

Characterization of the air-flow and the liquid distribution of orchard sprayers

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Introduction

- Current situation
 - High levels of spray drift
 - Low levels of spray deposition in canopy
 - Spray technology to be further optimised
- Desired situation
 - No liquid particles outside the red box
 - In canopy spray deposition should be maximised



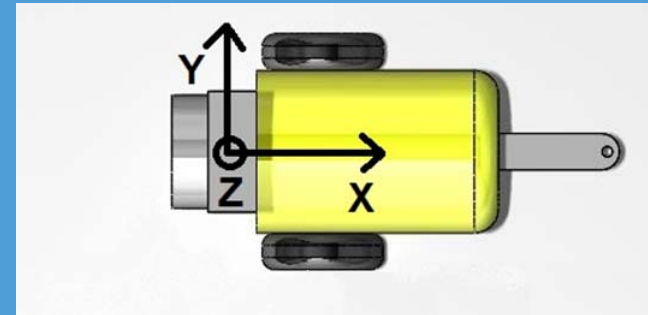
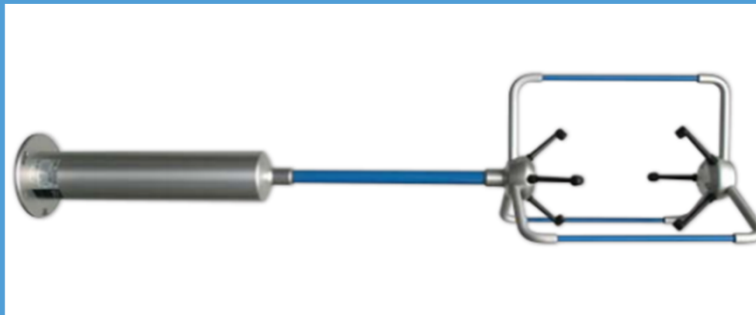
Introduction: Research questions

1. What air flow measurements are required to obtain usable and comparable data, that can be used for the quantification and characterisation of the total air flow in 3D-space of different orchard sprayers?
2. What is the characterisation and quantification of the air flow of an orchard sprayer in a stationary position in terms of absolute velocity, direction and flux of air?
3. What is the corresponding liquid distribution of an orchard sprayer stationary in position?



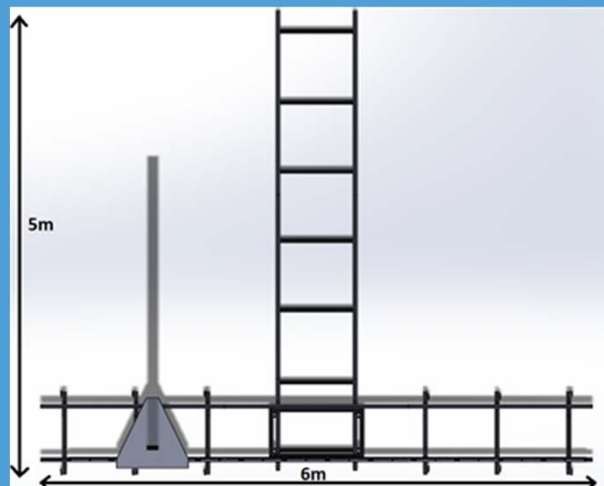
Materials and Methods

- First research question – air flow measurements
 - 3 Gill Windmaster anemometers available
 - The sensors measure the air velocity and direction in x, y and z at 20 Hz.
 - Accuracy check and measurement time analysis
 - Measure volume of 10 cm by 10 cm by 10 cm = grid size used



