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The BREAM project – model developments

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The Bream Project

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- Rationale and background for the BREAM project
- Progress so far
  - Model development (spray drift)
  - Comparison with experimental data
- Future plans

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BREAM – rationale and background

- Public concern
- Recommendations of the Royal Commission on Environmental Pollution
- Weaknesses of current exposure assessment
  - Based on application parameters typical of the 1980s
  - Distance from the sprayer too great
  - Single 'average' value – no real link to application/environmental parameters
  - Vapour drift not accounted for

Potential sources of exposure

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- **Direct spray drift**
  - **Airborne spray**
  - **Dermal contamination**
  - **Inhalation**
  - **At the time of application**
- **Indirect spray drift from surface contamination**
  - **Sedimenting spray**
  - **Dermal**
  - **Ingestion**
  - **After application**
- **Pesticide vapour**
  - **Inhalation**
  - **During and after application**

BREAM objectives

- Develop a model of potential exposure from a single application event – 'Bystander and Resident Exposure Assessment Model'
  - Consider one-off exposures as well as long-term or repeated exposures on bystanders
- Obtain experimental data for model development
- Conduct field trials for model validation

The three-scale approach

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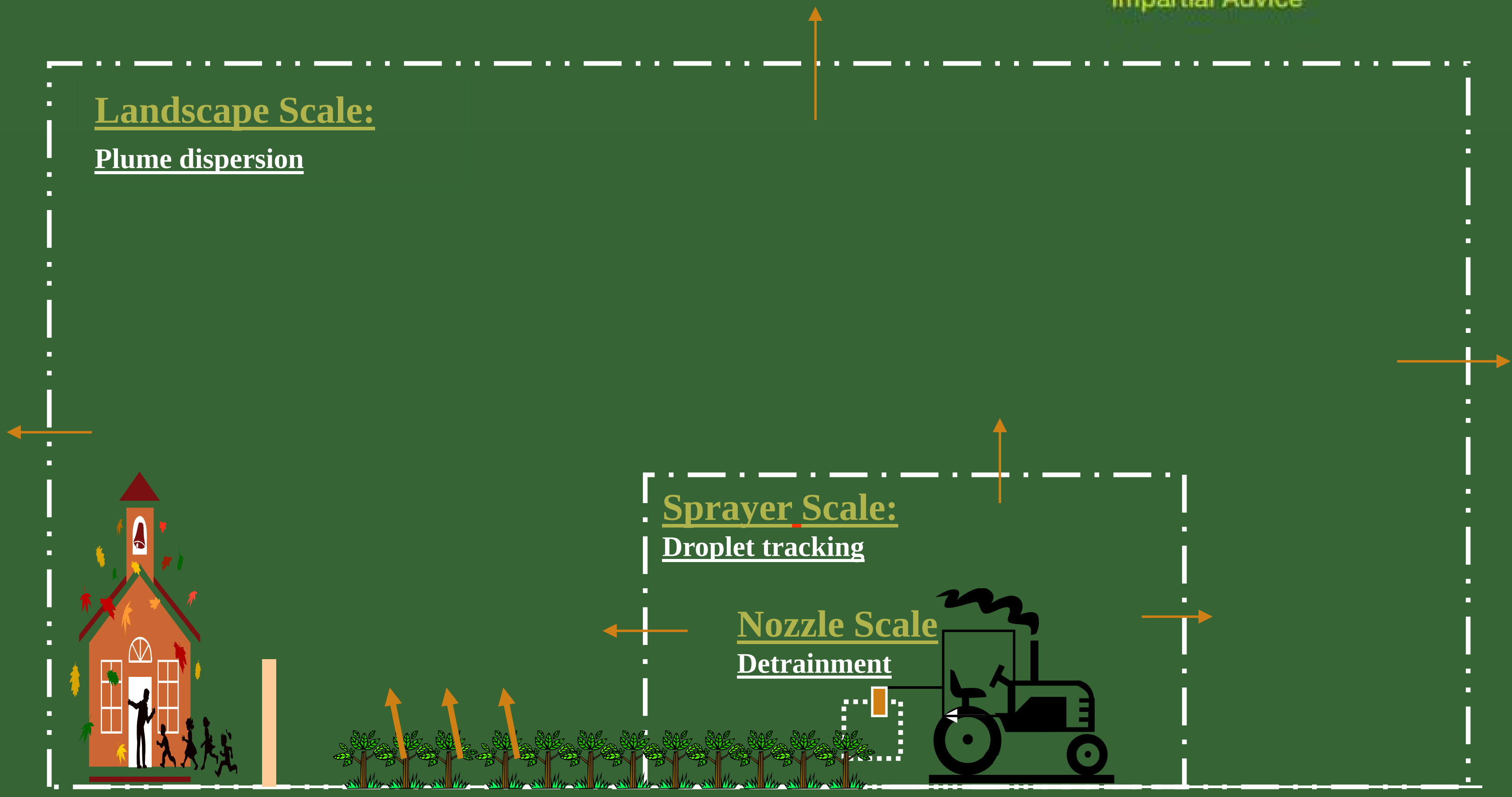

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Changes to Model plan

- Proposed scenarios agreed with Pesticides Safety Directorate and Advisory Committee on Pesticides
  - No bystander distances greater than 10 m from the treated area
    - Landscape-scale features not relevant to spray drift
    - Vegetation originally proposed as a ‘landscape’ feature
    - Needs to be incorporated into near-field model
- ‘Deliverable’ has to be a working model
  - CFD package not a practical option

The two-model, three-scale approach

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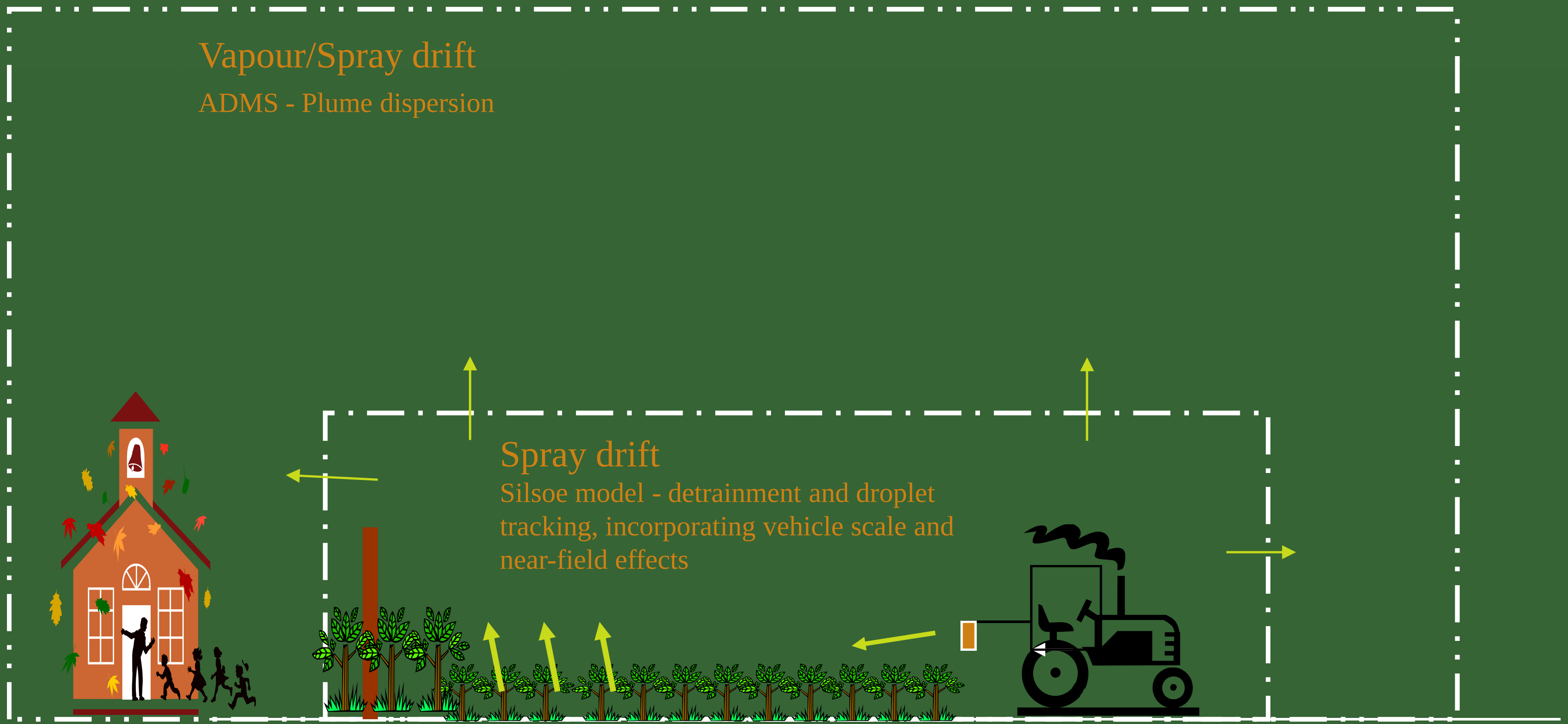

Progress to date
– Model development

- Original Silsoe spray drift model developed in 1980s and 1990s now being updated
  - Includes multiple nozzles and a moving sprayer
  - User-friendly interface for inputs
  - More detailed output for validation
- Specific 'bystander' scenarios
  - 12 kph, 24 m boom
  - 2 m from sprayer
  - Downwind structures and vegetation
- Include variability – 'probabilistic' inputs and outputs
  - Boom instability
  - Wind variation

Two sections to model:

Within box – Ballistic trajectory (droplet/nozzle/sprayer/wind interactions)

