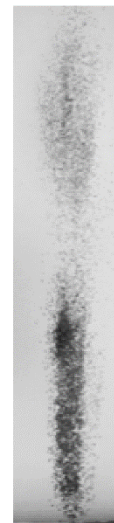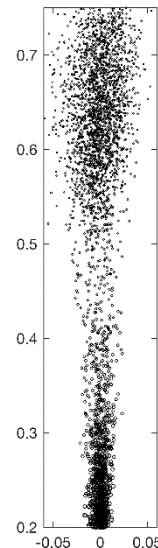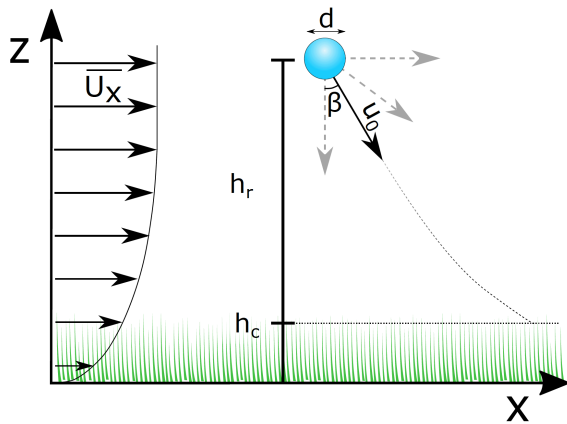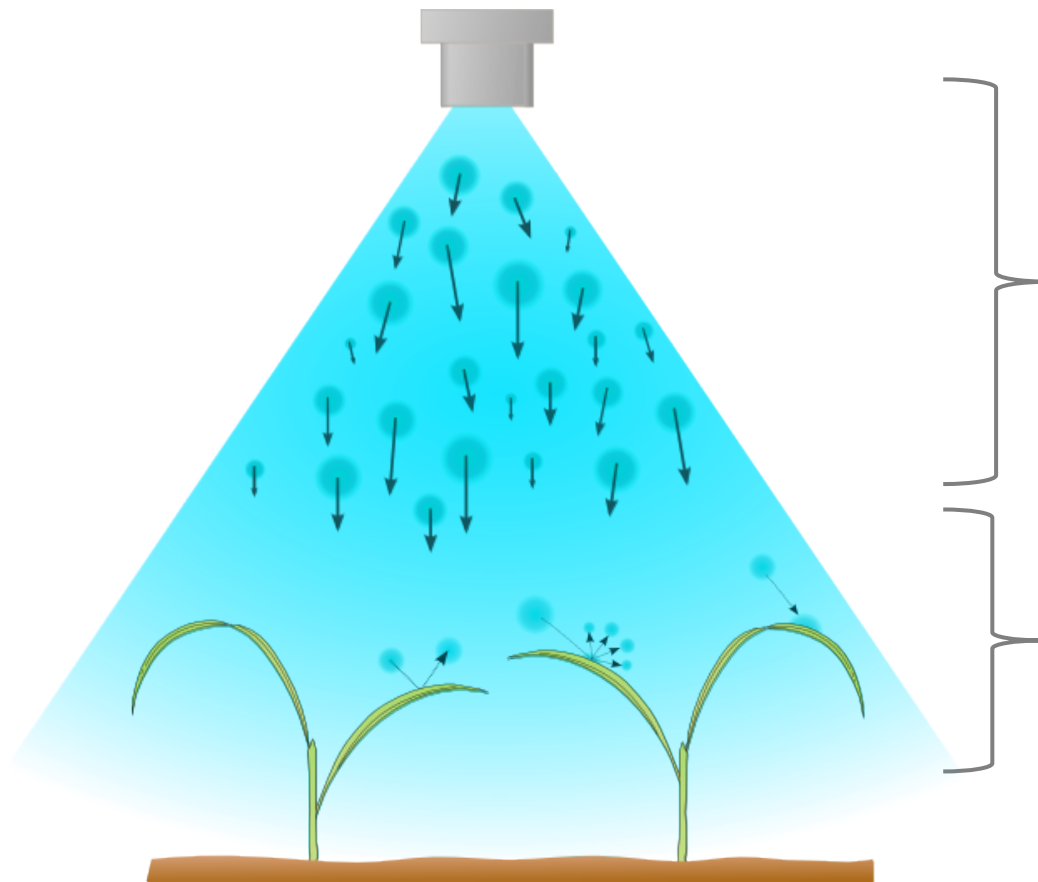# Comparison of a random-walk model for droplet transport and wind-tunnel measurements

