultural roads more important for surface water contamination than direct drift to surface waters?

Urs T. Schönenberger[a], Janine Simon[b,1], Christian Stamm[a,*]

[a]Eawag, Swiss Federal Institute of Aquatic Science and Technology, 8600 Dübendorf, Switzerland

[b]Albert-Ludwigs-Universität Freiburg, Fahnenbergplatz, 79085 Freiburg im Breisgau, Germany

[*]Corresponding author (christian.stamm@eawag.ch)

[1]Hochschule für Wirtschaft und Umwelt Nürtingen-Geislingen, Neckarsteige 6-10, 72, 622 Nürtingen, Germany (present address).

Table of contents

A1. Methods

A1.1 Definition of road areas

Road areas were derived from the dataset TLM_STRASSE of the topographic landscape model swissTLM3D (Swisstopo, 2020). Since this dataset only provides line data for roads, a buffer around road lines was added to generate a dataset of road polygons. The buffer width around each road segment was chosen based on the road categories as defined by the swissTLM3D. The range of road widths covered by each category, and the buffer widths used in this study are shown in table Table A 1. Afterwards, the resulting road polygon dataset was complemented with additional sealed traffic areas (parking lots and motor way stations) from the polygon dataset TLM_VERKEHRSBAUTE_PLY of the swissTLM3D model.

Table A 1: Road categories and buffer widths used for creating a polygon dataset from the road line dataset.

Category	Range of widths according to swissTLM3D	Buffer width used (estimated width / 2)
2m road	1.81 - 2.80 m	2.3 m / 2 = 1.15 m
3m road	2.81 - 4.20 m	3.5 m / 2 = 1.75 m
4m road	4.21 - 6.20 m	5.2 m / 2 = 2.6 m
6m road	6.21 - 8.20 m	7.2 m / 2 = 3.6 m
8m road	8.21 m - 10.20 m	9.2 m / 2 = 4.6 m
10m road	> 10.20 m	10.2 m / 2 = 5.1 m
Highways, motorways	not defined	10.2 m / 2 = 5.1 m
Other roads	< 1.80 m	0 m

A1.2 Definition of surface water areas

To determine the surface water areas in our study sites, we combined two datasets of the swissTLM3D (Swisstopo, 2020) model. Dataset F represents streams (TLM_FLIESSGEWAESSER, line dataset), from dataset B (TLM_BODENBEDECKUNG, polygon dataset) larger surface waters such as large streams, lakes, ponds, and swamps were extracted. Since the stream dataset (F) consists of line data, a buffer around streams was added to generate a dataset of stream polygons. This was only done for smaller streams, since larger streams are covered by the polygons of dataset B. To determine the buffer widths, we measured the width of each stream segment three times using aerial images with a resolution of 0.1 m (Swisstopo, 2019). The buffer width was then defined as half of the average width measured. For stream segments not visible on the aerial images (e.g. due to coverage by trees), we used the widths determined for the closest downstream segment for which a measurement was available. If no measured downstream segment was available, we used the closest measured upstream segment. If no measured upstream segment was available, we set the buffer width to 1m. This corresponds to a stream width of 2m and is expected to be an overestimation in most cases. Finally, the stream polygons resulting from dataset F were combined with the polygons of dataset B into one surface water area dataset.

A1.3 Spray drift model: Additional example

To improve the comprehensibility of the spray drift model described, we provide an additional example for the calculation of the width along the wind line $w_{FHT,i,p,w}$ (m). This width is used for the calculation of the drift reduction factor of forest, hedges and trees $f_{FHT,i,p,w}$ (see eq. 4). The additional example (see Figure A 1), aims on illustrating how the width along the wind line $w_{FHT,i,p,w}$ is calculated if multiple polygons of forest, hedges and trees (FHT) are located between the non-target area and the sprayed plot.

