WTDISP – Adapting a Lagrangian ground sprayer model using wind tunnel data

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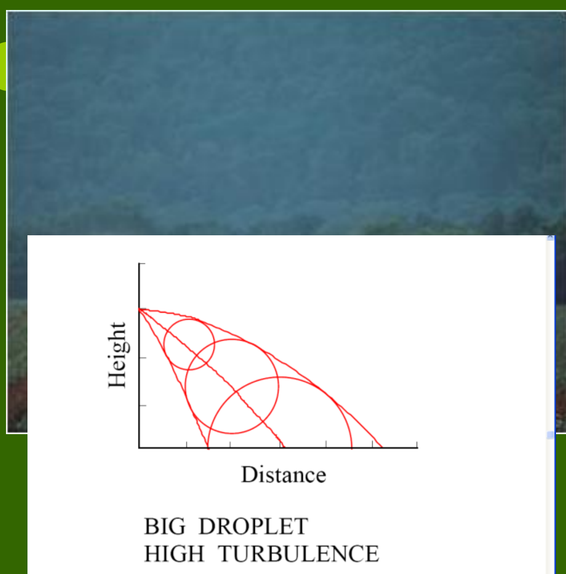
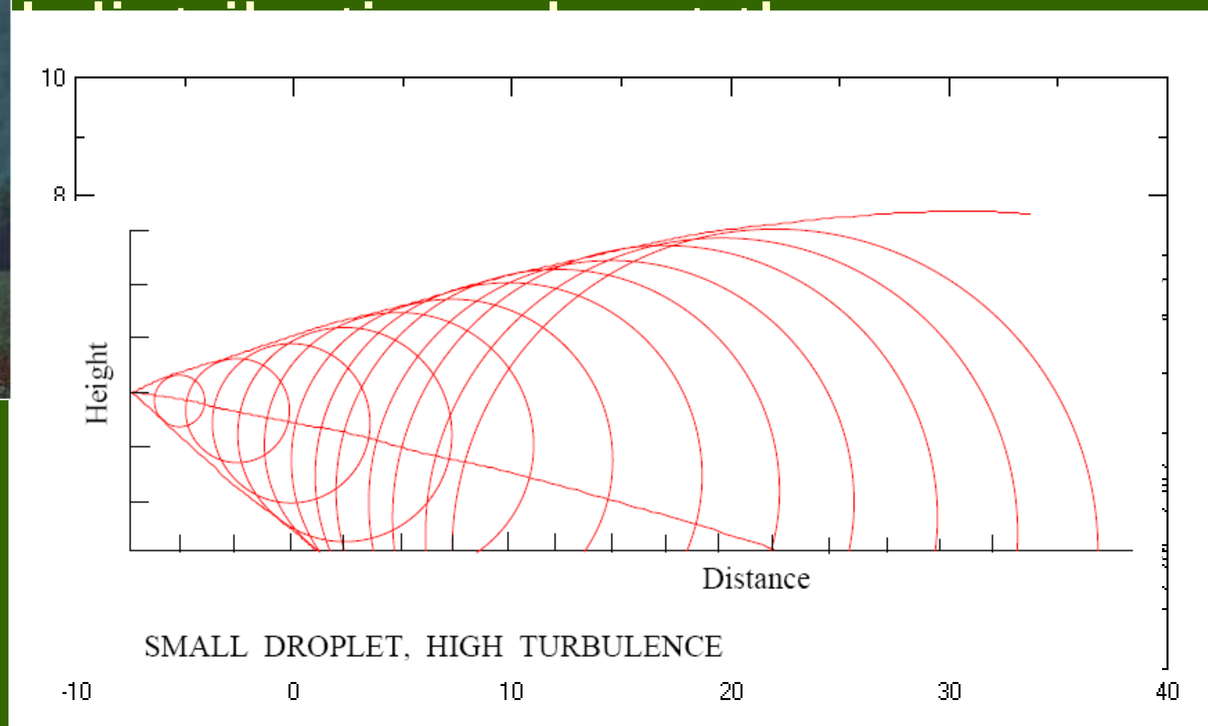
Model - AGDISP (AGricultural DISPersion)