Nicolas De Cock, Mathieu Massinon, Sofiene Ouled Taleb Salah & Frédéric Lebeau
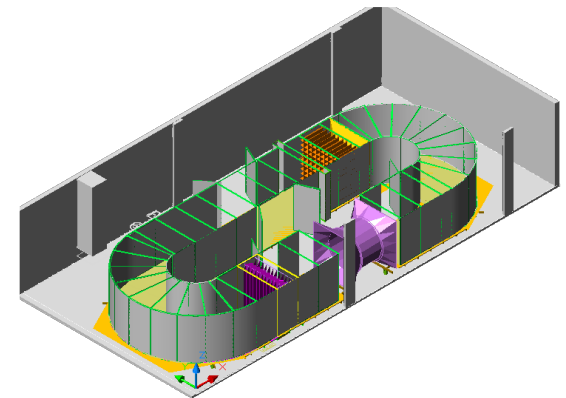
Deposition
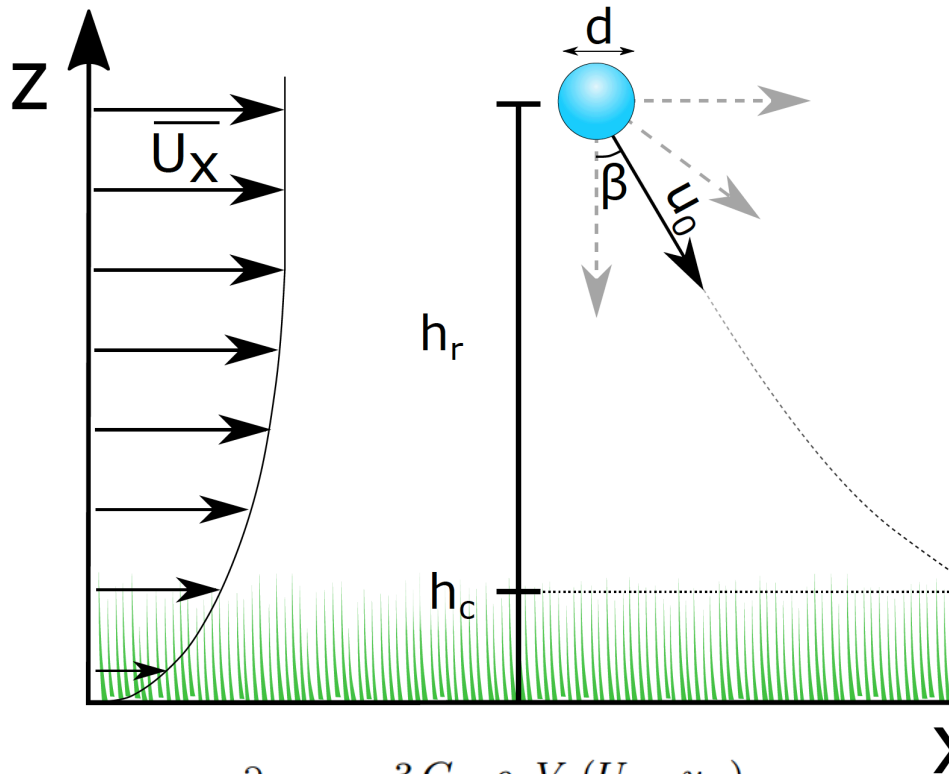From the nozzle to the plant
➜ Small droplets are more prone to drift

Retention
Droplet impacts on the plant surface
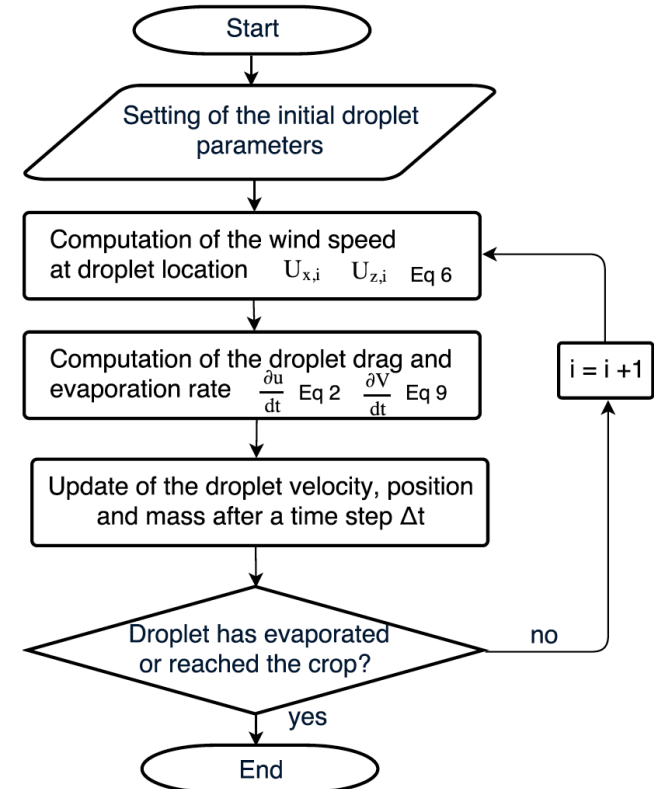➜ Large droplets have more energy when impacting the leaf surface

$$We = \frac{\rho \, v^2 \, l}{\sigma}$$

Random-walk model

Start

Setting of the initial droplet parameters

Computation of the wind speed at droplet location $U_{x,i}$ $U_{z,i}$ Eq 6

Computation of the droplet drag and evaporation rate $\frac{\partial u}{dt}$ Eq 2 $\frac{\partial V}{dt}$ Eq 9

Update of the droplet velocity, position and mass after a time step Δt

Droplet has evaporated or reached the crop?

