High resolution exposure modelling at landscape-level

On the development of the droplet and atmospheric dispersion (DAD) drift model

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Introduction

Modelling environmental concentrations of pesticides at landscape-level is of growing interest for pesticide registration and product stewardship. This includes decision making as well as the design of higher-tier monitoring studies and the optimal selection of mitigation measures. Typically, processes such as runoff, drainage, and leaching are well represented in existing modelling concepts at point and landscape scale. However, the modelling of off-target spray drift is often neglected or simplified at the landscape-level scale due to its high computational costs. Attempts at implementing spray drift into landscape-level modelling often rely on an external calculation of drift curves with pesticide masses added directly to the channel network. Although this approach enables the estimation of drift entries based on the proximity of source areas to water bodies, it may be insufficient in representing the spatial distribution of spray drift depositions in the landscape.

Objectives

- Enable landscape-level spray drift prediction, taking typical short-term weather conditions into account
- Development and validation of a spray drift model for ground application using independent observation data
- Enable a modular design as standalone or in combination with other modelling approaches:
  - Landscape-level assessment (e.g. SWAT)
  - Exposure assessment in combination with ecotoxicological modelling

Material & Methods

1. Model Inputs
- Weather conditions
- Drop size distribution
- Operational characteristics
- Physio-chemical properties of spray solution

2. a) Mechanistic Droplet Model
- Simulates droplet kinetics and evaporation
- Predicts dynamic droplet trajectory

2. b) Micro-Climate Model
- Indirect interaction between droplets
- Simulates mass and energy balance

3. 3D Gaussian Diffusion Model
- Longitudinal advection
- Vertical, lateral and longitudinal dispersion

4. Drift Pattern Prediction
- Mass flux function of concentration and vertical droplet velocity
- Base model resolution of 1x1 m

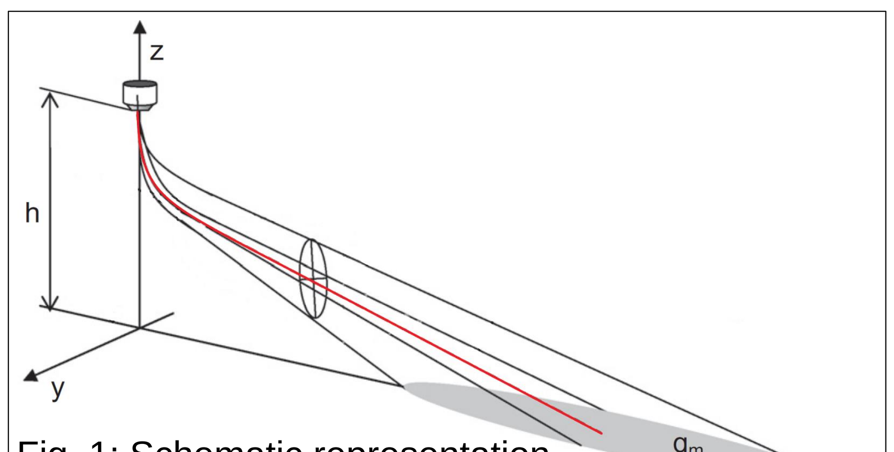

Fig. 1: Schematic representation of the diffusion model [1].

5. Model Output
- Drift Curve Prediction
- Landscape-level drift prediction

One-At-a-Time Sensitivity Analysis:

- Variation of 23 input parameters by ±25%, for all 7 application scenarios
- Comparison to reference run using the root mean square error - observations standard deviation ratio (RSR)

Model Setup & Validation:

- Model inputs based on two field-scale spray drift studies for ground application covering a wide range of drift potentials
- Canopy height, leaf area index and surface roughness height based on literature research
- Vertical and horizontal wind standard deviation parameterized based on two spray drift studies

Study 1 [2]	Study 2 [3]
▪ XR nozzle (high drift potential) ▪ DG nozzle (medium-low drift potential) ▪ AIXR nozzle (low drift potential) ▪ Four replicates per nozzle	▪ TTI nozzle (very low drift potential) ▪ Four identical test plots ▪ Three replicates per test plot