Outside box – Random walk trajectory
Droplet/wind interactions only

Near-nozzle ‘box’ model

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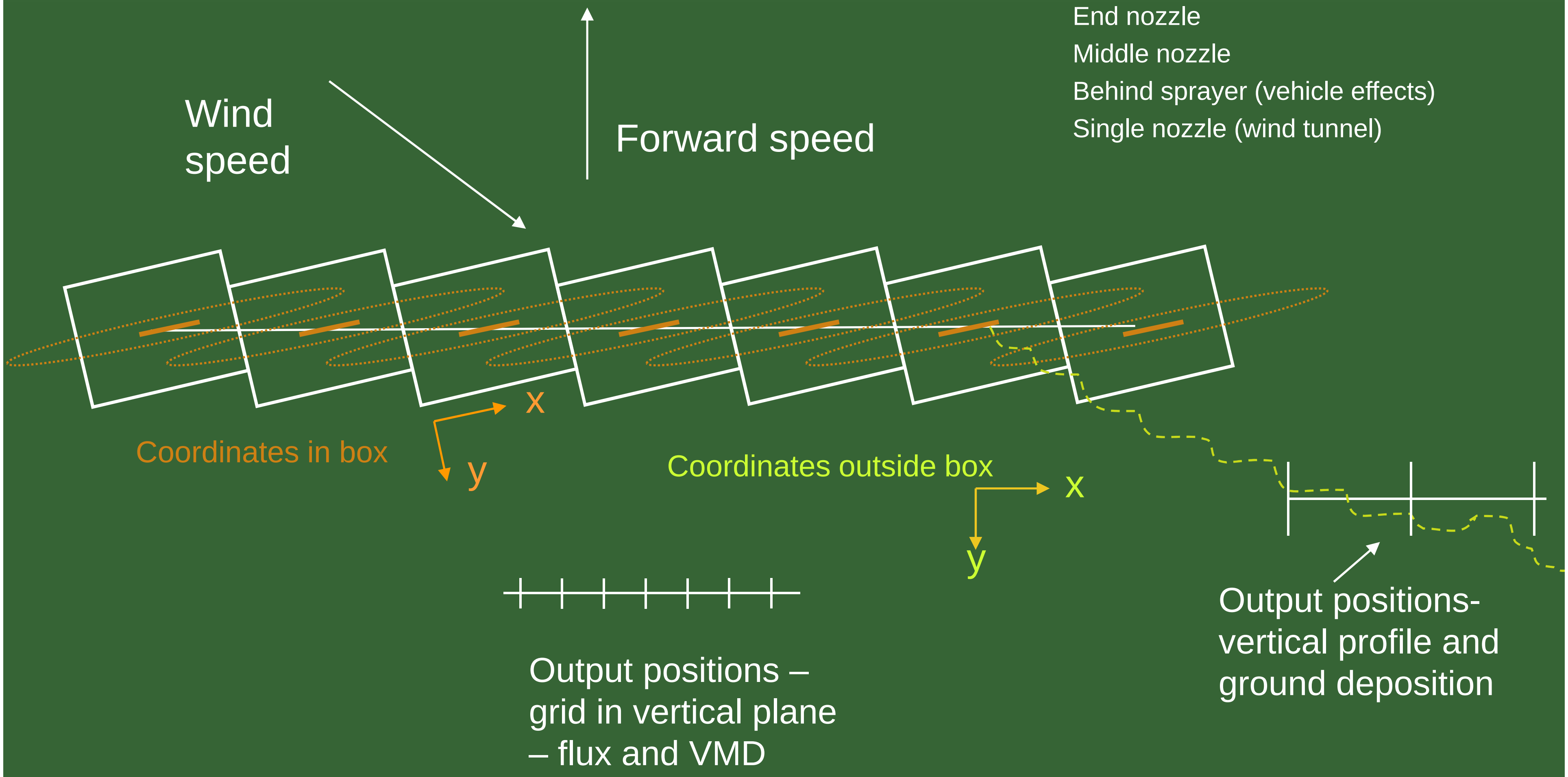
Different ‘boxes’ depending on position along boom:

- End nozzle
- Middle nozzle
- Behind sprayer (vehicle effects)
- Single nozzle (wind tunnel)



Experimental work

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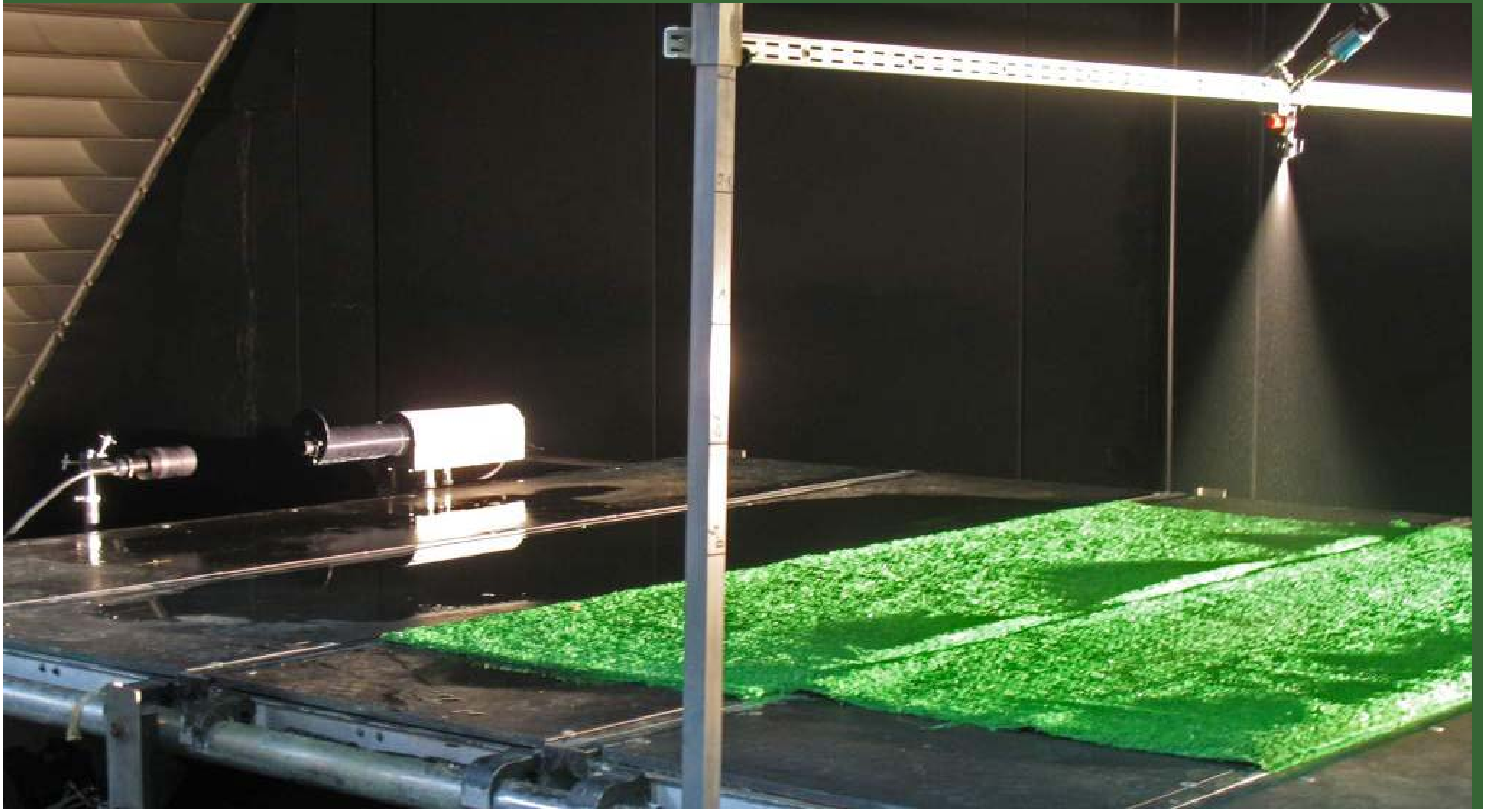
- wind tunnel and droplet size measurements to support model development