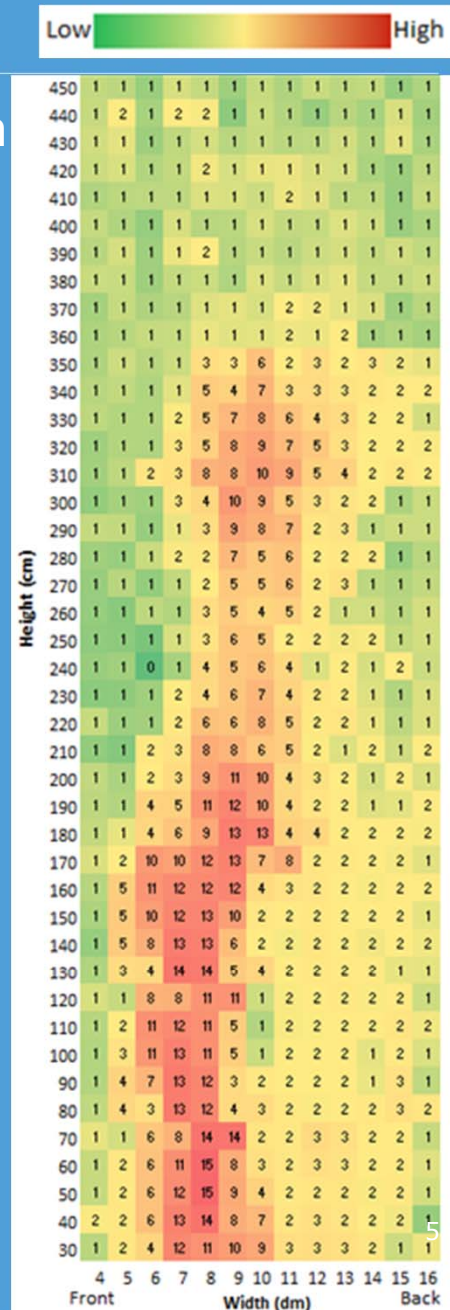
Airflow measurements

- Measurement setup and procedure was developed with Gill sensors
 - 740 grid points of 10 cm by 10 cm
 - 30 seconds per grid point
 - Both sides were measured of the Munckhof and HSS-CF sprayer
 - Multiple distances of the Munckhof on left side



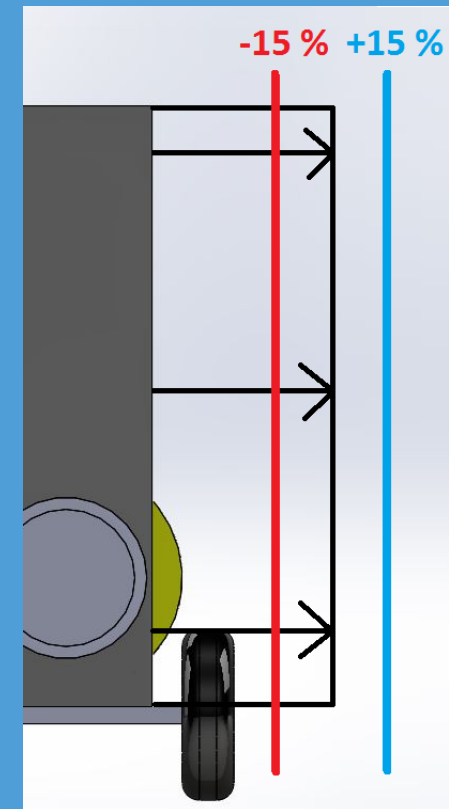
Settings

Pto	540 Rpm
Gearbox	High



Materials and Methods

- Assessment of air flow profile
- Homogeneous distribution of velocity and flux in height is demanded
- Low deposition risk in tree = Row velocities below 15 % of average
- Spray Drift potential = Row velocities above 15 % of average
- Max working height (height - air speed $> 4\text{m/s}$)
- CV of flux in height