For wind direction northeast (NE), between the plot p = 1 and the non-target area cell i = 17, only one FHT polygon is located. Therefore, the FHT width along the wind line equals the width along the wind line of this single polygon:

$$w_{FHT,17,1,\mathrm{NE}} = w_{FHT,A} \quad \text{(A1)}$$

Between the plot p = 2 and the non-target area cell i = 17, two FHT polygons are located. Therefore, the FHT width along the wind line is calculated as the sum of these two polygons:

$$w_{FHT,17,2,\mathrm{NE}} = w_{FHT,A} + w_{FHT,B} \quad \text{(A2)}$$

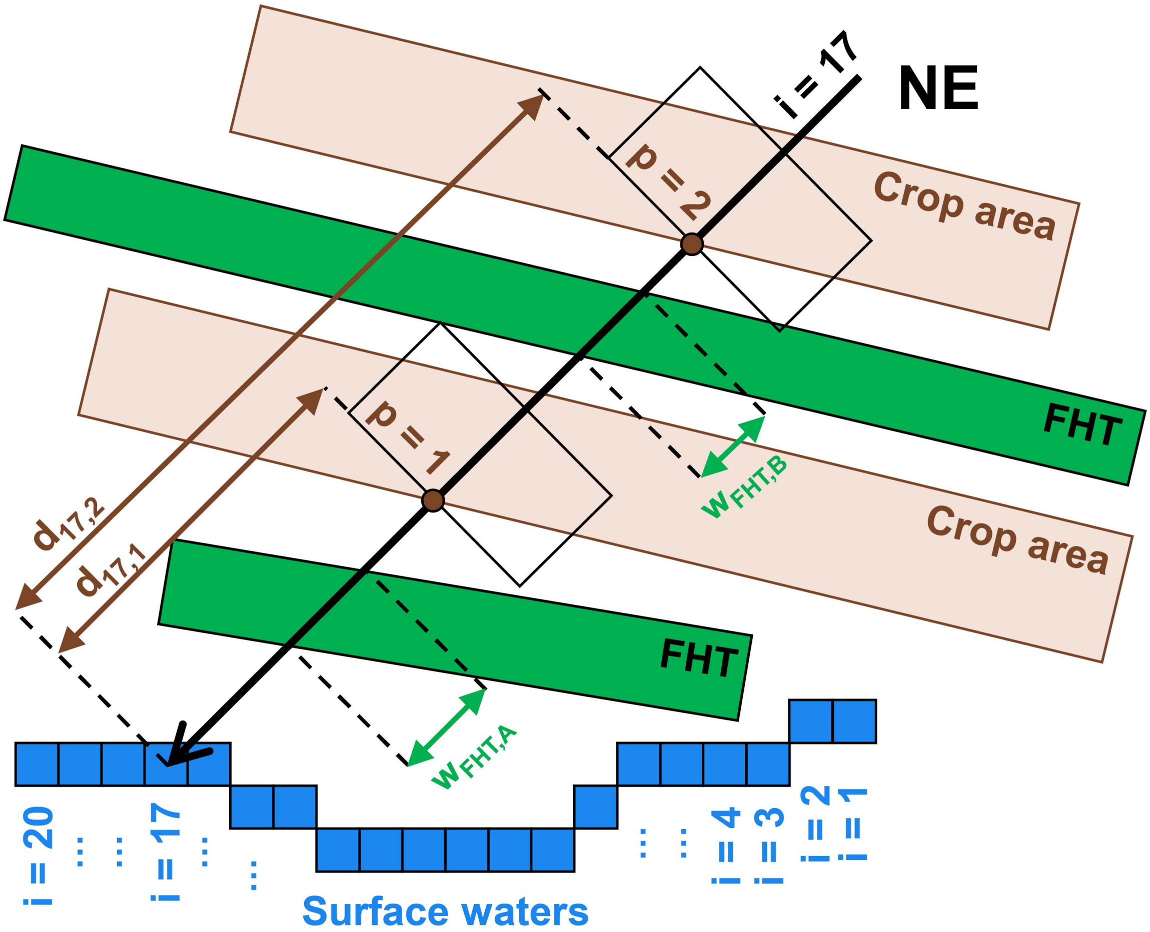

Figure A 1: Example of the calculation of drift distances $d_{i,p}$ and barrier widths $w_{FHT,i,p}$ for the non-target area cell i = 17 for the wind direction northeast (NE). In this example, two different polygons of forest, hedges and trees (FHT) act as a barrier.

