Development and Validation of a Mechanistic Ground Sprayer Model

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Summary

- By adapting the same analytical Lagrangian approach used successfully in the aerial spray model AGDISP, with the addition of jet entrainment effects at the nozzles, a mechanistic ground sprayer model has been developed and validated by SDTF and Canadian field data.
- The ground model predicts spray deposition downwind from the application area for any set of initial conditions, and may be used to estimate spray drift levels from tested ground sprayer nozzles.

Ground and Aerial Differences

- In the ground model the aircraft is removed and the droplet exit velocity from the nozzles becomes important.
- So too does jet entrainment, as this effect supports and sustains the further movement (air speed v) of the spray toward the surface

$$v = aU_{jet}\left(\frac{L}{h}\right)^{\delta^2/2K}$$

where a = 0.88, U_{jet} comes from Bernoulli's law (equating static and dynamic pressures), L (0.14 m) is the coherent length of the liquid sheet, and h is the distance below the nozzle.

Data Differences

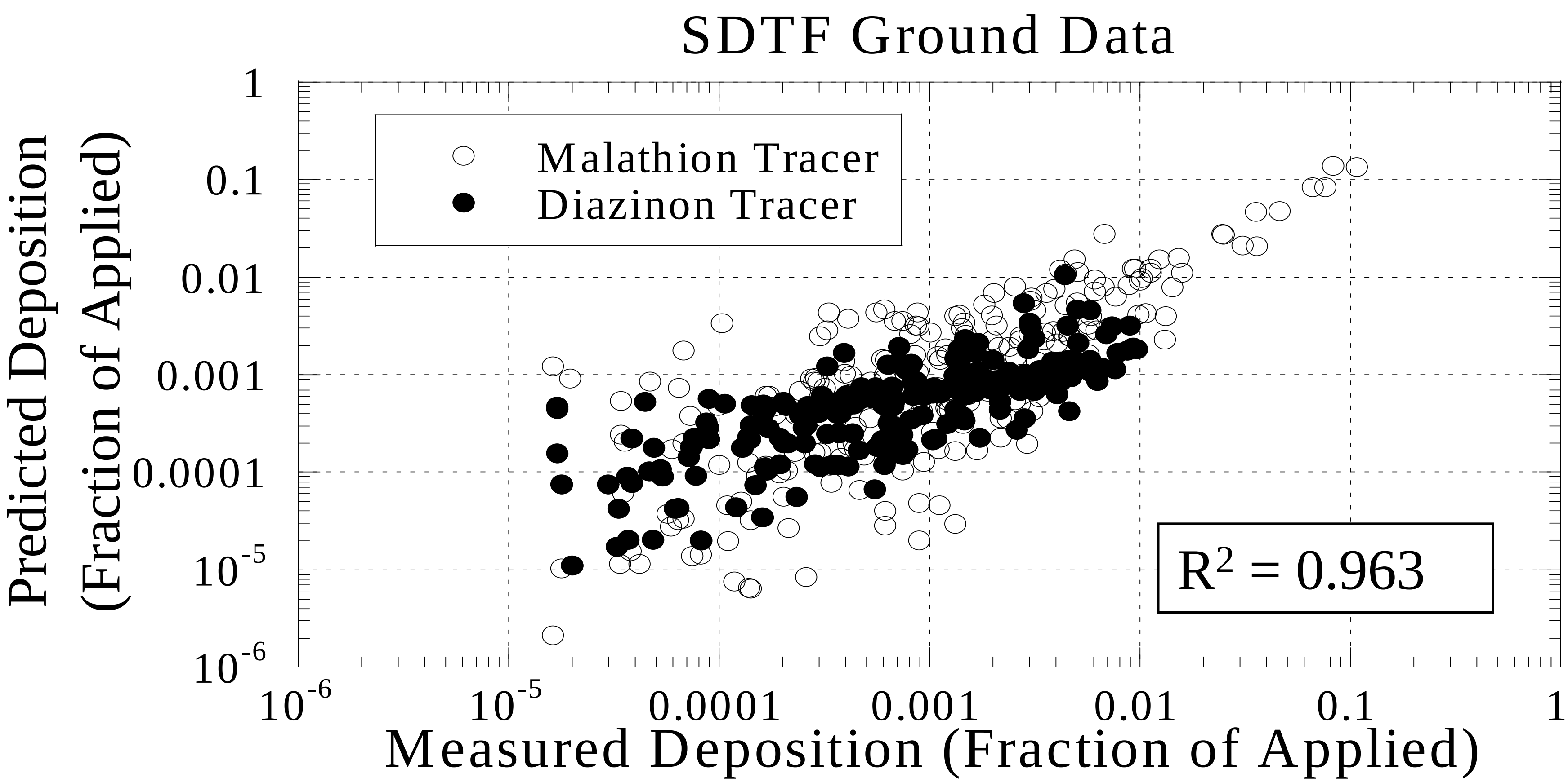
- SDTF: 46 trials; nozzles 8004, 8004LP, 8010LP, TX-6; 51 cm and 127 cm boom heights; Diazinon and Malathion tracers (nonvolatile fraction 0.0022 to 0.0117); z_o = 1.09 to 4.88 cm; 1.68 m/s to 8.59 m/s wind speeds; 6.7 to 32.9°C; 8.0 to 72.8% relative humidity.