Materials and Methods

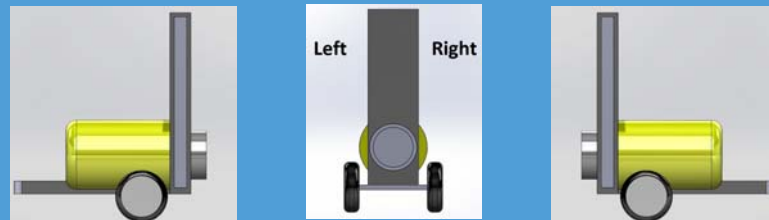
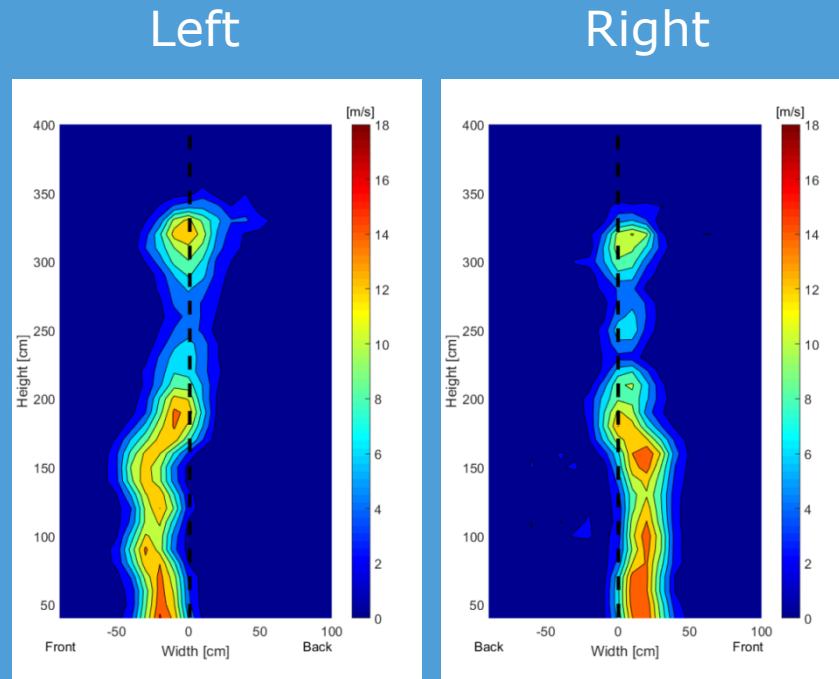
- Research question 3: Liquid distribution measurement
 - Collector will drive multiple times through the air-liquid stream
 - Relative liquid distribution in height measured
 - 10 distances each side and 5 repetitions per distance



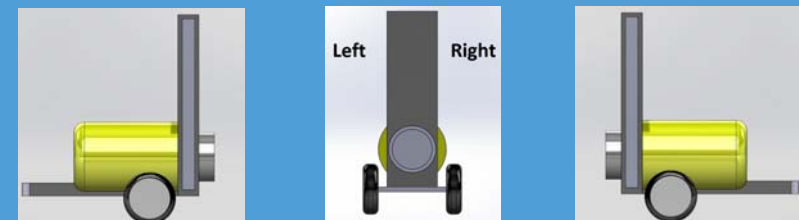
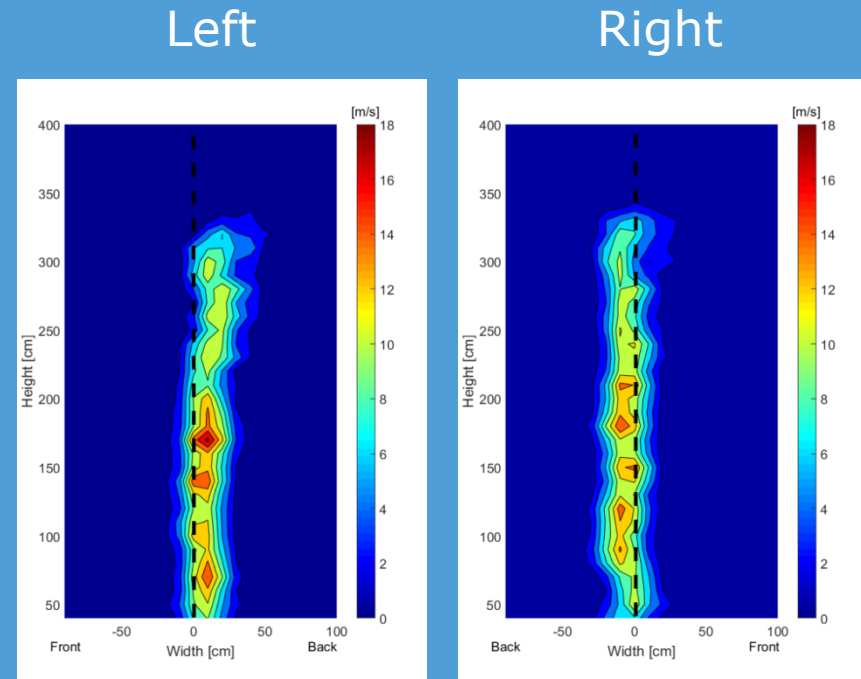
Settings	
Pto	540 Rpm
Gearbox	High
Spray pressure	7 bar
Nozzle type	Albuz ATR lilac (very fine)
Nozzle delivery	0.43 [l/min]
VMD (D_{V50})	143 μm