Results

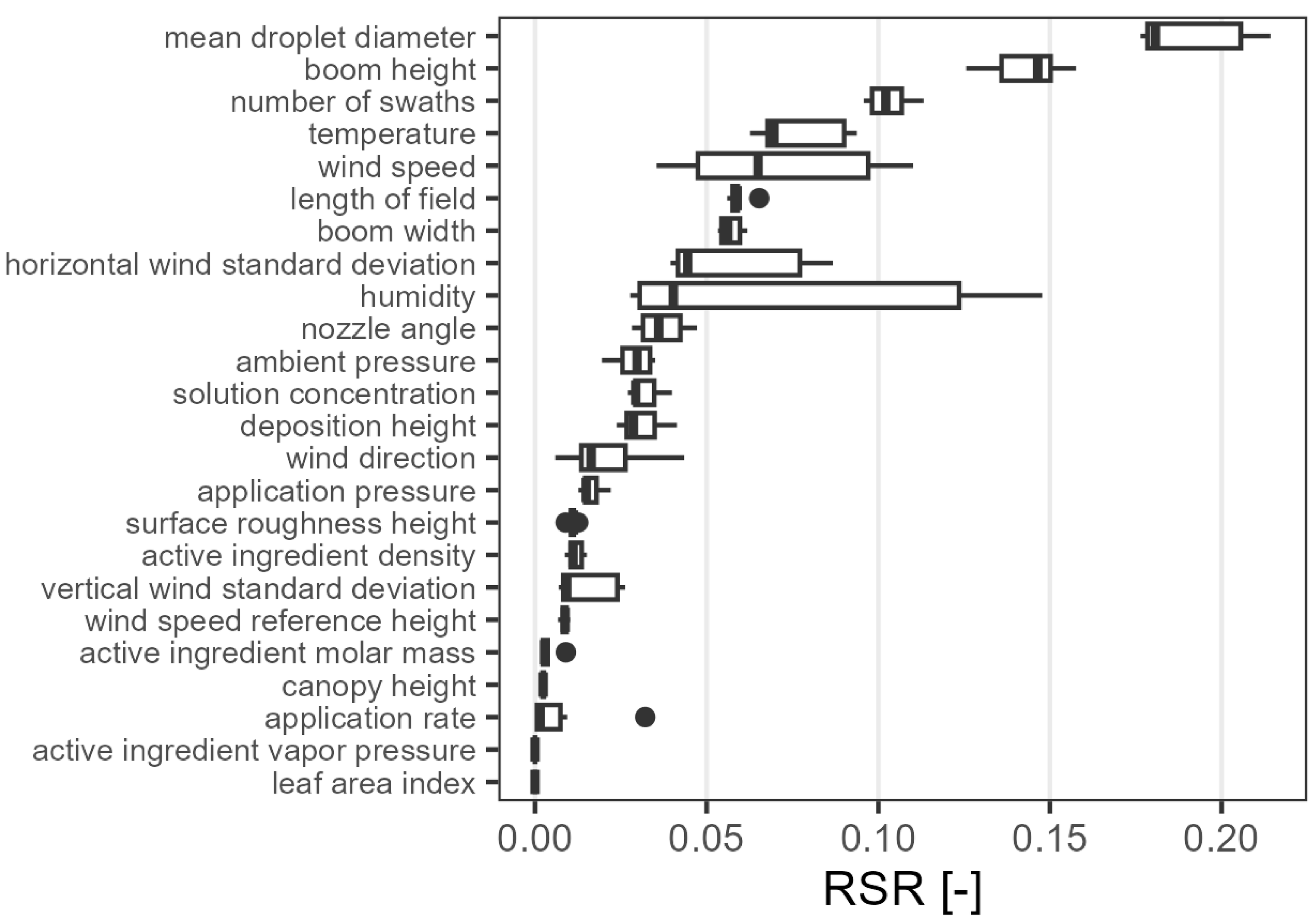

Fig. 2: Input parameter ranking from most sensitive to least sensitive based on the RSR.