no

i = i +1

yes

End

$$\frac{\partial u_x}{dt} = \frac{3\,C_D\,\rho_g V_r(U_x - u_x)}{4\,\rho_l\,d}$$

$$\frac{\partial u_z}{dt} = \frac{3\,C_D\,\rho_g V_r(U_z - u_z)}{4\,\rho_l\,d} - g$$

Random-walk model
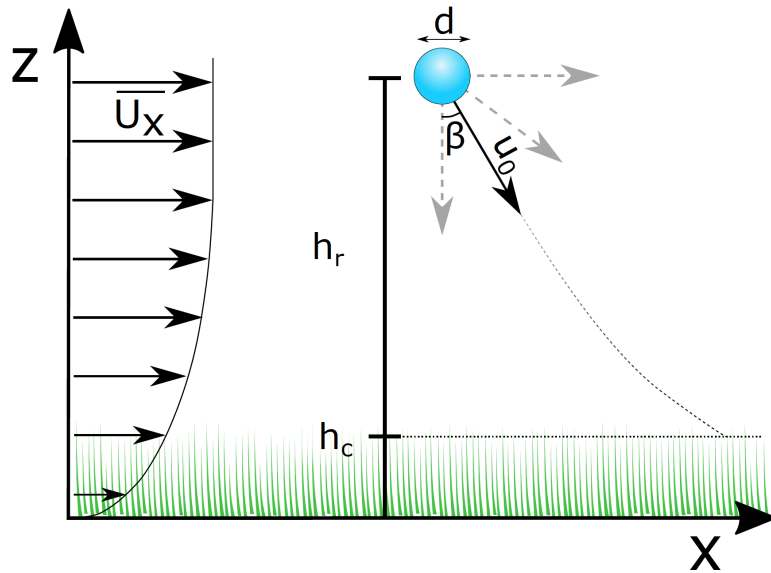
Set as constant in the wind tunnel

mean   fluctuations   fluctuations

$$U_x = \overline{U_x} + U_x' \;\; ; \;\; U_z = U_z'$$

Random value [-1:1]   Time step

$$U_{x,i+1}' = U_{x,i}' \, e^{-\frac{\Delta t}{\tau_{Lx}^*}} + \epsilon \, \sigma_x \sqrt{2} \left(1 - e^{\left(-\sqrt{\frac{\Delta t}{\tau_{Lx}^*}}\right)} \right)$$

RMS of the horizontal velocity   Lagrangian time

$$\frac{\partial u_x}{dt} = \frac{3\,C_D\,\rho_g V_r(U_x - u_x)}{4\,\rho_l\,d}$$

$$\frac{\partial u_z}{dt} = \frac{3\,C_D\,\rho_g V_r(U_z - u_z)}{4\,\rho_l\,d} - g$$
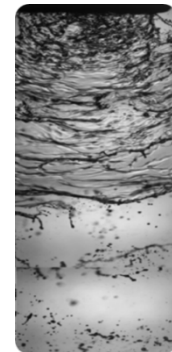
Goals

Compare numerical simulations of the transport of a spray with measurements in wind tunnel