Results of air flow measurements

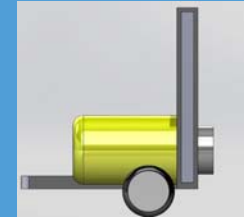
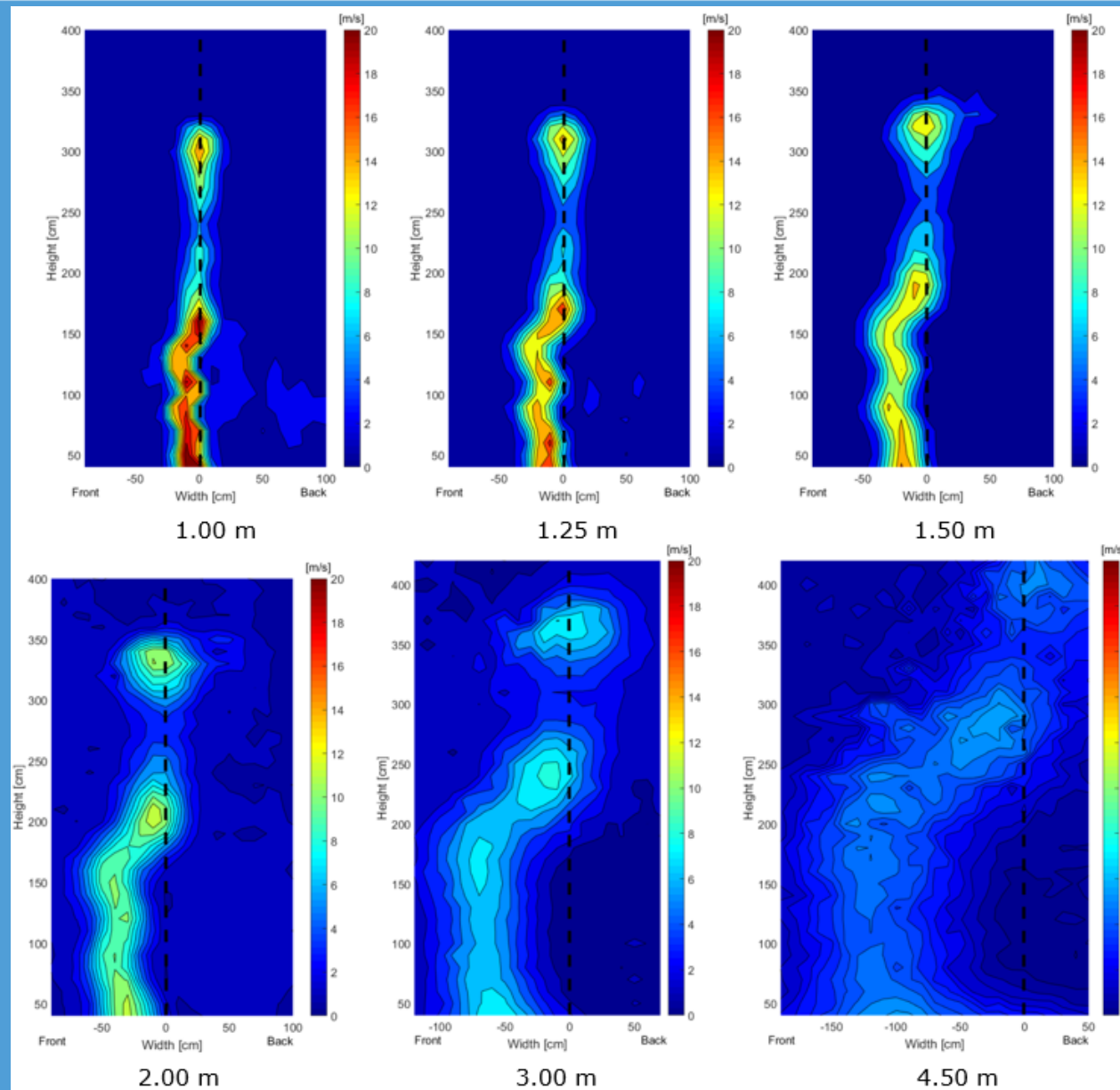
■ Munckhof cross flow fan sprayer