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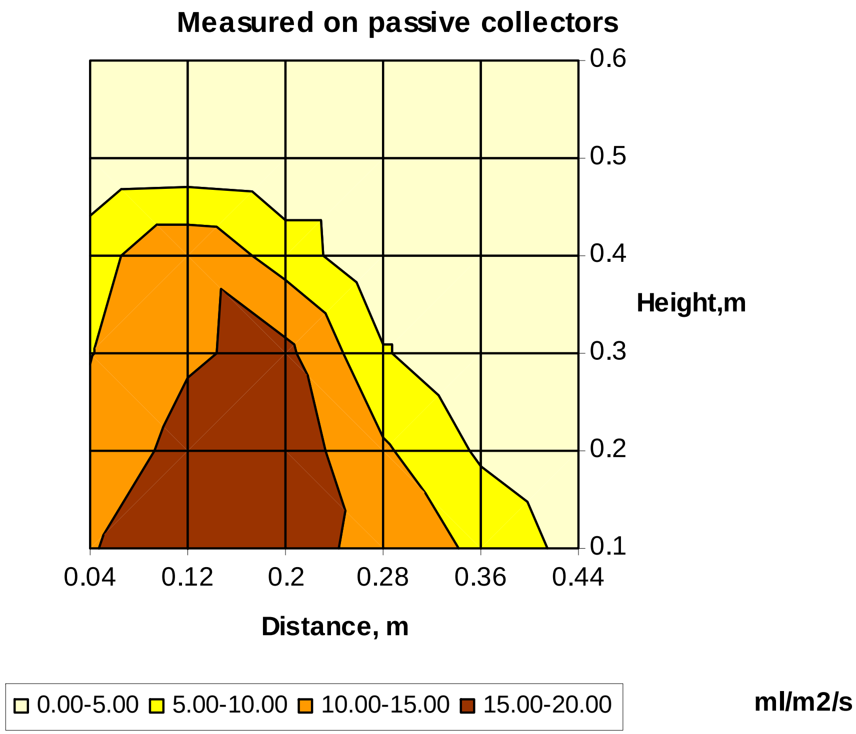
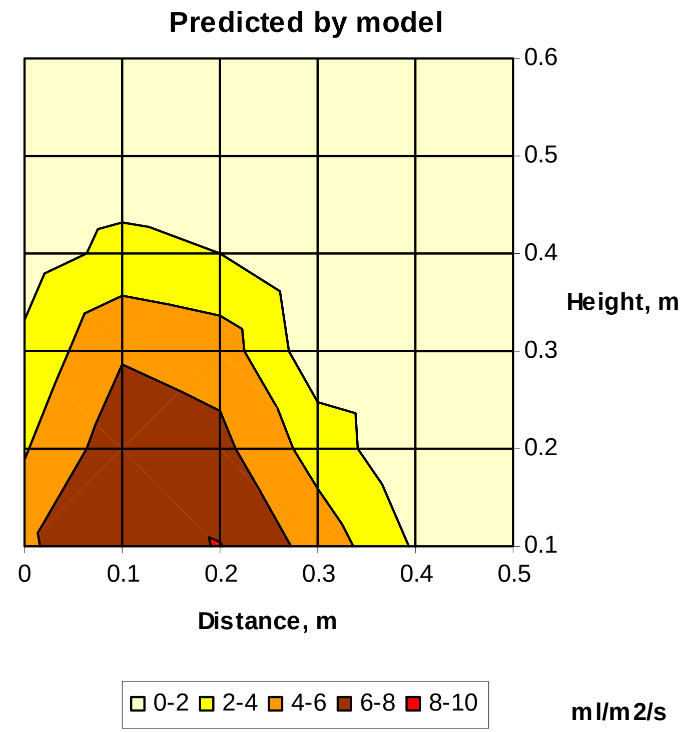
Wind tunnel measurements – 03 flat fan nozzle
2 m downwind of a single nozzle





Vertical profile - predicted

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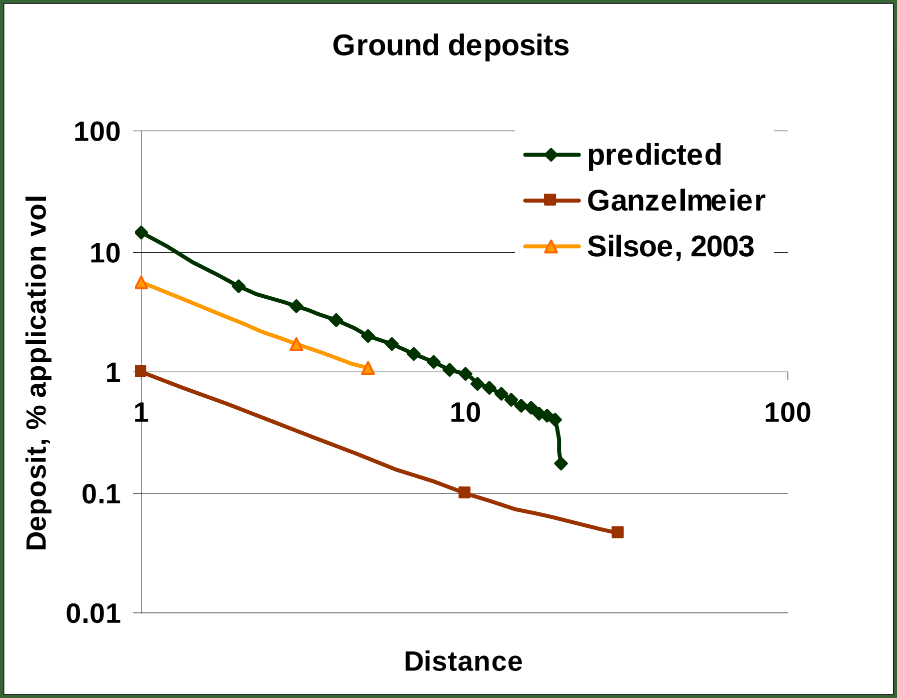
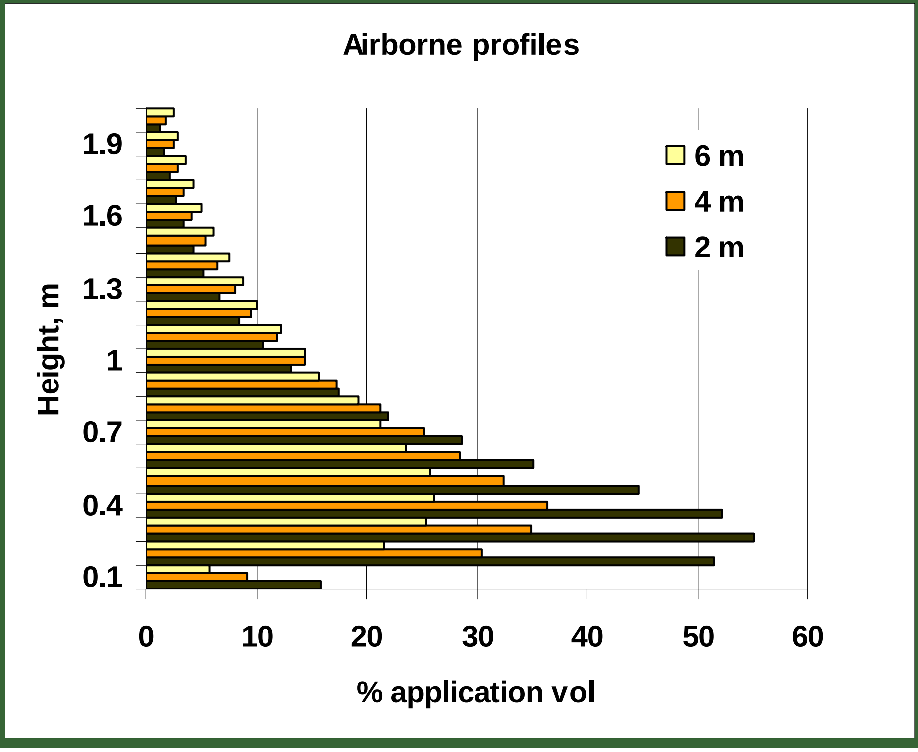
03 nozzle,
3 m/s wind speed,
12 m boom,
8 km/hr forward speed,
0.5 m boom height,
short crop (0.1m)





Correlation between airborne spray and bystander deposit

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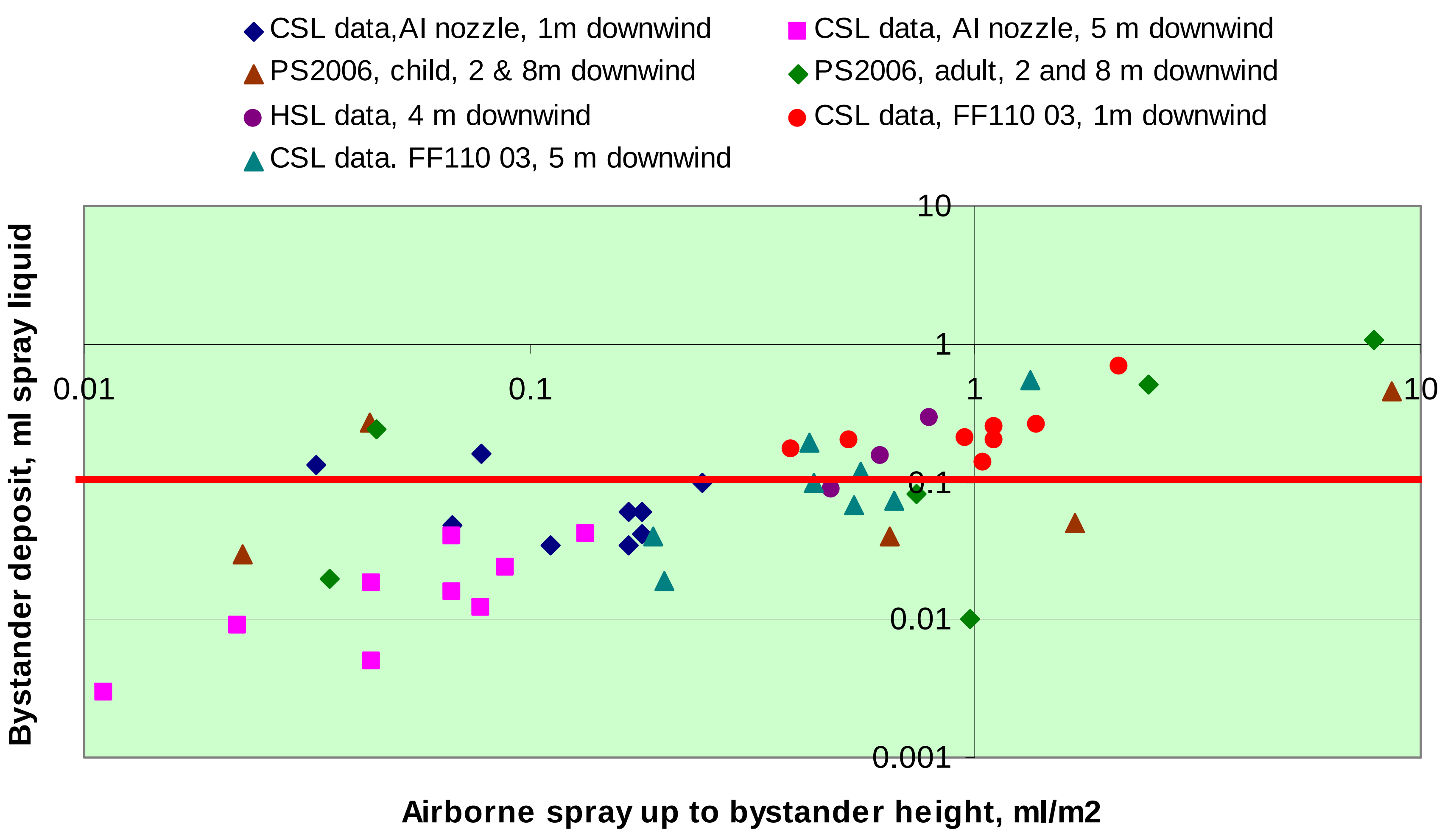