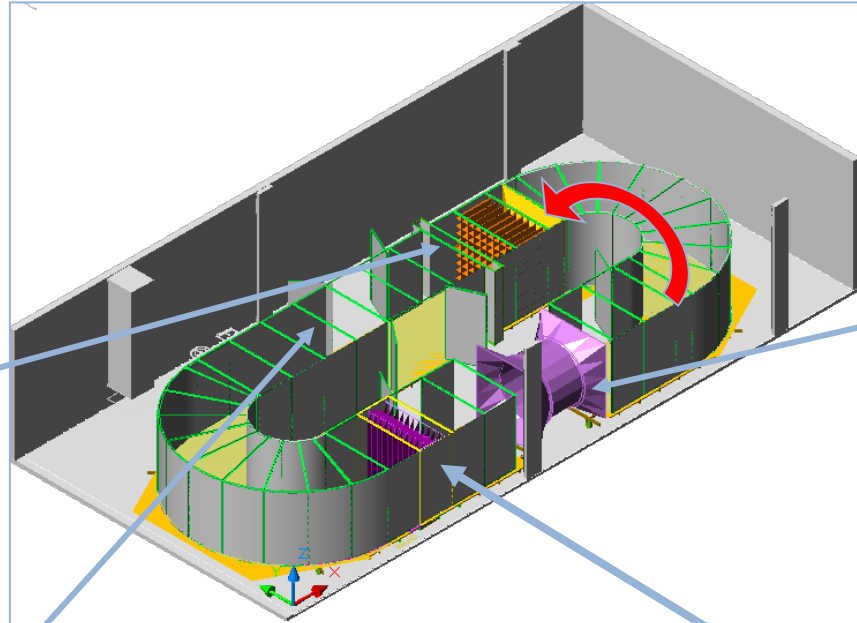Spray from single jet break-up

Spray from a 110-03 @ 3 bars

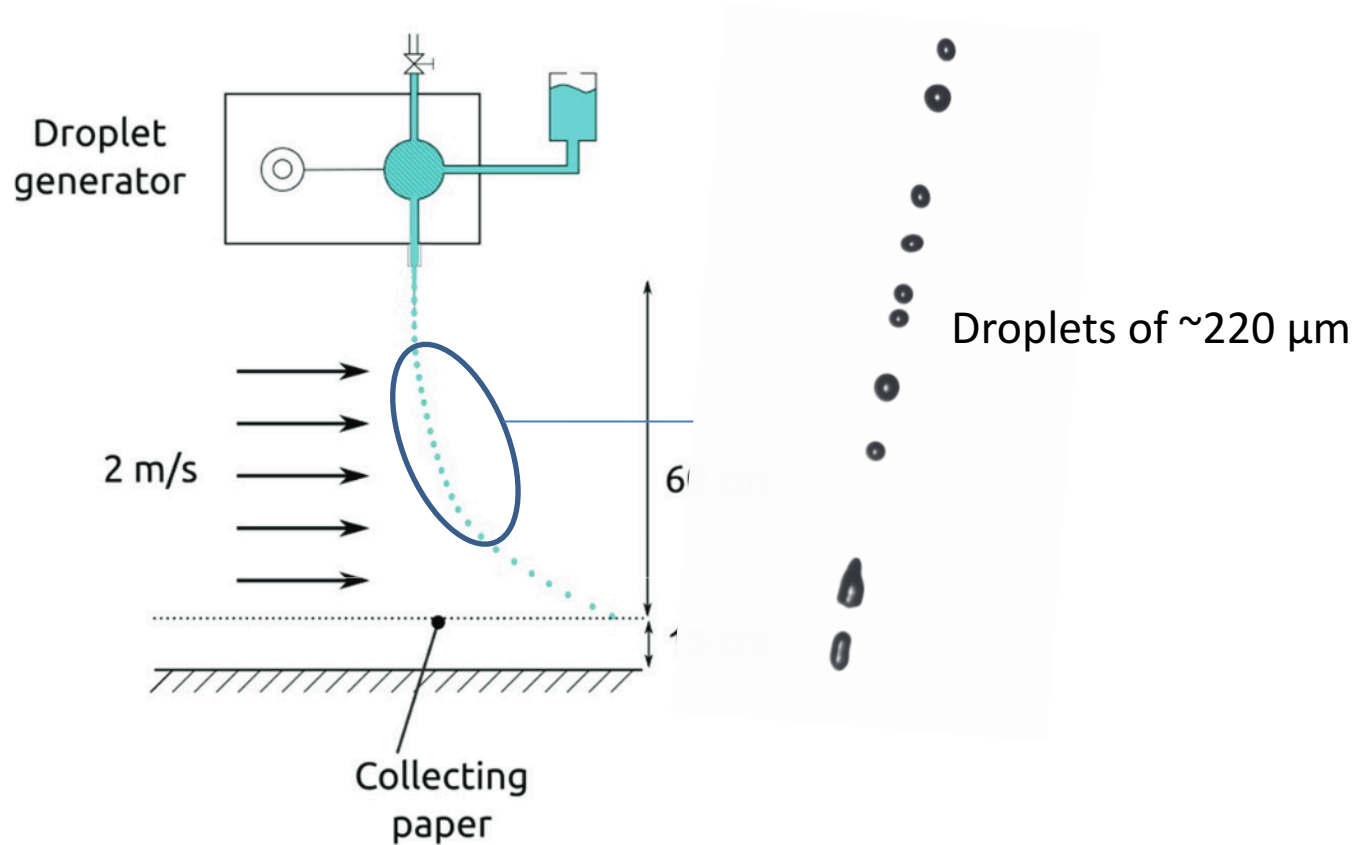# Wind tunnel

Moving boom

Speed up to 6 m/s

Large test section

2 x 2 x 8 m
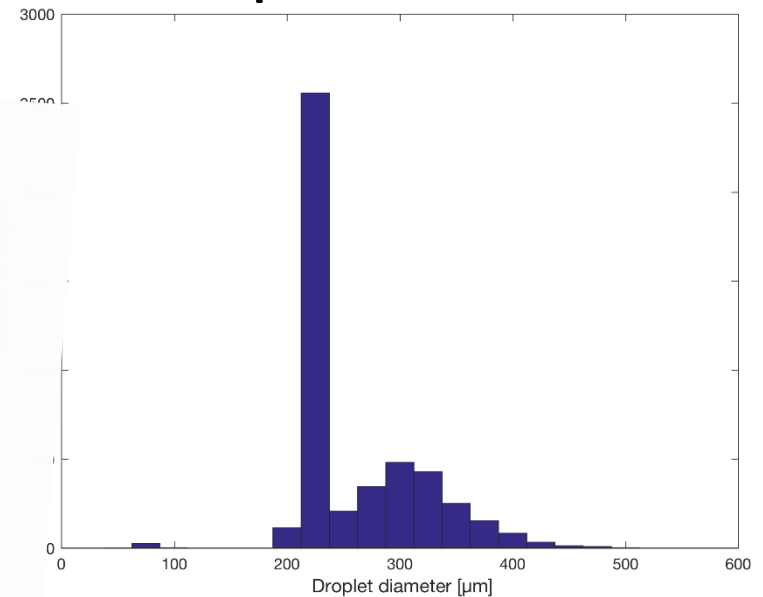
Droplet filter

Experimental set-up

Droplets of ~220 µm

Reduced span spray

Rayleigh break-up

Droplet size distribution

Experimental parameters

- Droplet velocity: 8.5 m/s
- Liquid: Tap water + nigrosin (black dye)
- Wind speed: 2 m/s with 5% turbulence intensity
- Humidity of 60% and temperature of 20°C