HSS-CF spout sprayer

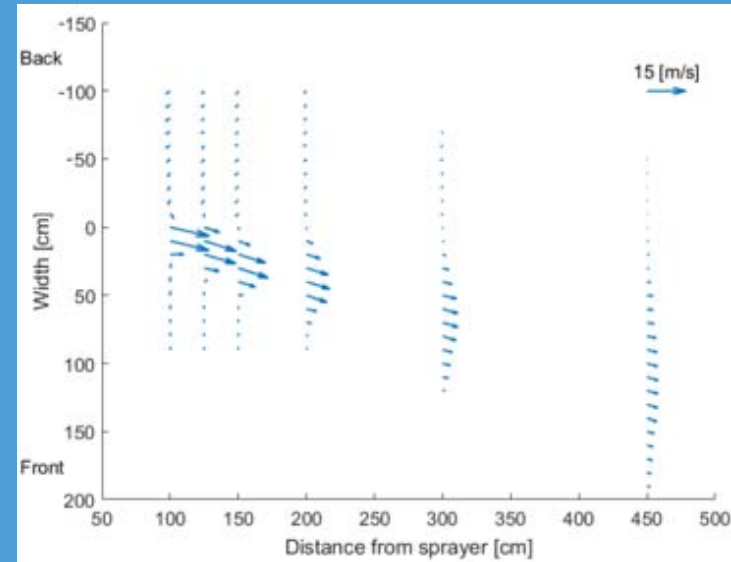
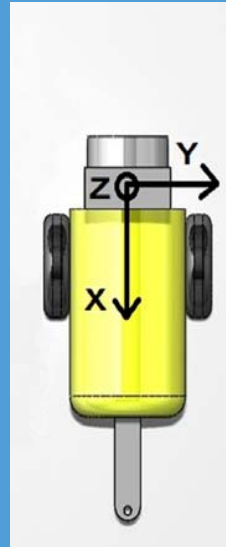


Results at multiple distances of Munckhof

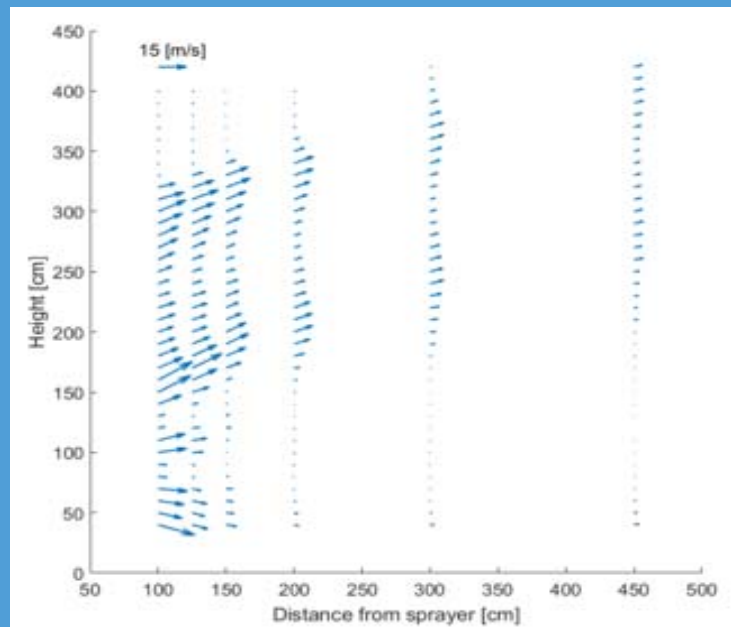
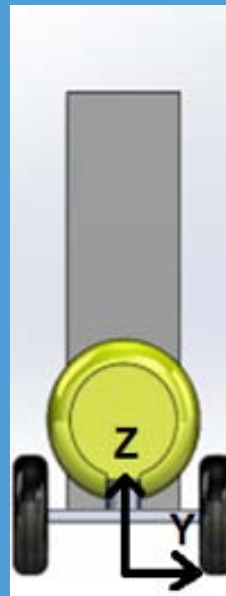