- Lagrangian – Models paths of droplets
- Uses ensemble averaging for each droplet size (10 µm to 1000 µm (1mm)) - average path





AGDISP - Ground Boom Model

- Preliminary version
  - AGDISP originally developed for aerial spraying
- Thought that ground model has basic physics
  - Spray jet from nozzle
  - Air flow
  - Need refinement and analysis
    - Sheet length measurements for different nozzles
    - Droplet velocity measurements below nozzle
    - Turbulence model at ground level

AGDISP Ground Boom Model - Validation

- Spray Drift Task Force Data (1992,1993)

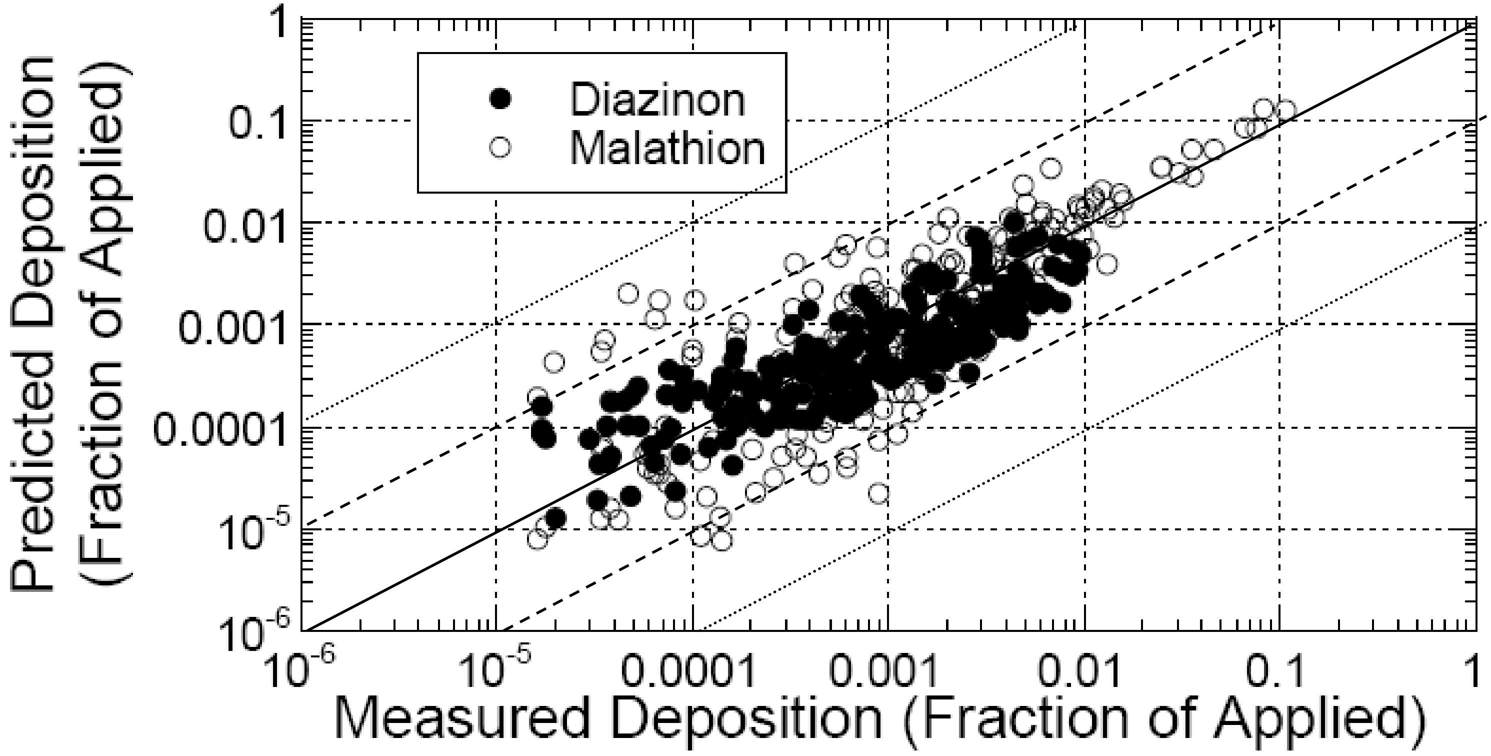


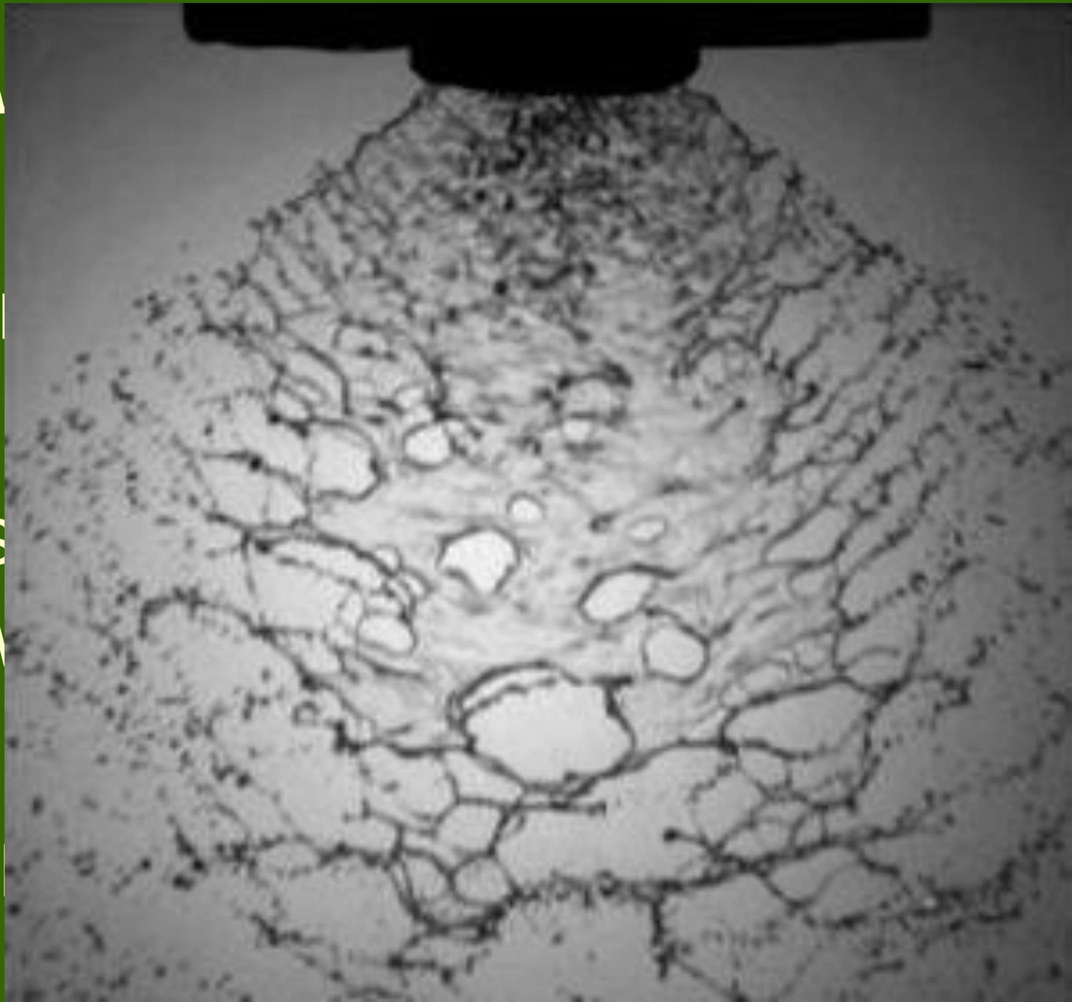
Figure 3. Modified ground sprayer results for L = 0.14 m and $\delta^2/2K = 0.57$. $R^2 = 0.964$.