A2. Results

A2.1 K_{OC} of different pesticide categories

In Figure A 2, the distribution of the organic carbon-water partition coefficients (K_{OC}) is shown for herbicides, fungicides and insecticides authorized for use in Switzerland in the year 2021. The list of authorized pesticides was extracted from the Swiss Plant Protection Product Registry (BLW, 2021) and linked with K_{OC} values obtained from the pesticides properties database (Lewis et al., 2016). Consequently, this analysis only covers authorized pesticides with a K_{OC} available in the pesticide properties database (i.e. 82 herbicides, 79 fungicides, and 38 insecticides). The mean K_{OC} equaled 92 mL g^{-1} for herbicides, 1100 mL g^{-1} for fungicides, and 1700 mL g^{-1} for insecticides.

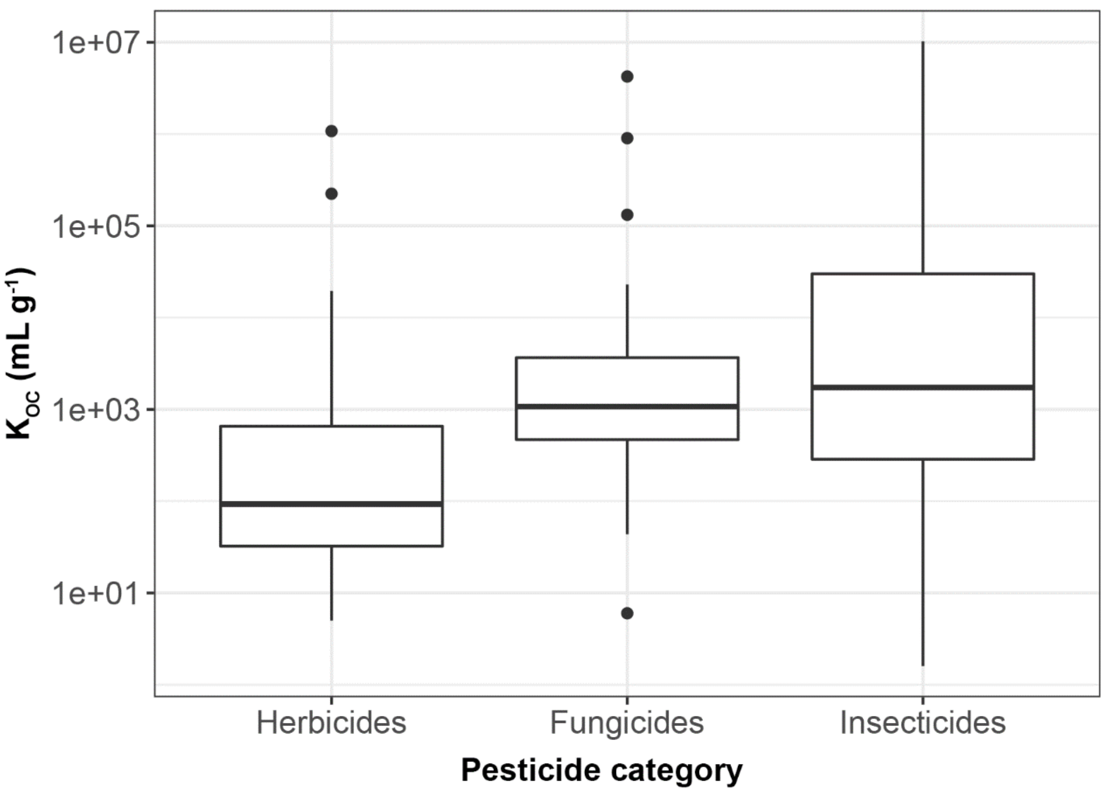

Figure A 2: Distribution of the organic carbon-water partition coefficients (K_{OC}) of herbicides, fungicides, and insecticides authorized for use in Switzerland in the year 2021.