Results of slices of Munckhof sprayer

- $[x, y]$ plane
1.00 m in z



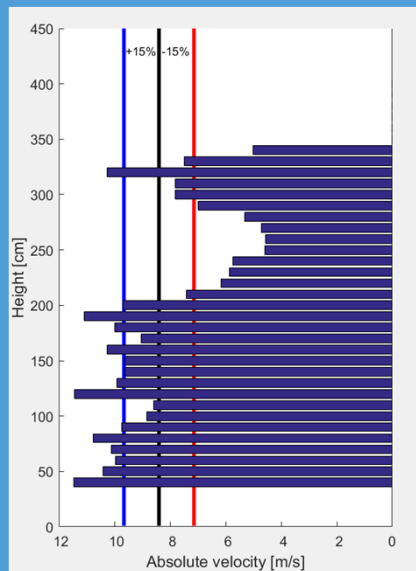
- $[y, z]$ plane
0.00 m in x



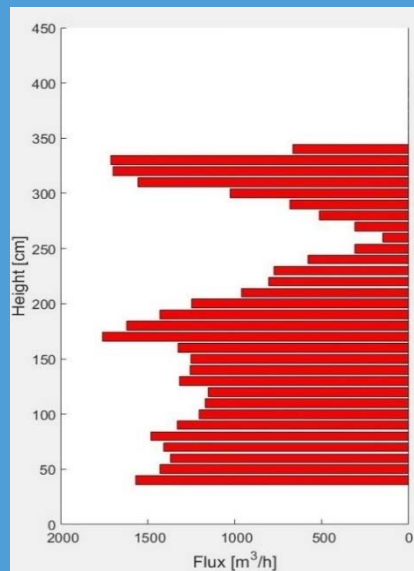
Results of assessment

■ Munckhof cross flow left side

Absolute velocity (m/s)

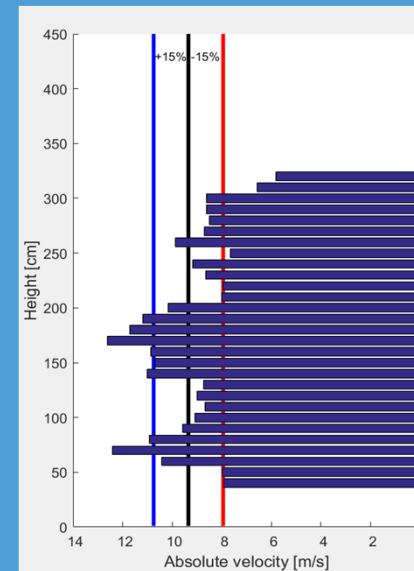


Flux (m³/h)

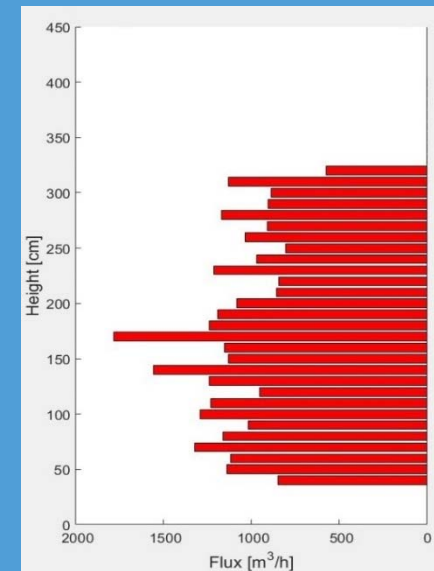


HSS spout sprayer left side

Absolute velocity (m/s)



Flux (m³/h)



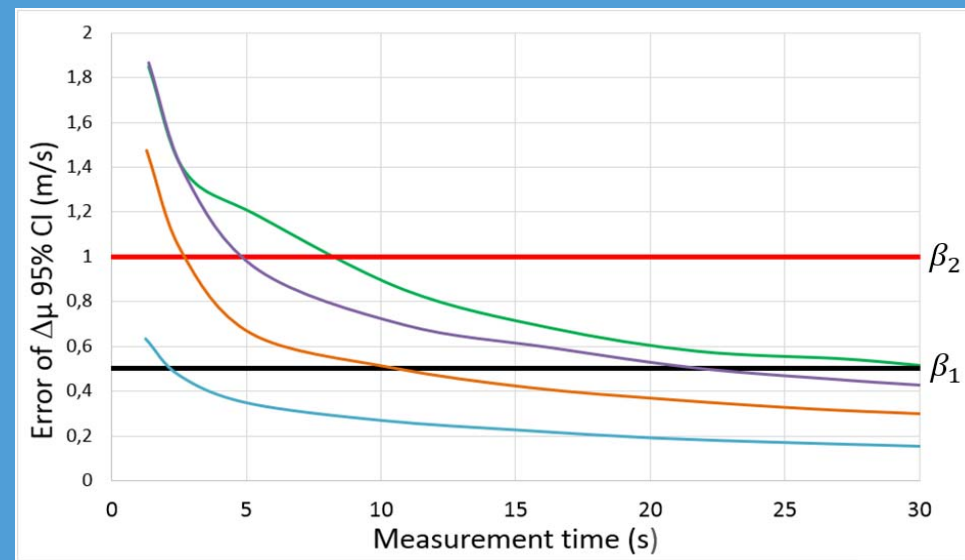
	Munckhof cross-flow fan sprayer	HSS spout sprayer left side
Max working height with $V > 4$ m/s	3.50 m	3.20 m
Potential of bad deposition (Heights with a $V < 85\%$ of \bar{V})	29 %	14 %
Drift potential (Heights with a $V > 115\%$ of \bar{V})	42 %	24 %
CV of flux distribution in height.	39 %	22 %