Validation with other data sets

- AGDISP overestimates
  - Canada data – Wolf (2001)
  - New Zealand data – Woodward (2008)
  - Belgian Data – Nuyttens - Barton
- Examine ways to improve the model
- Presently inputs into AGDISP
  - Measured droplet sizes close to spray jet
  - Amount of spray per hectare
  - Other variables – wind, humidity etc

Spray breakup and initial dispersion of droplets from spray jet from nozzle

- Difficult to model
- Calibrate model w
  area
- Measurements 2 r
  tunnel
- Presently used as
  comparisons betw
- WTDISP
  - Take this approac

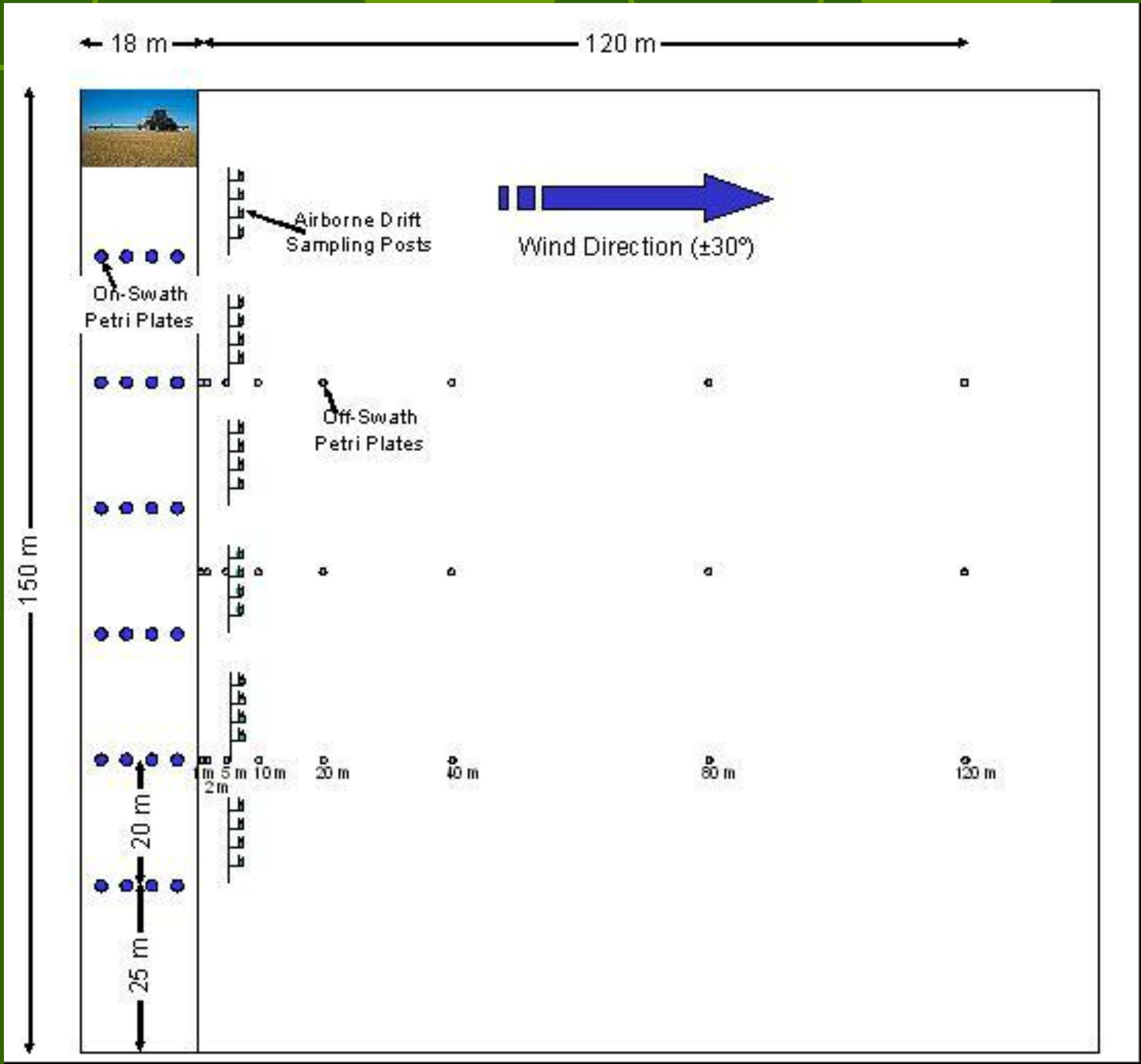


Wind Tunnel DISP (WTDISP)