Droplet diameter [µm]

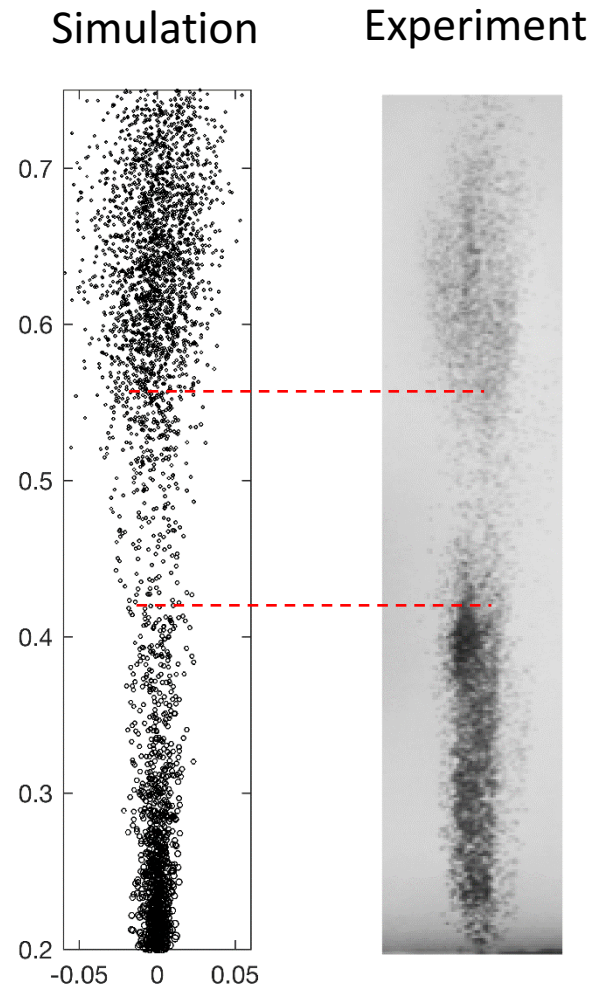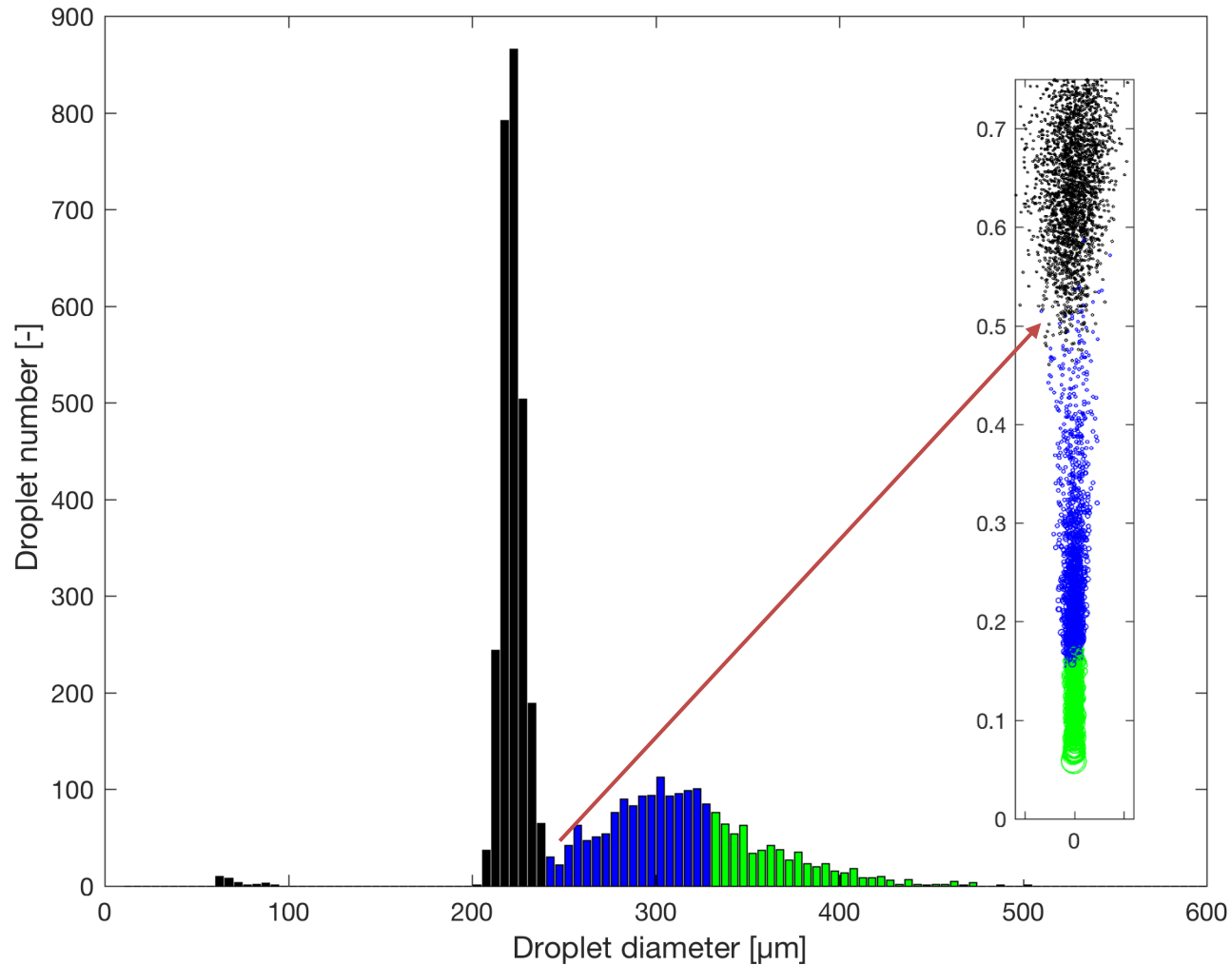# Reduced span spray