Sensor check

- Accuracy check (with system Peter Triloff)

	$ V $ (m/s)	Standard deviation
HSS-CF spout sprayer		
Metek Uno	4,00	4,55
Gill Windmaster	3,98	4,89
Munckhof cross-flow fan sprayer		
Metek Uno	4,74	4,17
Gill Windmaster	4,68	4,57

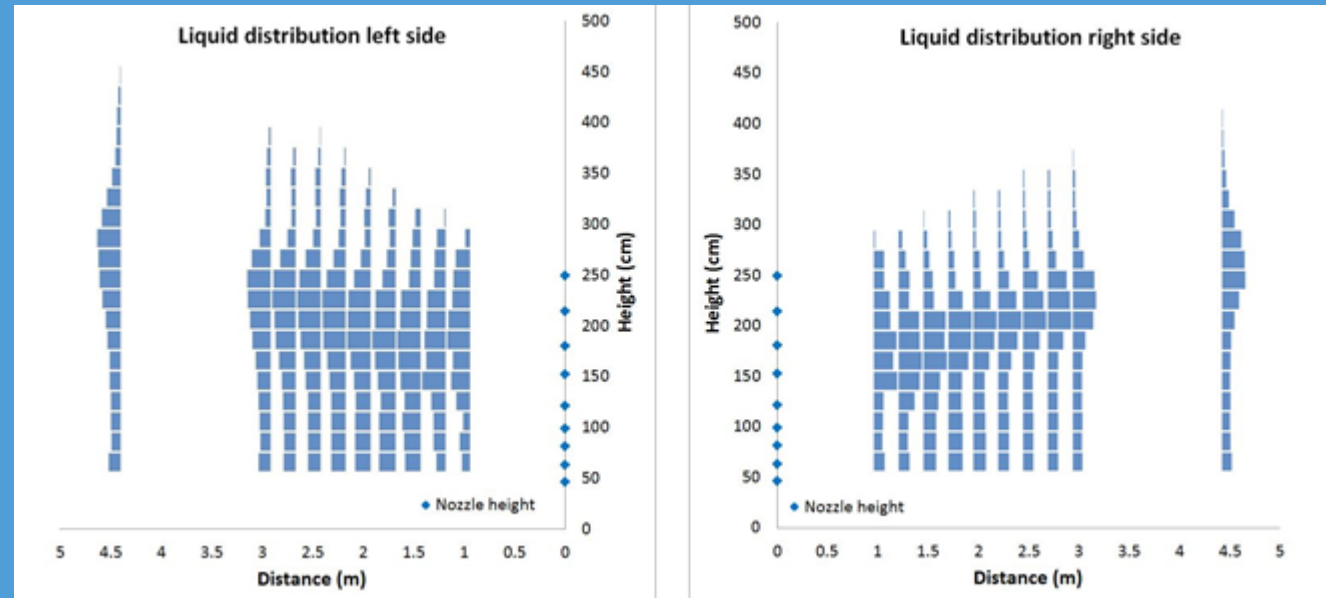
- Measurement time analysis (combination of precision and turbulence)