- Canadian: 21 trials; nozzles XR8003VS, AI110025, TT11005, AI11004; 60 cm and 90 cm boom heights; formulated 2,4-D-amine (nonvolatile fraction = 0.00914); z_o = 0.543 cm; 2.81 m/s to 9.17 m/s wind speeds; 12.1 to 28.4°C; 12.9 to 50.0% relative humidity.

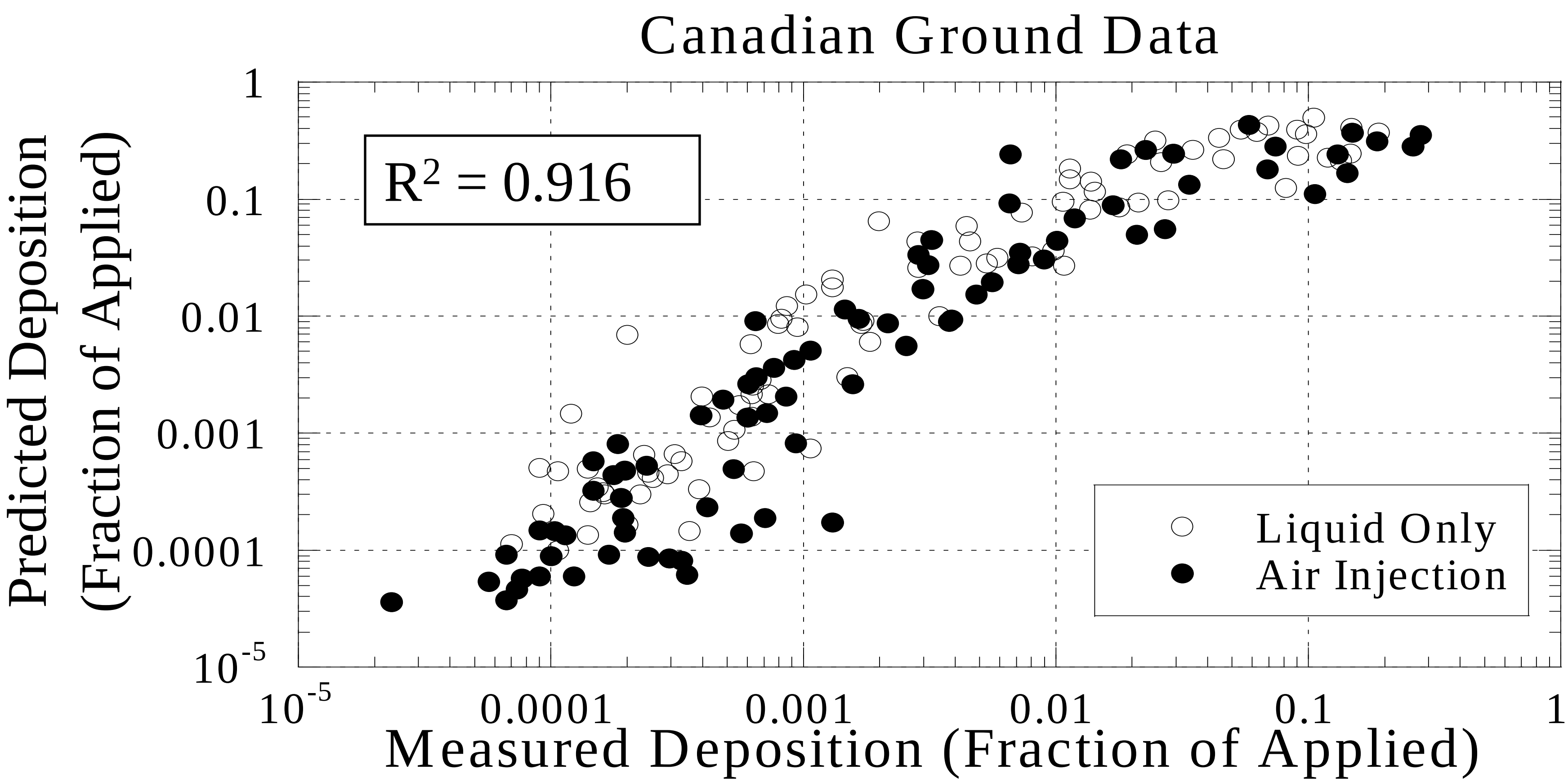
Model Difference

- The power law on jet entrainment has been adjusted for air injection nozzles, from a value of $\delta^2/2K = 0.57$ for the SDTF data to 2.04 for the Wolf data.
- All other model parameters remain the same between the two data sets.