A statistical emulation approach to quantify uncertainty and variability in bystander exposure

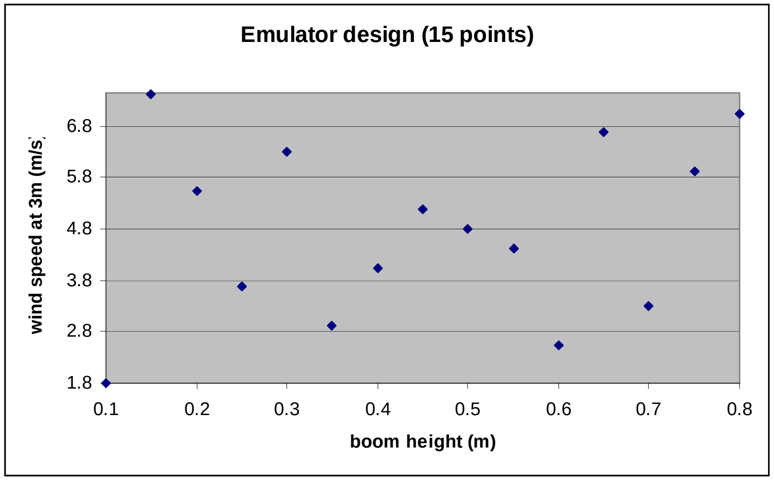
Marc Kennedy

Risk Analysis Team

Central Science Laboratory

Emulation

- The **emulator** of the computer code is an accurate statistical representation created using a small number of code runs
  - Plus uncertainty due to the approximation
  - Correctly reproduces training data

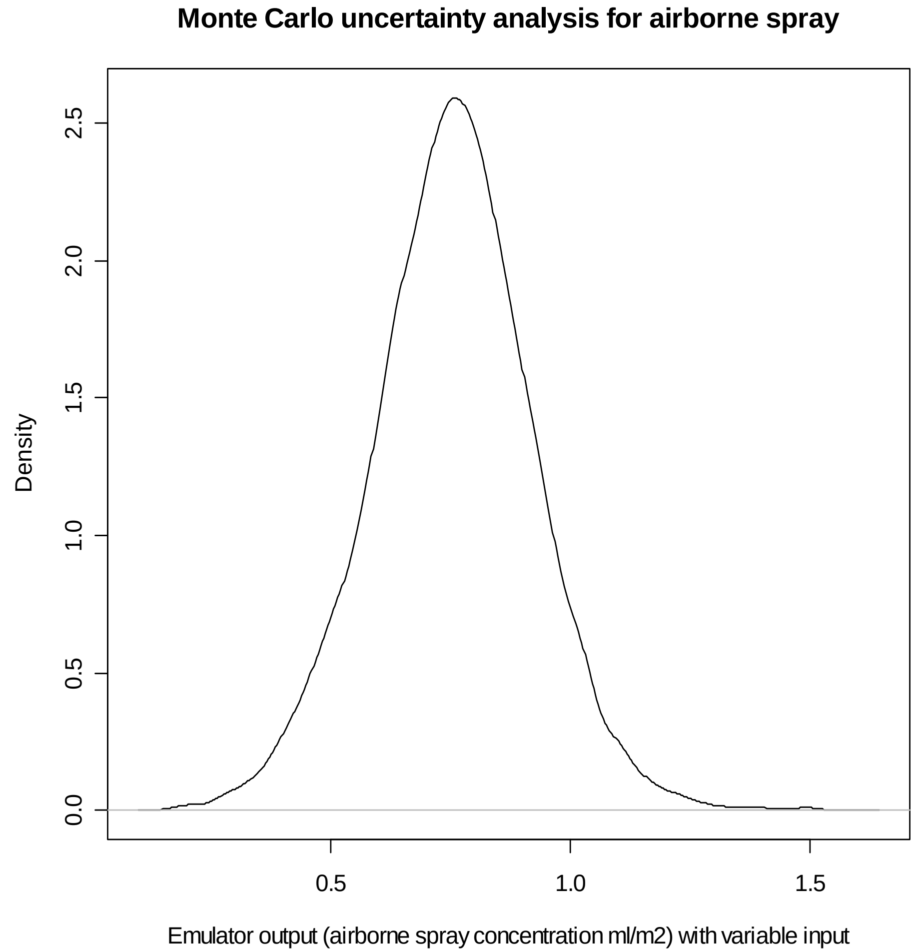


Uncertainty analysis

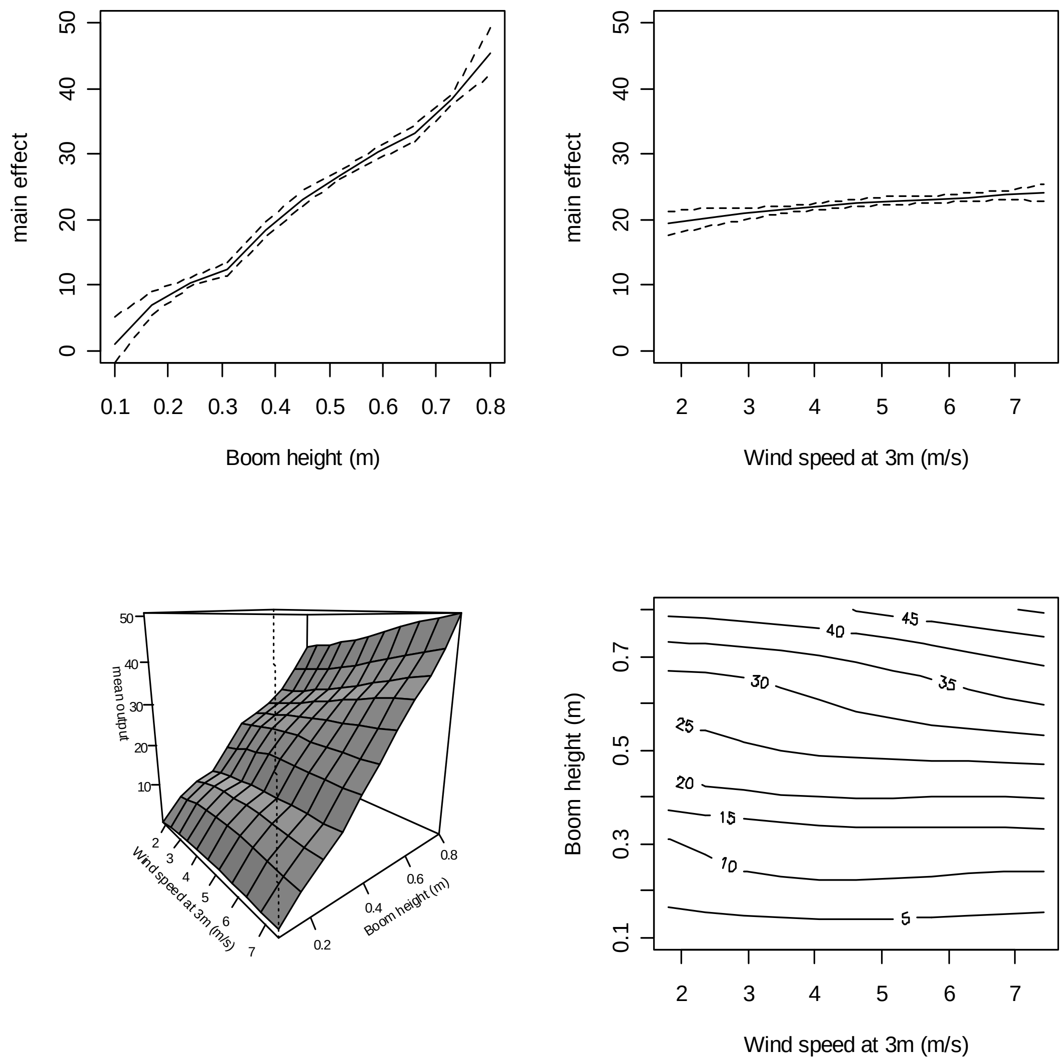
Monte Carlo estimate, based on 10000 runs of the emulator with independent input distributions

Wind Speed ~ N(4.5, 1)

Boom height ~N(0.5, 0.1^2)



Emulator main and joint effects of boom height and wind speed



These results were obtained before outputs were scaled to match bystander data

Sensitivity analysis

Contributions to the total output variance from each input main effect and their interaction effect

input	%contribution
Boom height (0.1 – 0.8 metres)	97.67
Wind speed (1 – 8 metres/sec)	1.25
Boom height.wind speed interaction	1.08

Boom height is the dominant variable in terms of driving variability in the output, assuming these ranges.