- Impact of 5000 droplets
- Marker sizes have been adapted to the droplet diameter

Simulation   Experiment

- Top picture of the collecting paper

Reduced span spray

F/M spray
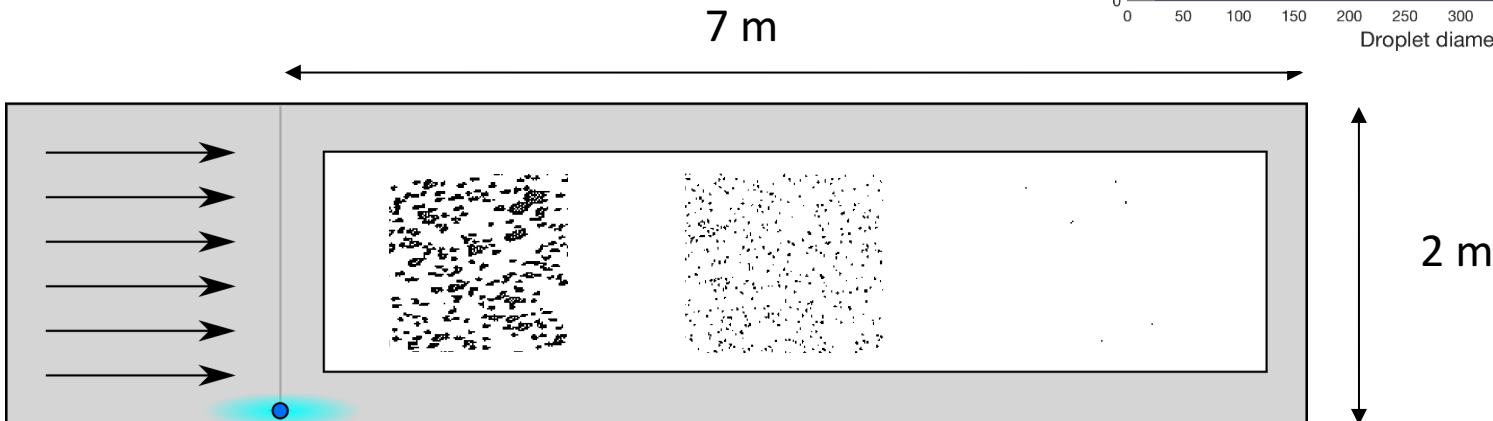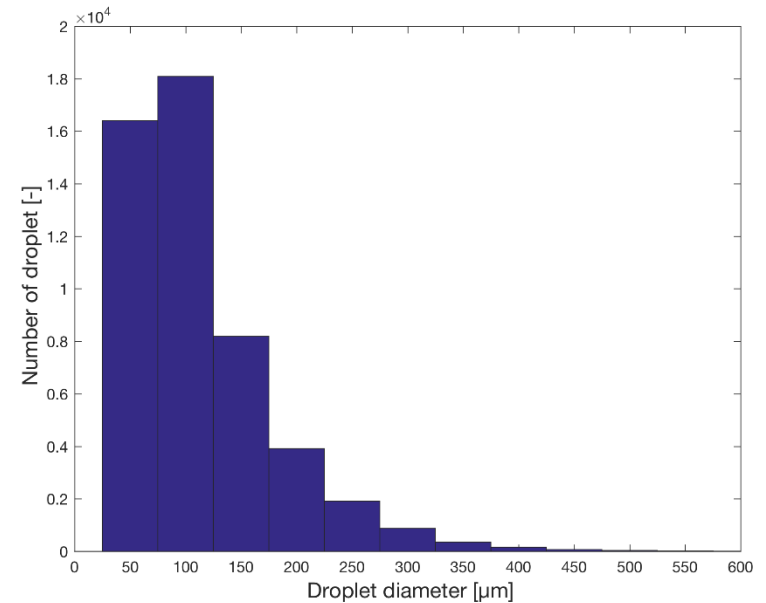
Droplet size distribution