Model Comparison with SDTF Data

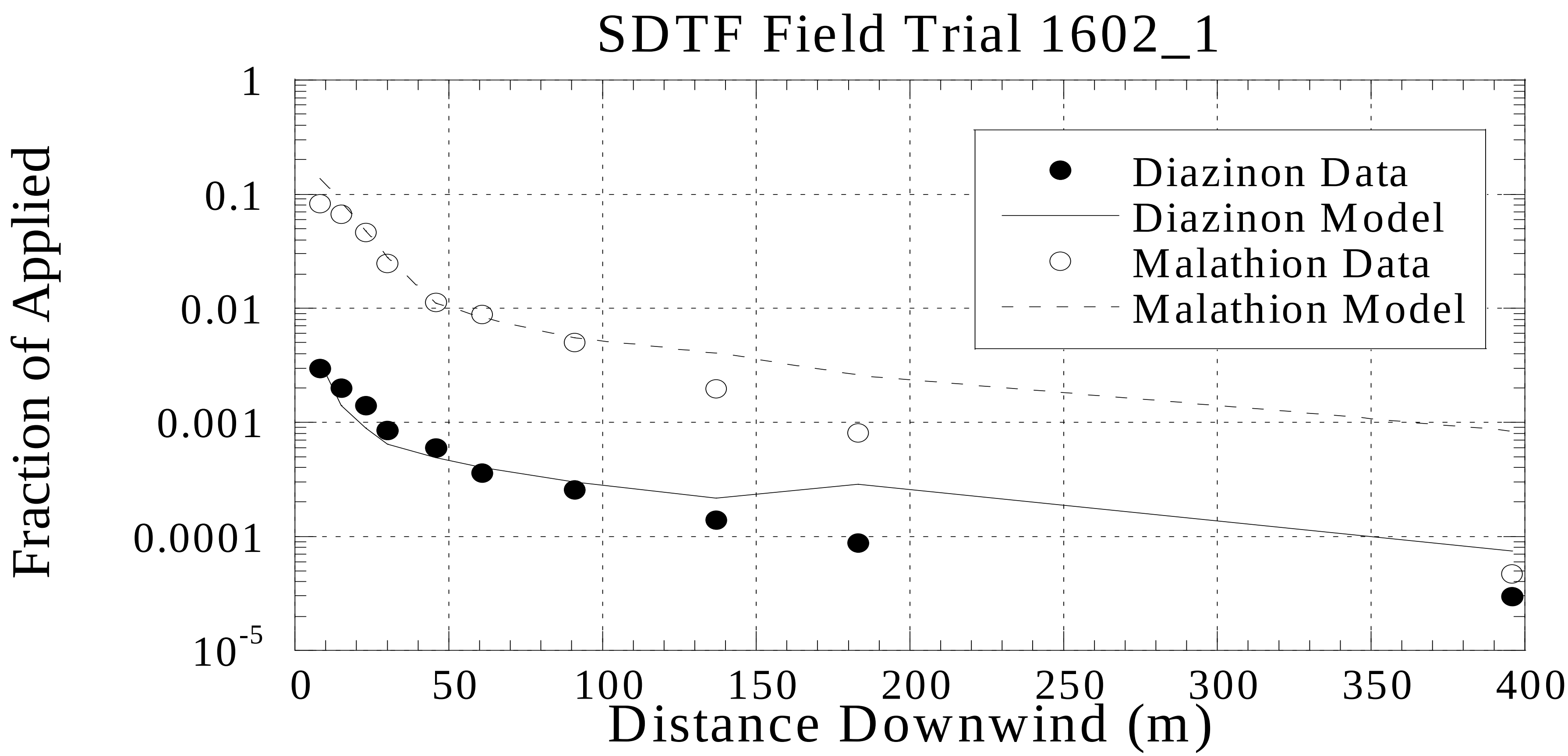


Model Comparison with Canadian Data

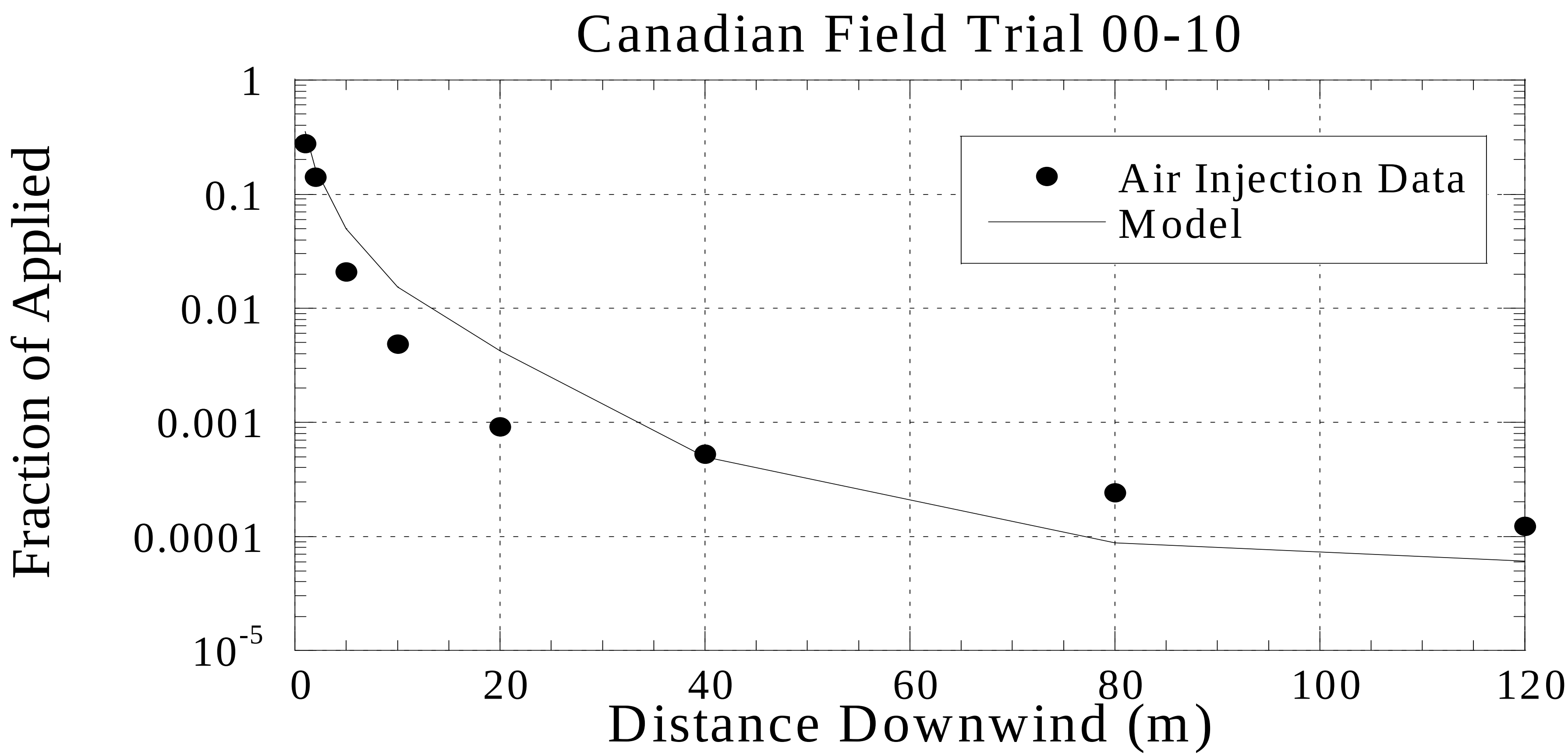


Results and Observations

- Model comparisons with data are consistent across changes in surface roughness, wind speed, wind direction, temperature, and relative humidity. Relative humidity appears unimportant in both data sets and model (important in aerial model).
- The largest differences between model and data occur with the largest droplets (consistent with large droplet helicopter runs in aerial).
- Details of the jet exiting the nozzle may play a more important role than in aerial.
- Model verification and refinement require further testing on additional data sets.



Lowest ambient temperature (6.7°C): Diazinon (8004, $D_{V0.5}$ = 312 μm), Malathion (TX-6, $D_{V0.5}$ = 162 μm)



Lowest ambient temperature (12.1°C): AI11004

Model Shortfalls

- Overall, the model predicts higher deposition close to the application area edge than seen in the two data sets. This behavior may impact buffer determination.
- The behavior of the model with respect to boom height is unclear but probably incorrect.
- The model includes only two nozzle types and is not directly applicable to other nozzles.
- There is some question about whether the model properly accounts for ligament breakup into droplets, where that phenomenon occurs, and the effect of ambient cloud meteorology (specifically relative humidity) in the vicinity of the nozzle exit.

Conclusions and Recommendations

- The ground model predicts spray deposition downwind from the application area for any set of initial conditions, and suggests that the model may be a useful qualitative tool for estimating spray drift levels from ground sprayers, especially those with tested spray nozzles for which entrainment effects have been measured.
- The model has limited quantitative applicability, however, without additional ground sprayer data in and around the commonly used nozzles. This information can only be obtained by additional data collection and interpretation.
- Model features will be demonstrated in the Workshop.