Bayesian model of bystander data

- For a general (log10) airborne spray value *x*, the expected (log10) bystander exposure is

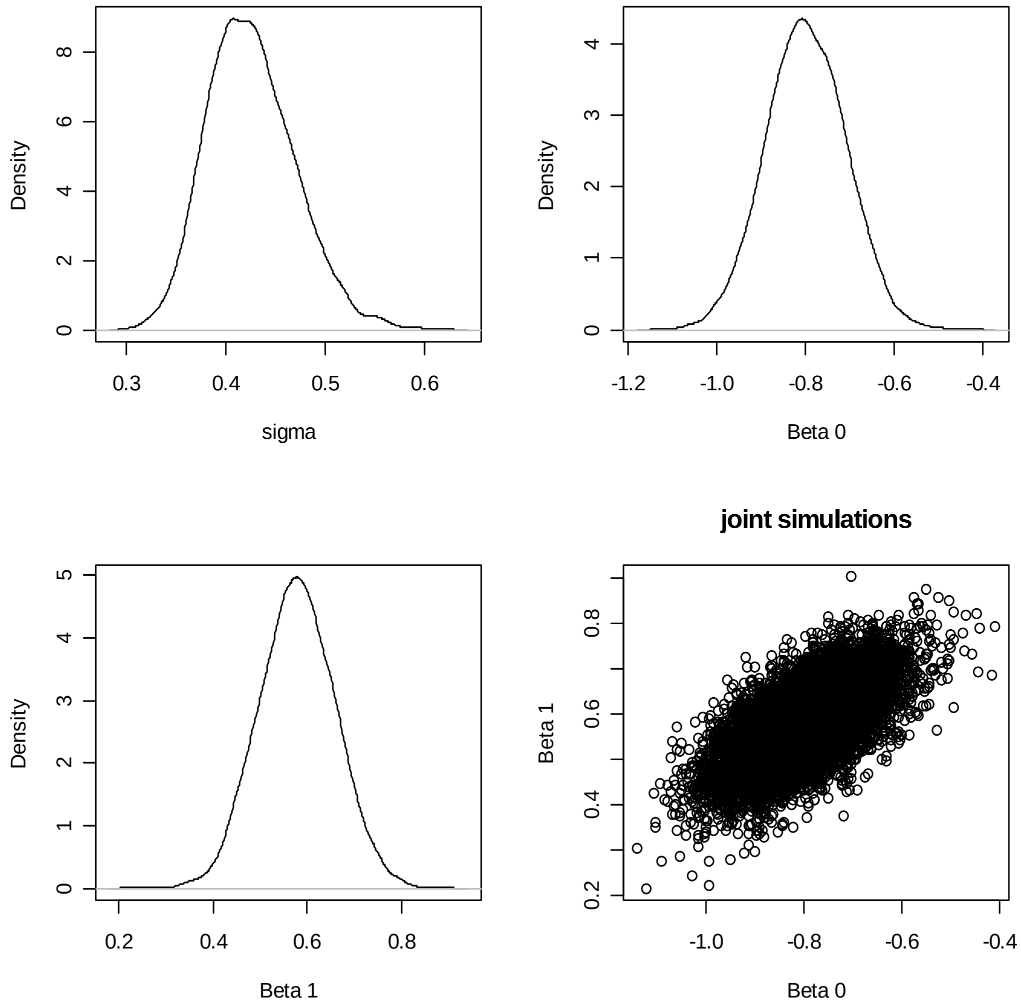
$$\beta_1 x + \beta_0$$

- Due to variability the actual exposure is distributed as

$$N(\beta_1 x + \beta_0, \sigma^2)$$

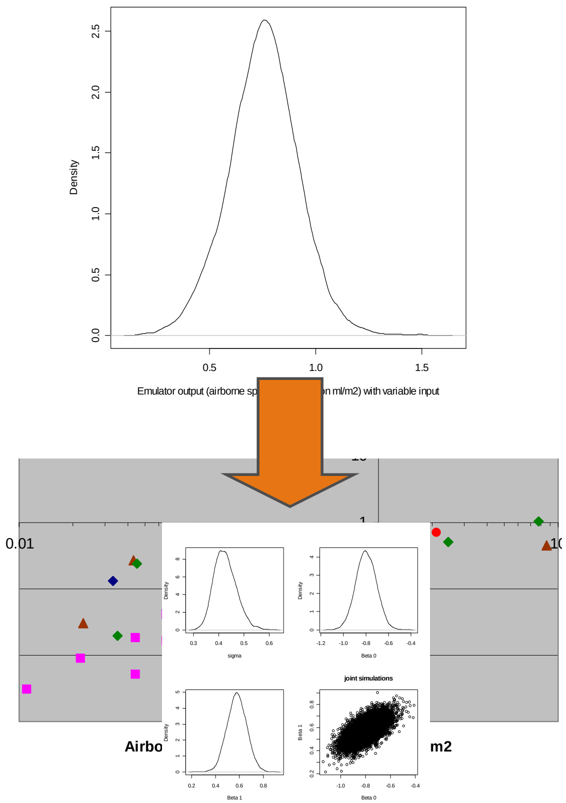
- Bayesian analysis of the bystander exposure data produced uncertainty distributions for the parameters $(\beta_1, \beta_0, \sigma)$

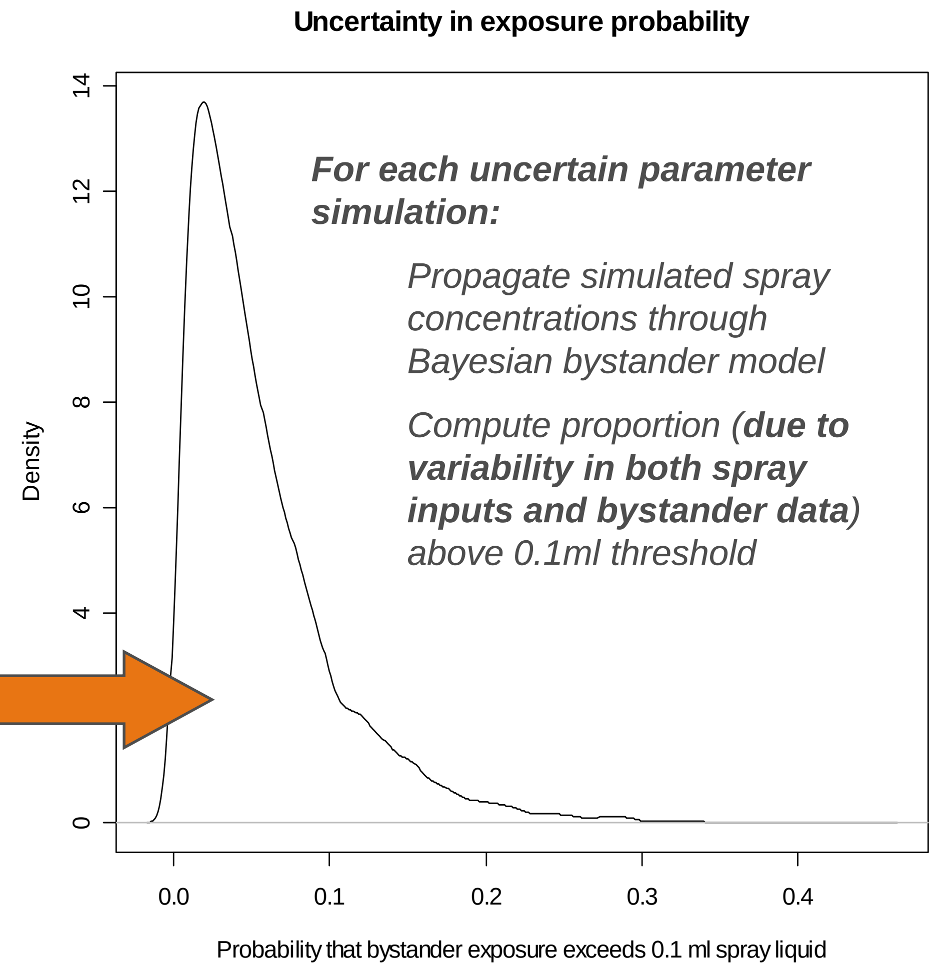
Parameter uncertainty for bystander model



Linking the emulator and bystander models

Airborne spray uncertainty simulations





For each uncertain parameter simulation:

Propagate simulated spray concentrations through Bayesian bystander model

*Compute proportion (**due to variability in both spray inputs and bystander data**) above 0.1ml threshold*

Field experiments – model validation and additional bystander data

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Field measurements November 07

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Additional factors to include