Experimental parameters

- Nozzle: 110-03 at 3 bars crossing the test section at 2m/s
- Liquid: Tap water + nigrosin (black dye)
- Wind speed: 2 m/s with 5% turbulence intensity
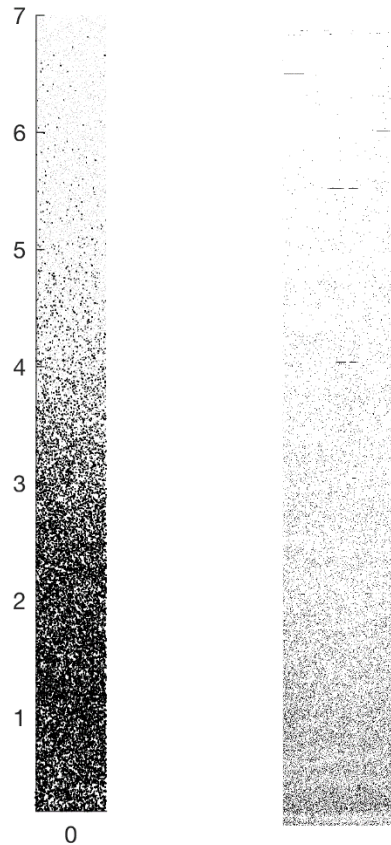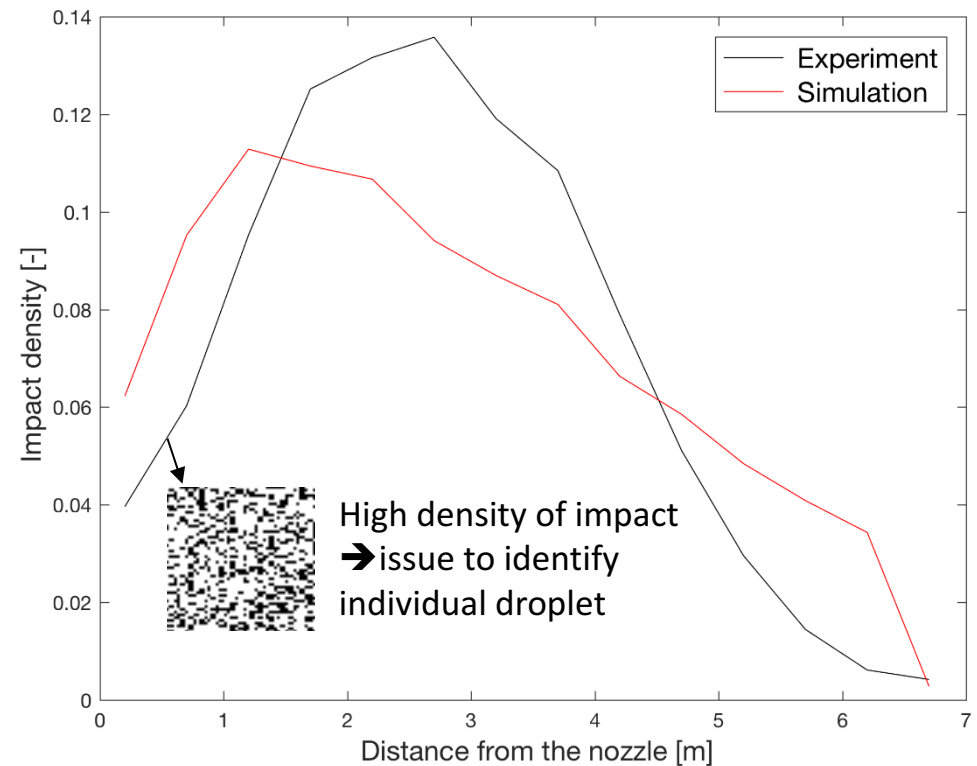- Humidity of 60% and temperature of 20°C