A2.2 Local sensitivity analysis

The results of the local model sensitivity analysis are shown in Figure A 3 for arable land sites and in Figure A 4 for vineyard sites.

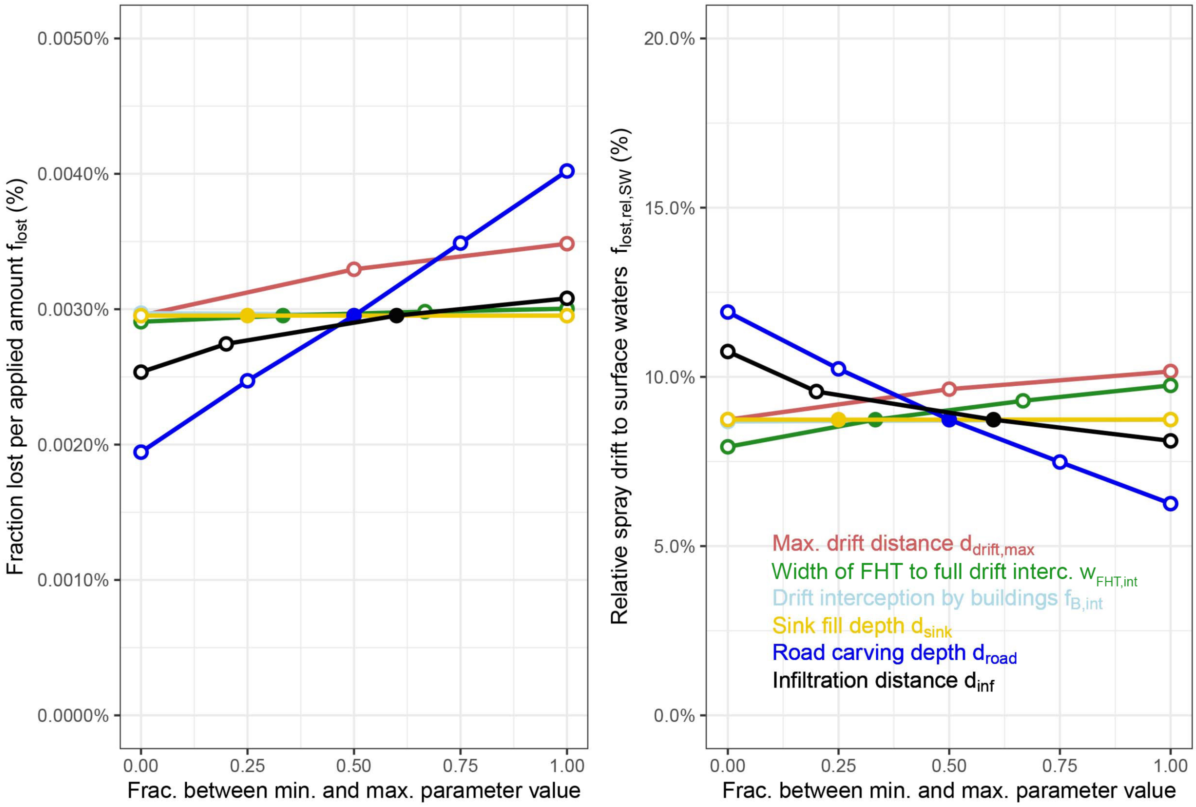

Figure A 3: Model sensitivity on parameter changes for arable land sites. Left: Sensitivity of fraction lost per applied amount (f_{lost}). Right: Sensitivity of relative spray drift deposited on surface waters ($f_{lost,rel,SW}$). Filled dots represent the results of the reference parameter set.