- Downwind structures
- Downwind vegetation
- Vehicle effects

CFD studies of downwind structures

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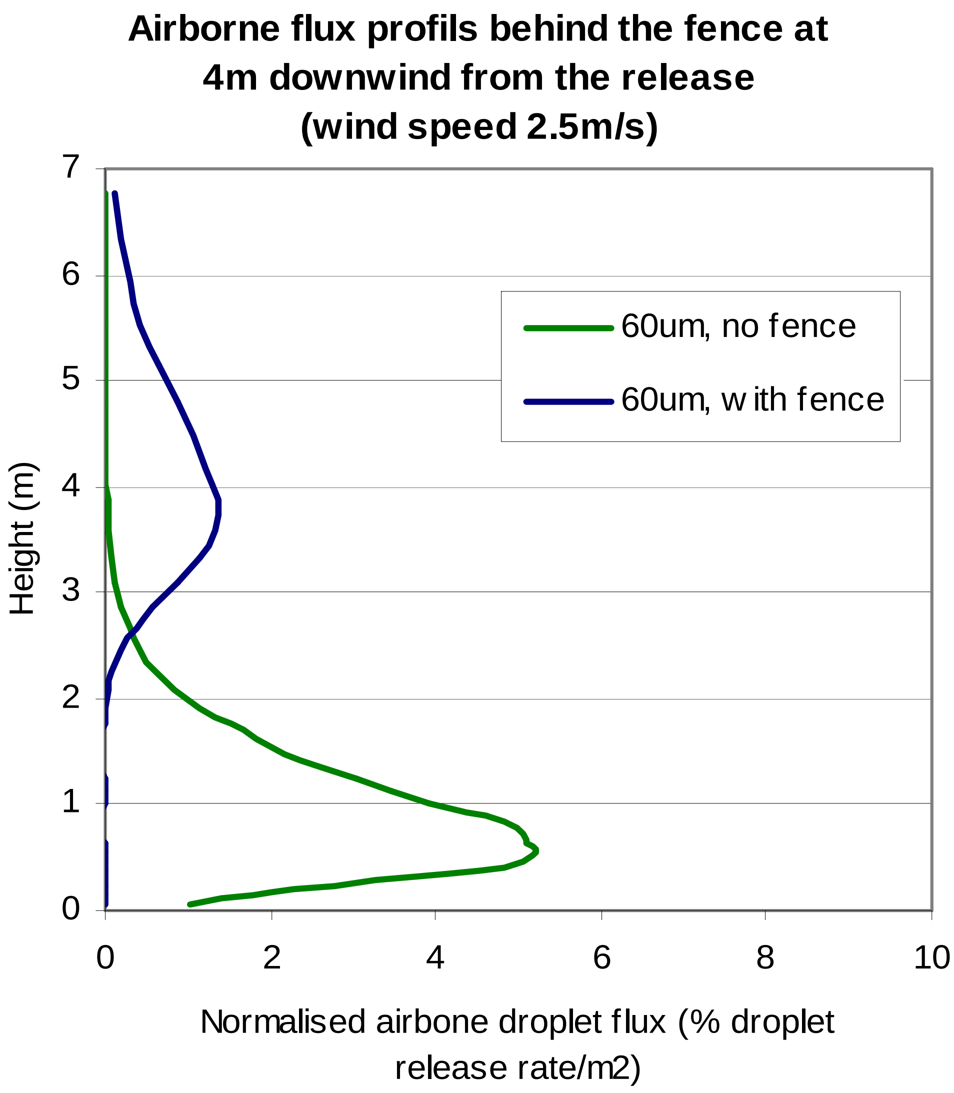

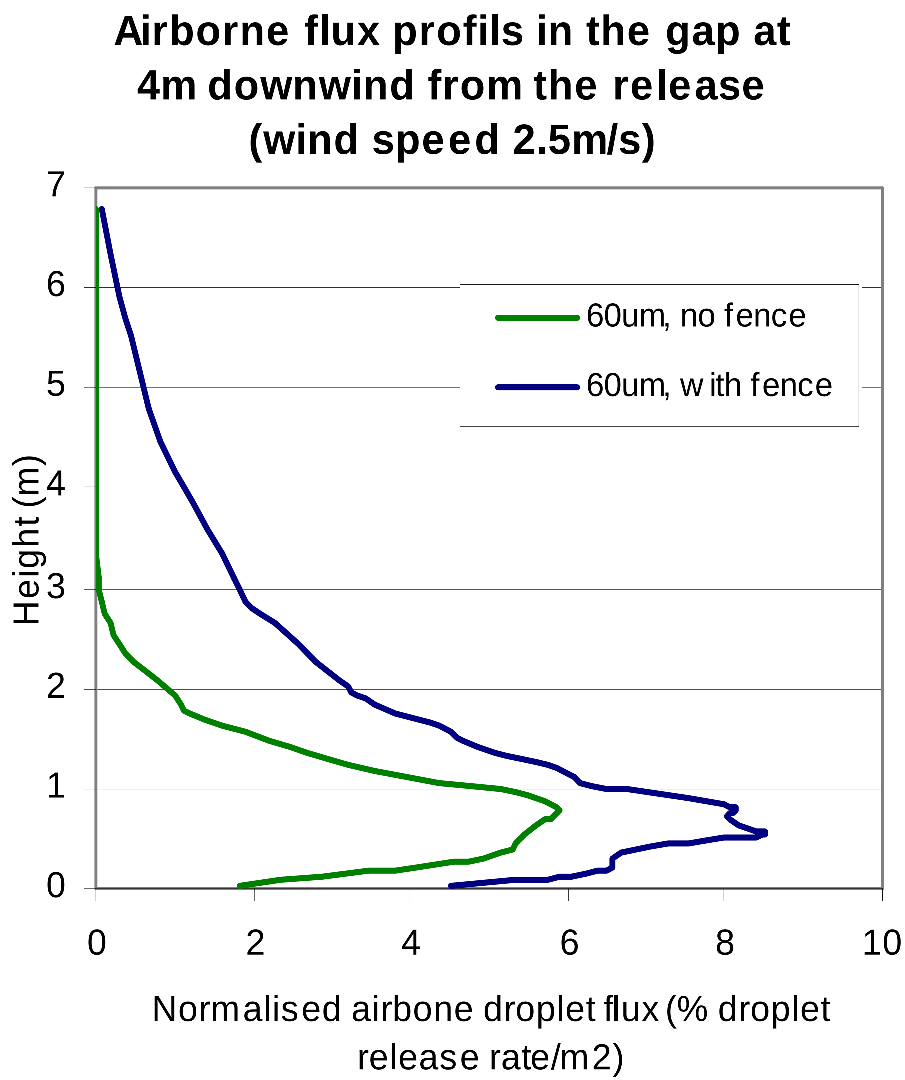

CFD model: Investigating the effect of sprayer

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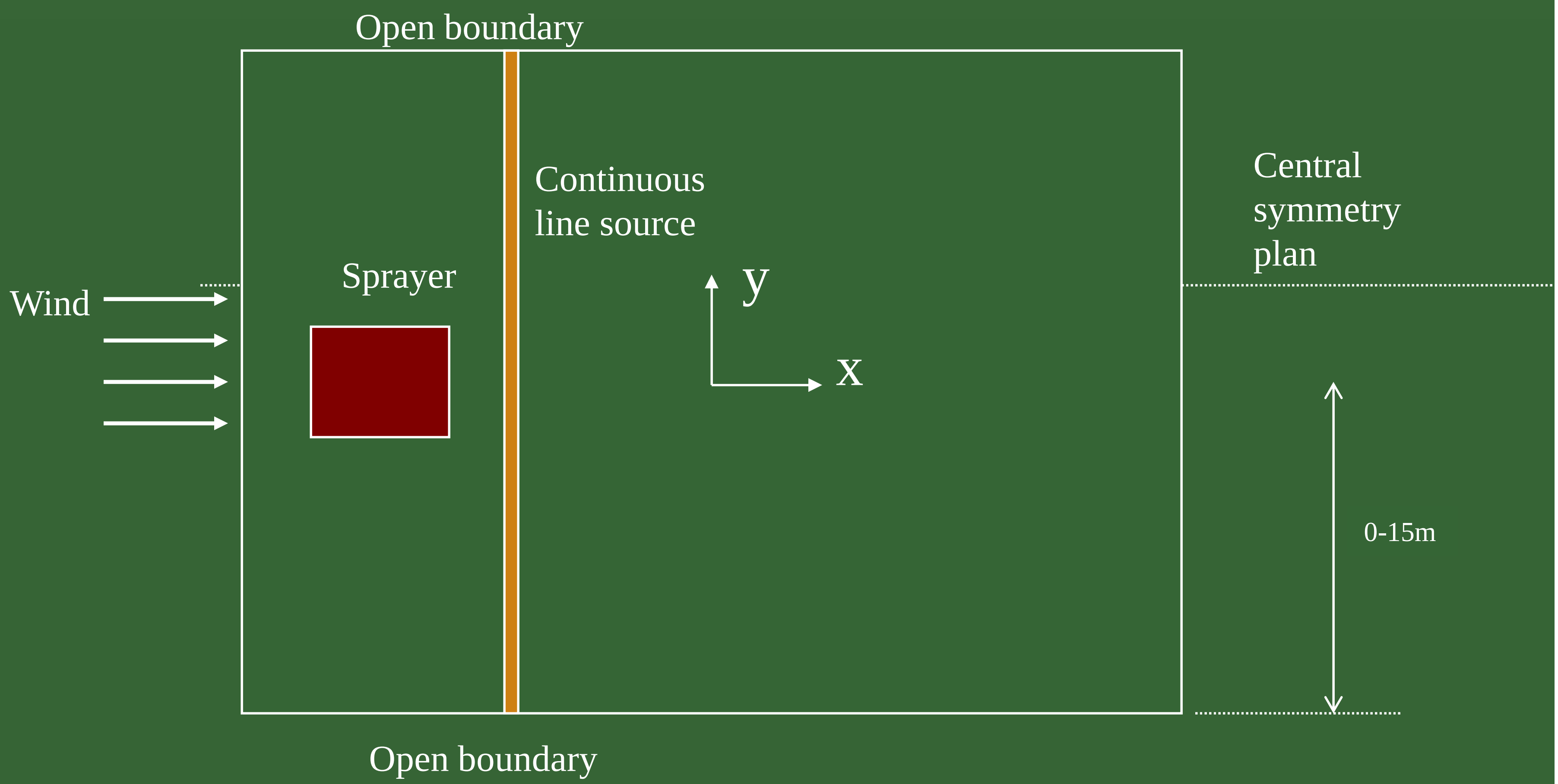

CFD model investigating the effect of sprayer (vertical view)