- Measure droplet
  - Flux (Flow per unit area)
  - and Droplet spectrum (range of sizes)
  - 2 m downwind
- Overcome modelling difficulties close to nozzle
- Canadian Field data Wolf (2001)
  - 4 nozzles - 21 trials
- Wind tunnel measurements - Hewitt (2008)
  - 1 nozzle

Canadian Field trials – Wolf 2000

- Sprayer
  - 18 m boom
  - 36 nozzles
  - 3.58 m/s
- Measured Deposition
- Airborne Drift 5 m downwind

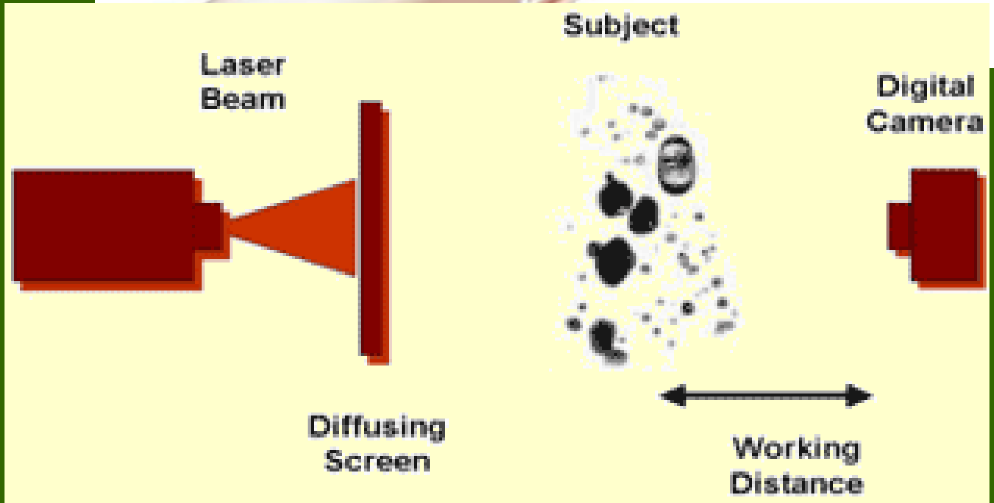


Silsoe Wind Tunnel

- Measurements undertaken 2 m downwind
- Stationary nozzle with spray fan at right angles to the wind
- Wind 4.5 m/s
- 80 % humidity