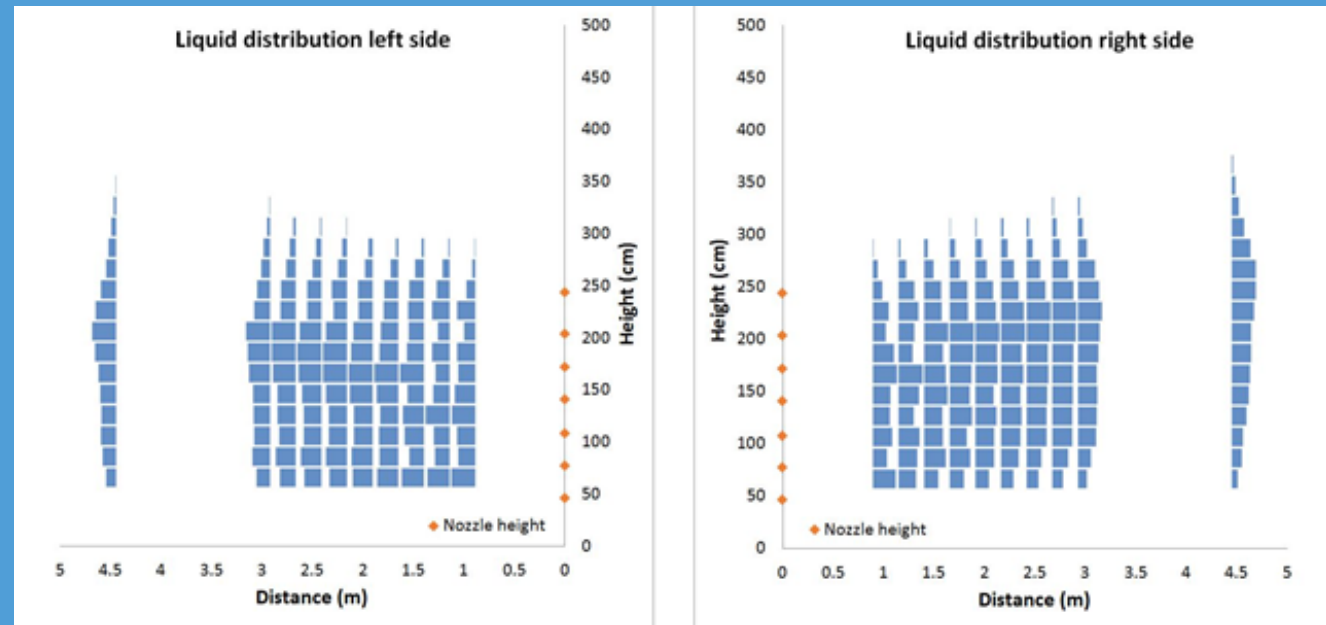
Munckhof cross-flow fan sprayer at (—) 1.00 m, at (—) 1.50, at (—) 4.50 m
HSS-CF spout sprayer at (—) 1.50 m

Results of liquid distribution

■ Munckhof cross-flow



■ HSS-CF



Discussion

- Air flow measurements
 - New approach
 - Measured cross-sections and slices visualises the air flow
 - Input for validation of CFD modelling

- Gill Windmaster sensor
 - Validation of sensors important
 - Rejected readings
 - Not solved by software update

- The air flow assessment
 - Made it possible to assess and compare orchard sprayers and its settings (left/right side)

Discussion

- Liquid distribution
 - Limiting system due to constant motion
 - Blown out effect at short distances
 - Only relative liquid distribution measurements in height possible
 - Needs improvement

Conclusion

- Required for air flow measurements
 - A cross section measurements with grid of 10 by 10 cm to capture the air flow
 - Understand accuracy of sensor
 - Measurement time could be chosen
- Air flow measurements
 - Differences in performance of sprayers can be shown and quantified
 - Differences of sprayer settings can be determined
- Liquid distribution measurements
 - Liquid followed the direction of the air flow
 - A parabolic distribution of the Munckhof cross flow fan sprayer
 - A more uniform distribution of the HSS spout sprayer

Recommendations

- Air flow measurements
 - Further testing of Gill Windmaster to solve rejected readings
 - Further research needed to find right values for criteria's developed for the assessment
- Liquid distribution measurements
 - Absolute liquid distribution measurements required
 - Grid of liquid measurement should match with air flow grid
- Link air flow and liquid distribution with spray deposition in the tree; from static machine measurement to dynamic process and result
(presentations Michielsen and Wenneker)

Thank you for your attention

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