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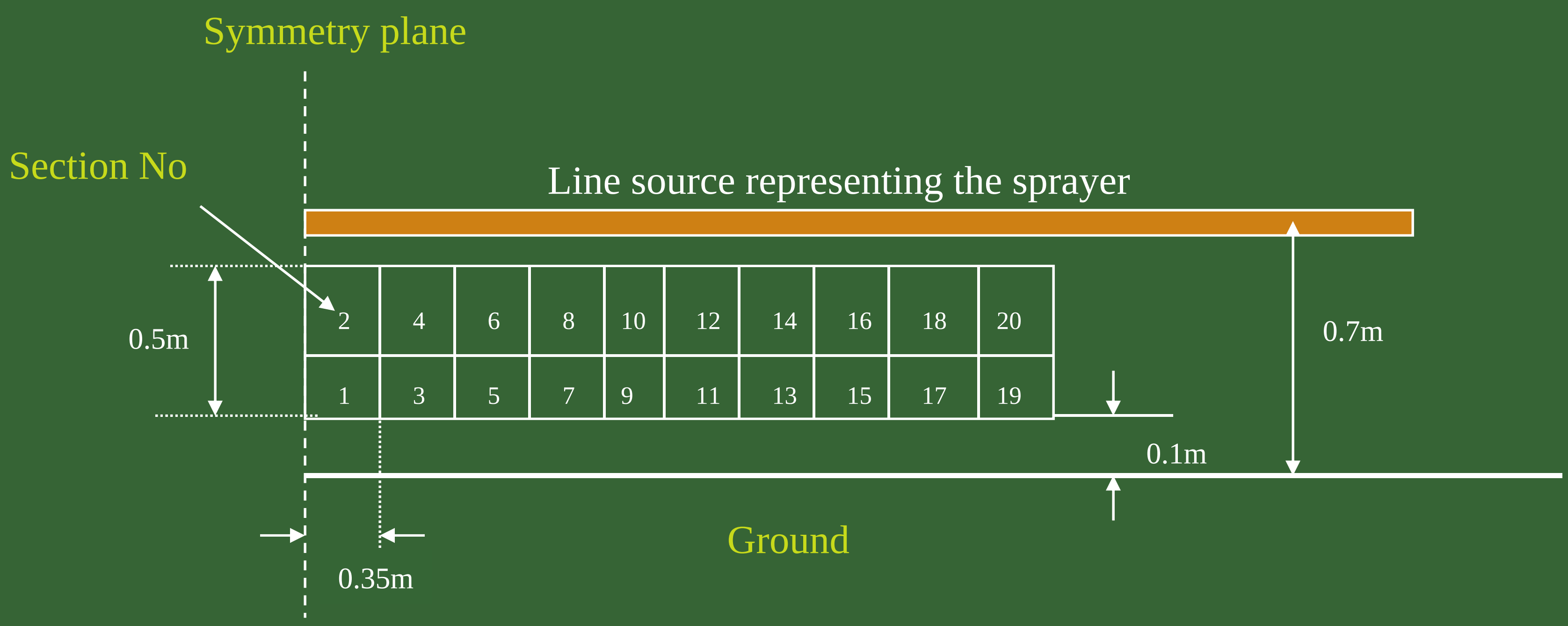