7 m

2 m

Simulation   Experiment

Relative impact density in respect to the distance

- Impact of 100 000 droplets

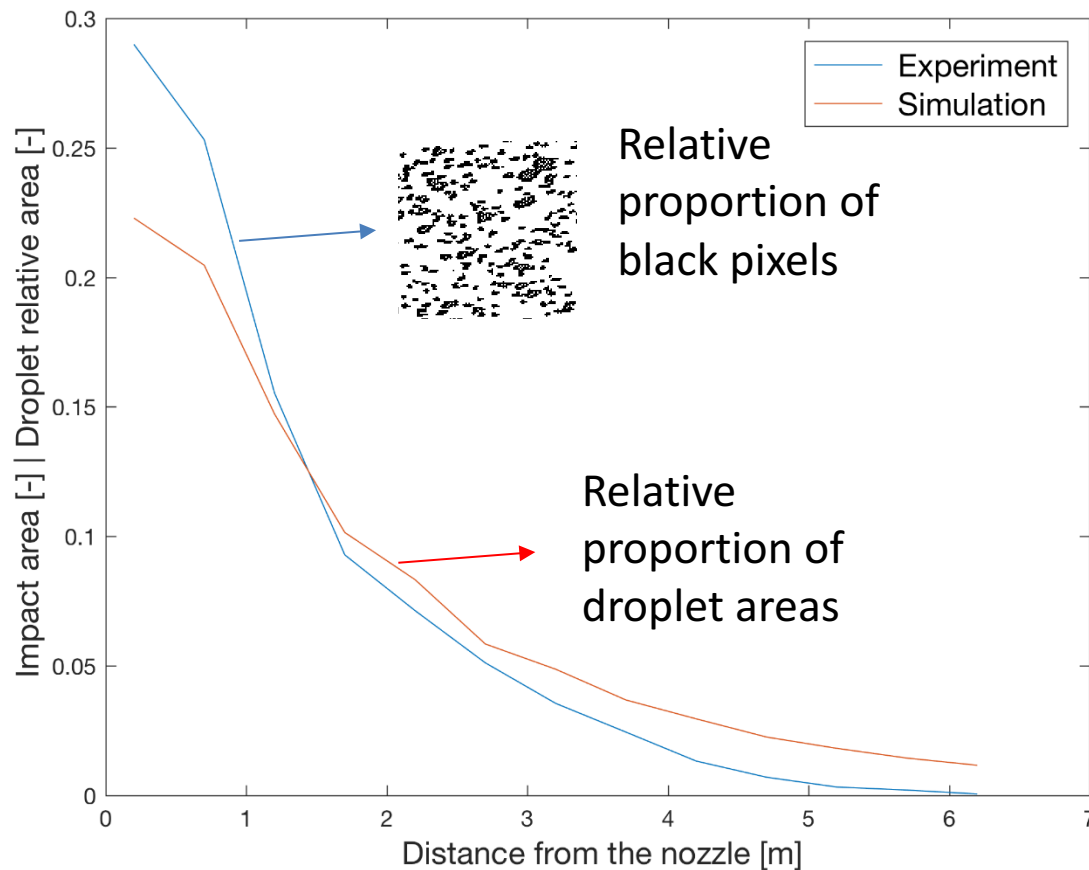High density of impact
➔ issue to identify individual droplet

Relative impact area in respect to the distance from the nozzle
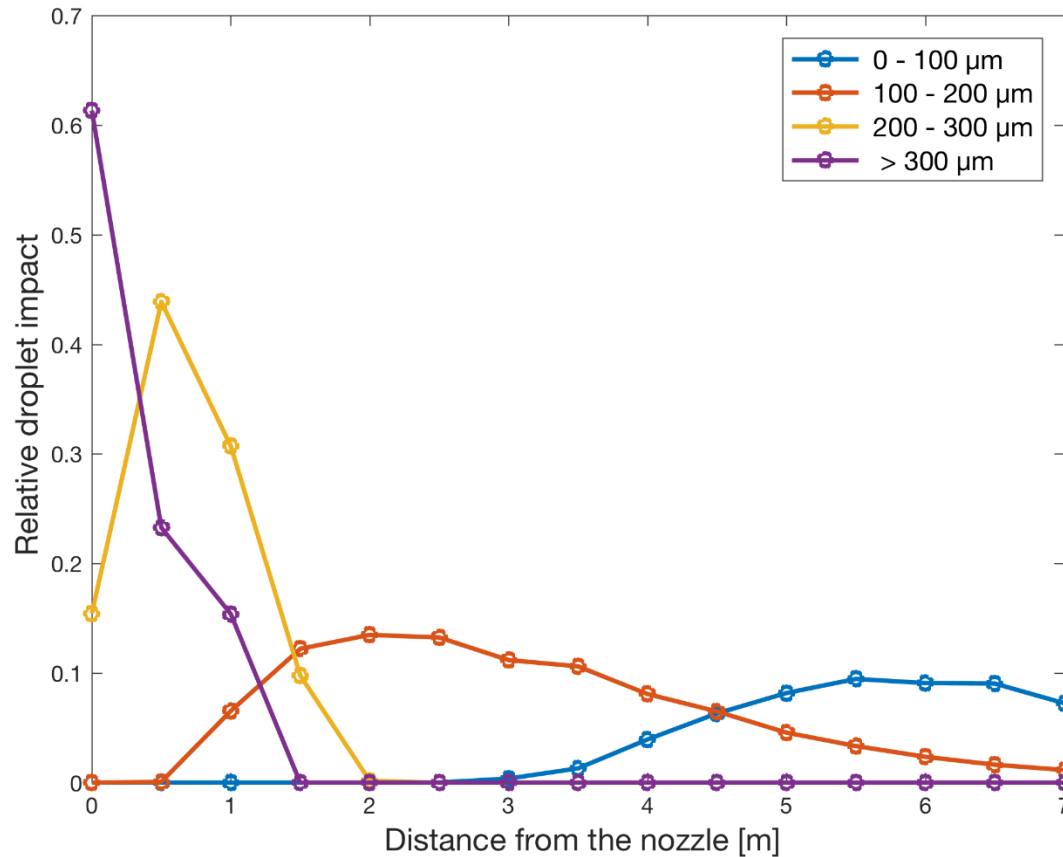
F/M spray

Travelled distance in respect for different droplet size

Conclusions

- Simulation and the experiment showed qualitative agreement
- Paper combined with dye provides an interesting spatial information about droplet deposition

Perspective

- Comparison of the droplet velocity before impaction
- Improvement of the experimental data processing