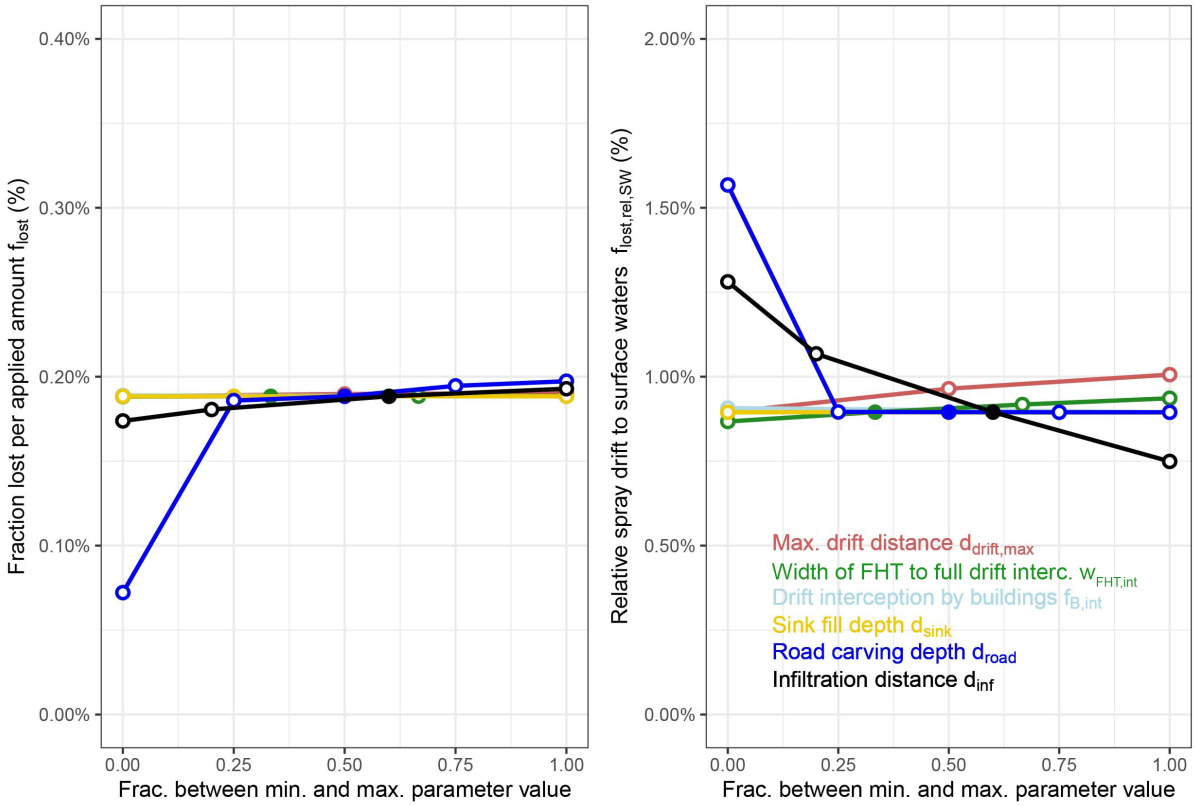

Figure A 4: Model sensitivity on parameter changes for vineyard sites. Left: Sensitivity of fraction lost per applied amount (f_{lost}). Right: Sensitivity of relative spray drift deposited on surface waters ($f_{lost,rel,SW}$). Filled dots represent the results of the reference parameter set.

References

BLW. Swiss Plant Protection Product Registry. Bundesamt für Landwirtschaft (BLW), URL: https://www.psm.admin.ch/, Date accessed: 13.10.2021, 2021.

Lewis KA, Tzilivakis J, Warner D, Green A: An international database for pesticide risk assessments and management., Human and Ecological Risk Assessment: An International Journal, 22, 1050-1064, doi: 10.1080/10807039.2015.1133242, 2016.

Swisstopo. SWISSIMAGE – The Digital Color Orthophotomosaic of Switzerland. Swisstopo, Federal Office of Topography, Wabern, 2019.

Swisstopo. swissTLM3D – The Topographic Landscape Model. Swisstopo, Federal Office of Topography, Wabern, Switzerland, 2020.