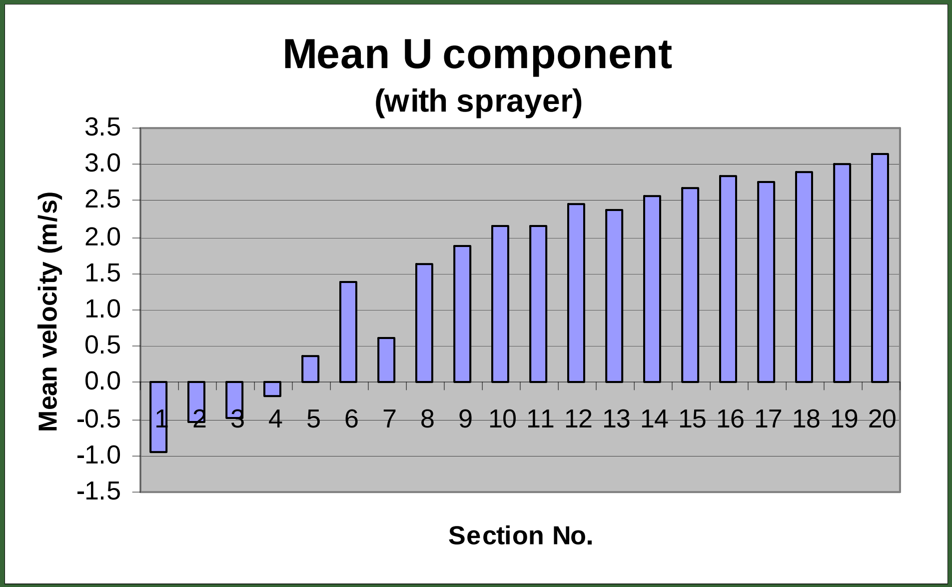

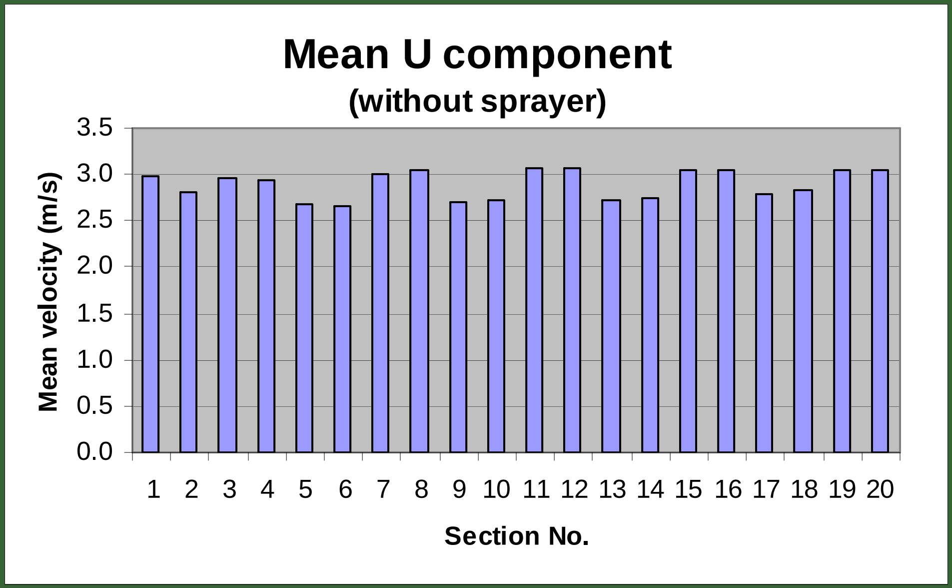

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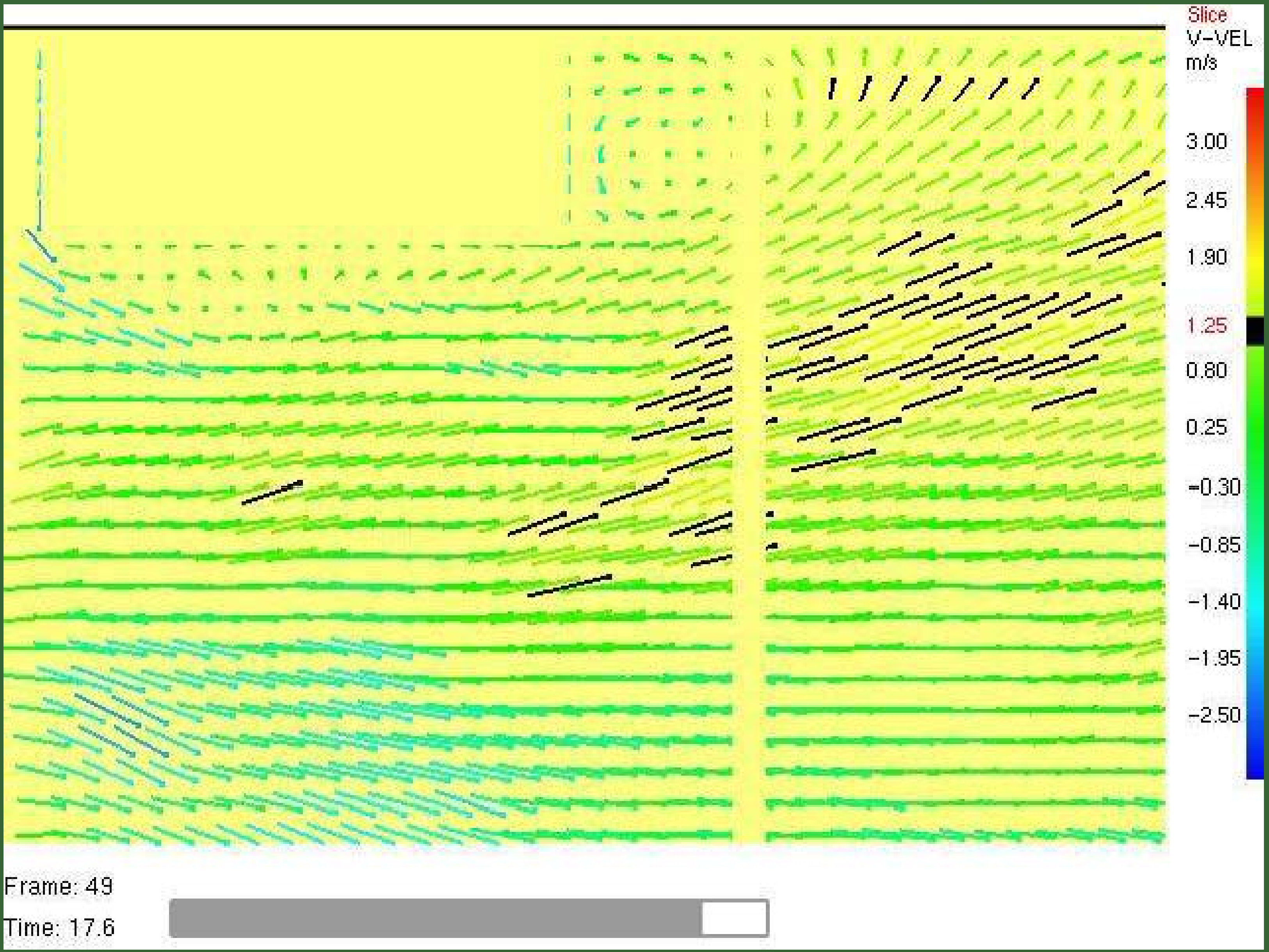
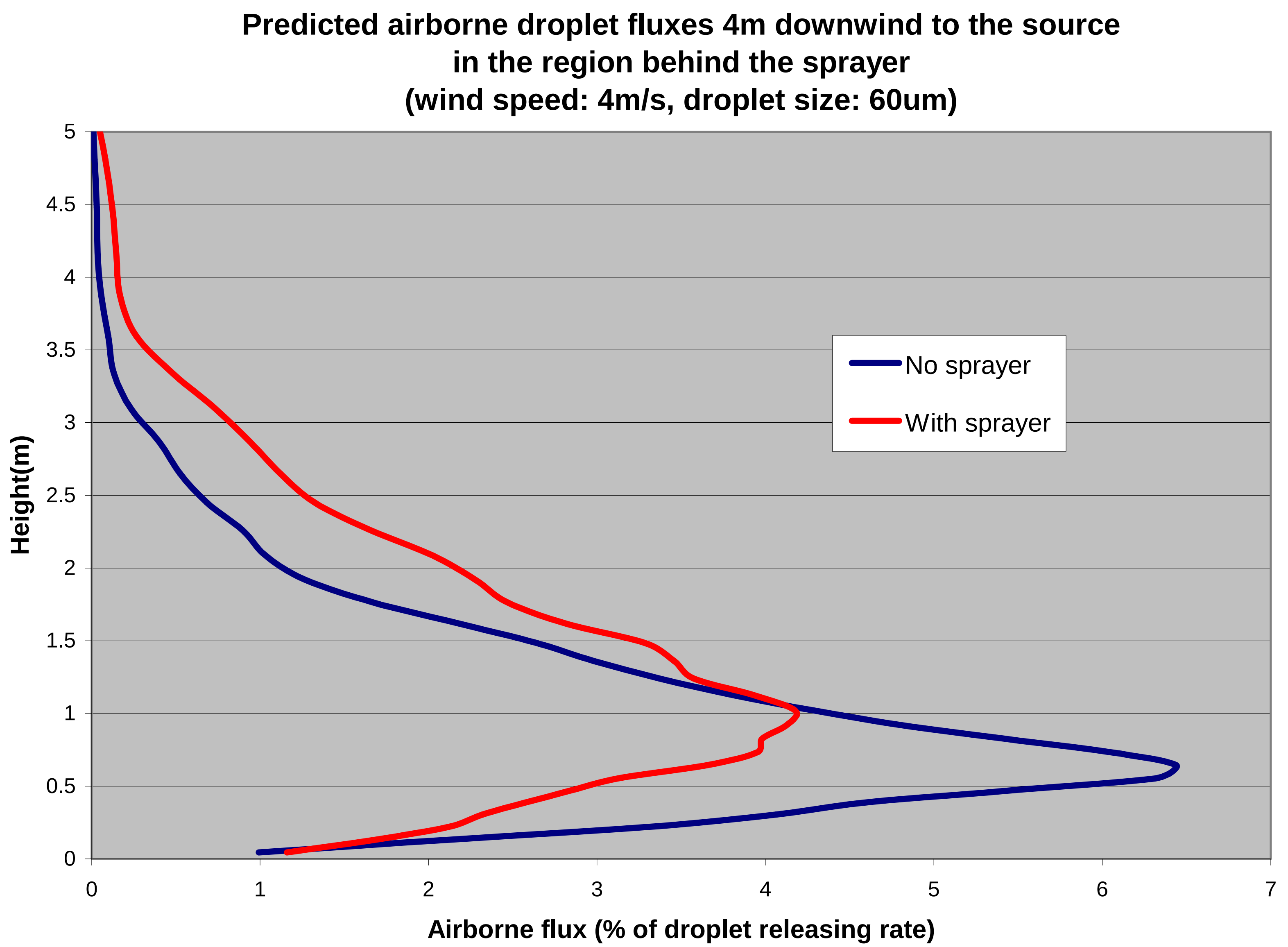
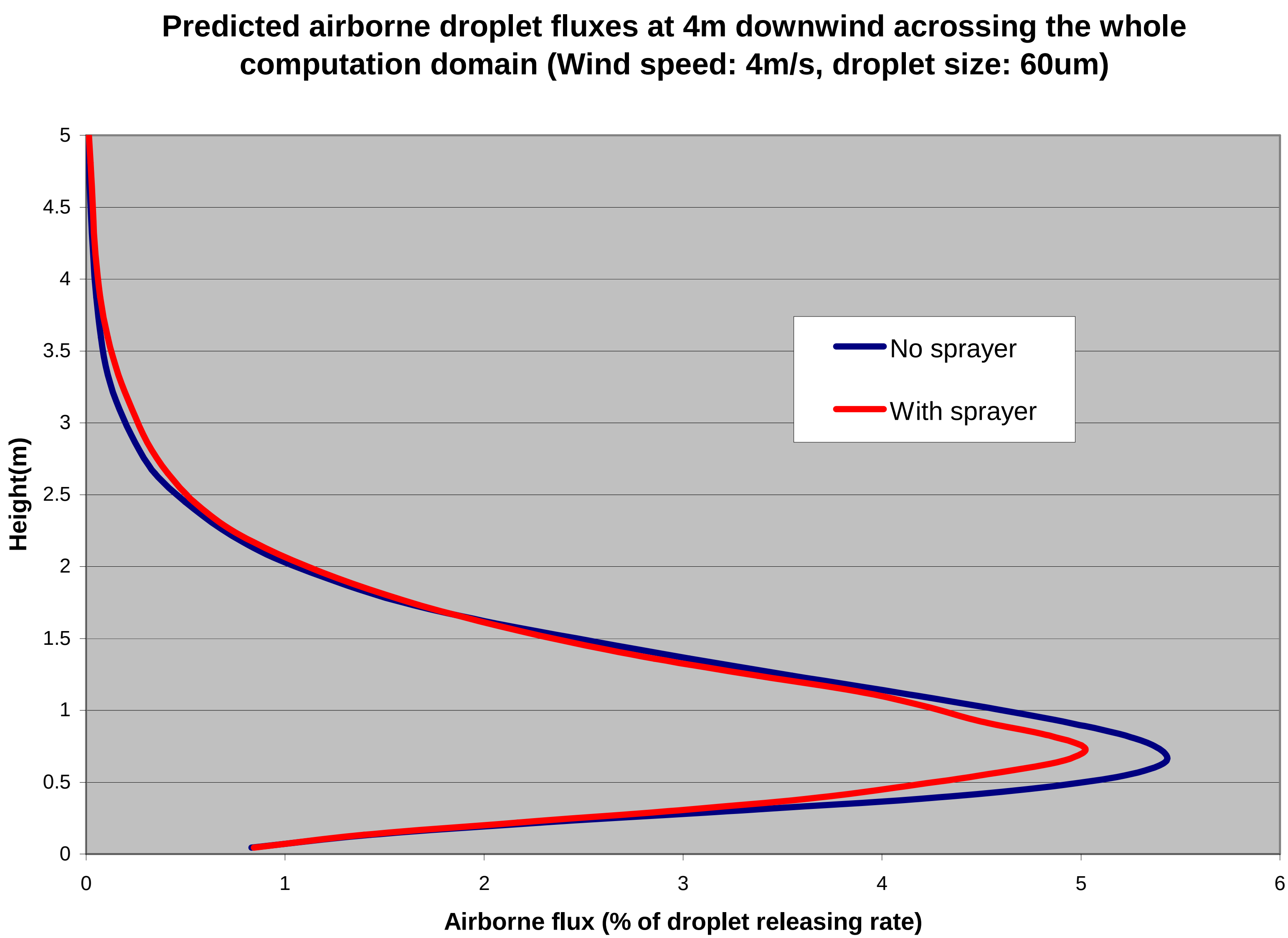


Slice
V-VEL
m/s
3.00
2.45
1.90
1.25
0.80
0.25
-0.30
-0.85
-1.40
-1.95
-2.50
Frame: 49
Time: 17.6



Predicted airborne droplet fluxes 4m downwind to the source
in the region behind the sprayer
(wind speed: 4m/s, droplet size: 60um)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Height(m)
0
1
2
3
4
5
6
7
Airborne flux (% of droplet releasing rate)
No sprayer
With sprayer


Predicted airborne droplet fluxes at 4m downwind acrossing the whole computation domain (Wind speed: 4m/s, droplet size: 60um)
Height(m)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
Airborne flux (% of droplet releasing rate)
No sprayer
With sprayer

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Future plans

- Crude modification to account for possible downwind structures
- Vegetation – method of inclusion to be decided
- Exclude vehicle effects for now – further experimental work to validate model predictions

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Thanks to the team at Silsoe, without whom no work would ever get done…

Paul, Andy, Christine, Clive and Donna