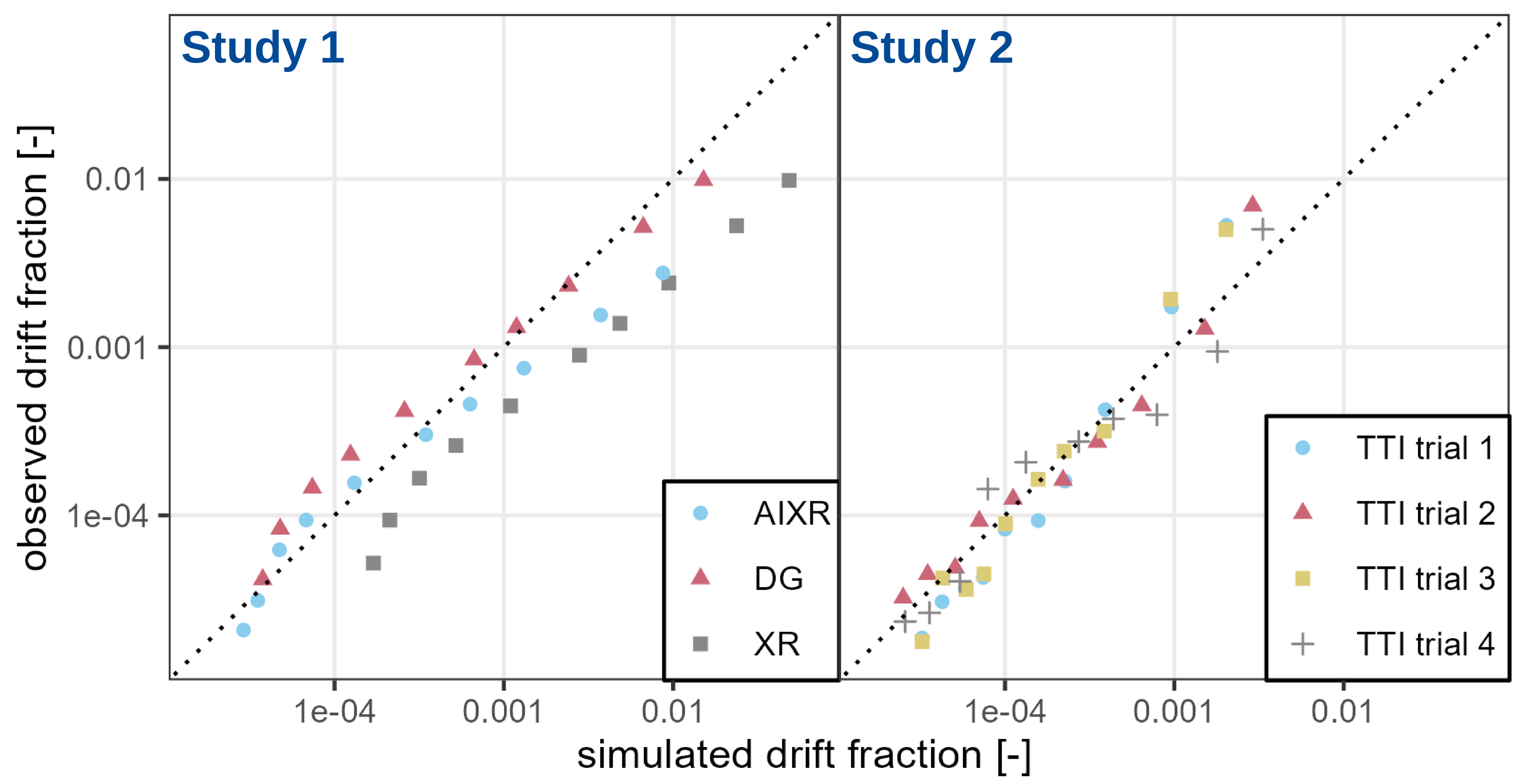

Fig. 3: Observed and simulated drift fractions for the 7 application scenarios, with study 1 on the left and study 2 on the right.

- Mean droplet diameter and spray boom height are the most sensitive input parameters
- Low sensitivity to characteristics of active ingredient
- High variability of parameter sensitivity between application scenarios for mean droplet size, temperature, wind speed, horizontal dispersion, and humidity

Study 1:

- Very good model performance 0.921 (R^2) and 0.273 (RSR) against observation data
- Systematic model overprediction of the XR11003 scenario
- Agreement between DG nozzle and XR nozzle in the observations is unrealistic and potentially associated with study design

Study 2:

- Very good model performance 0.928 (R^2) and 0.264 (RSR) against observation data

Conclusions & Outlook

- Sensitivity analysis indicates coherent and comprehensible model behavior
- The droplet and atmospheric dispersion drift model was successfully validated against two field trials, with overall very good model performance
- Assessment of dominant spray drift factors at landscape scale is ongoing
- Landscape-level assessment of pesticide exposure in waterbodies is planned employing SWAT+ to combine drift and other transport processes (i.e. drainage, runoff, or lateral flow).

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References

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