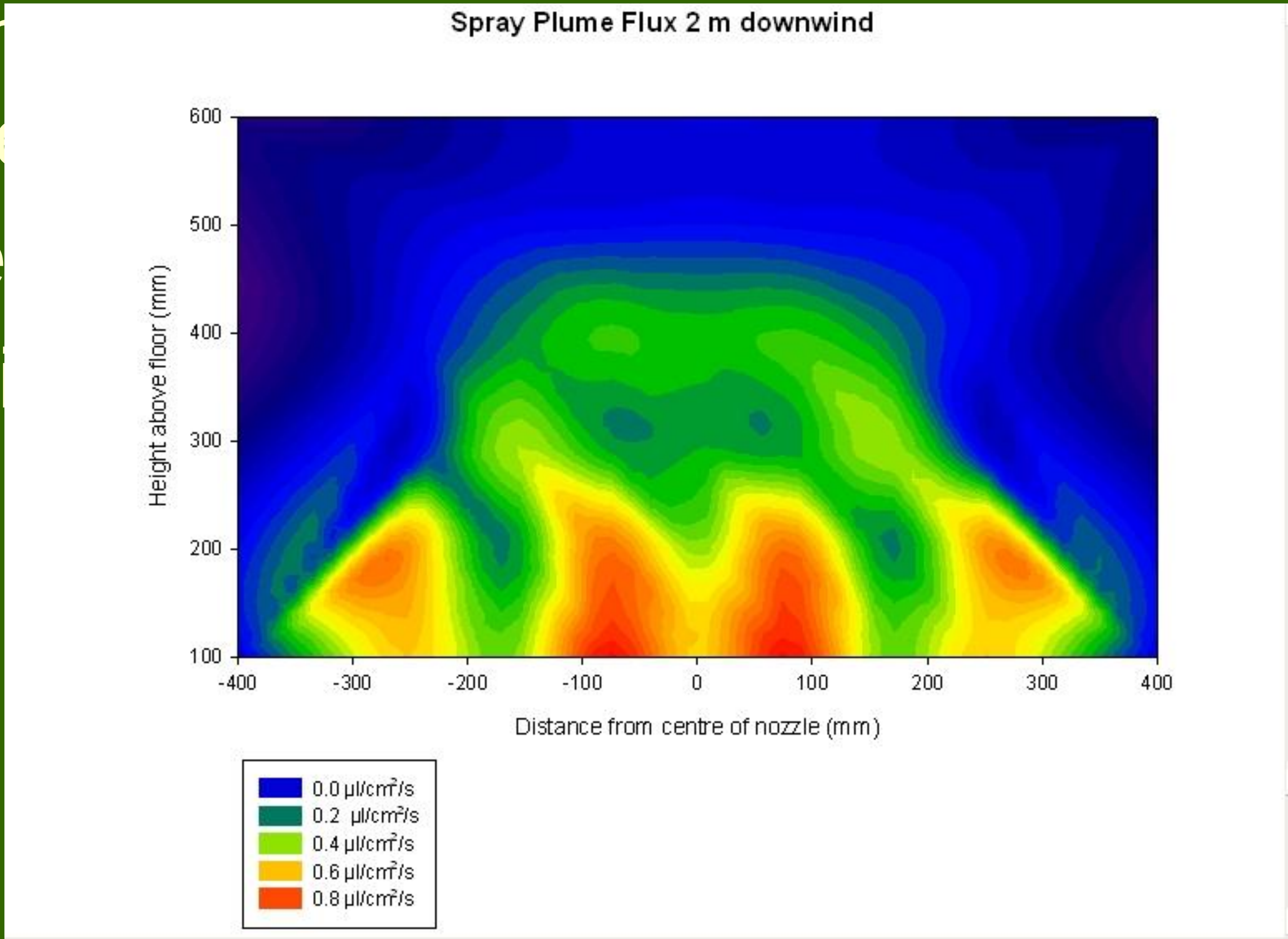
Measurements with Oxford Laser

- Droplet spectrum &
- Flux
- Measurements over spray cloud 2 m downwind
- Grid Spacing
  - 100 mm vertically
  - 80 mm horizontally



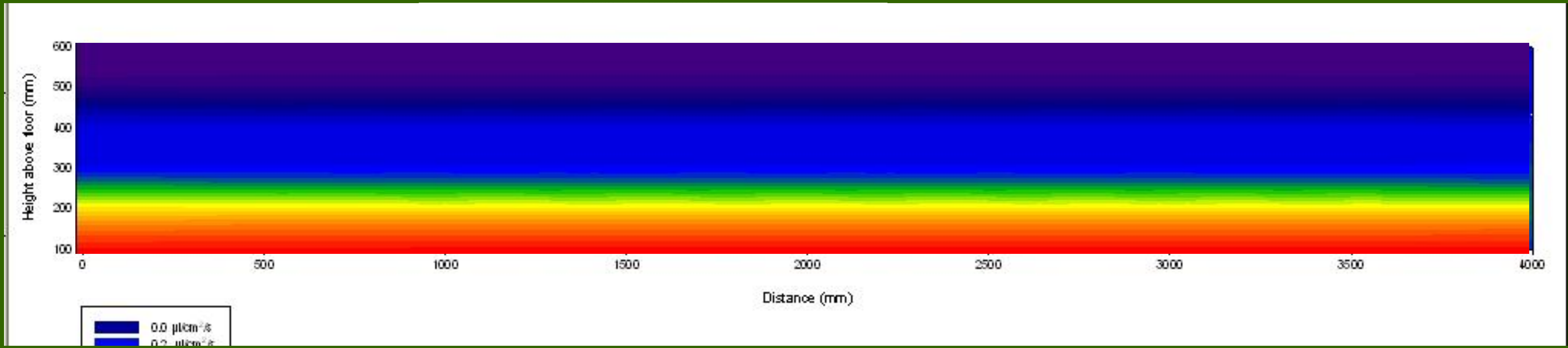
Result

- Spray cloud of flux
- How to com
  between the
- Wind tunne
- Field - Movi



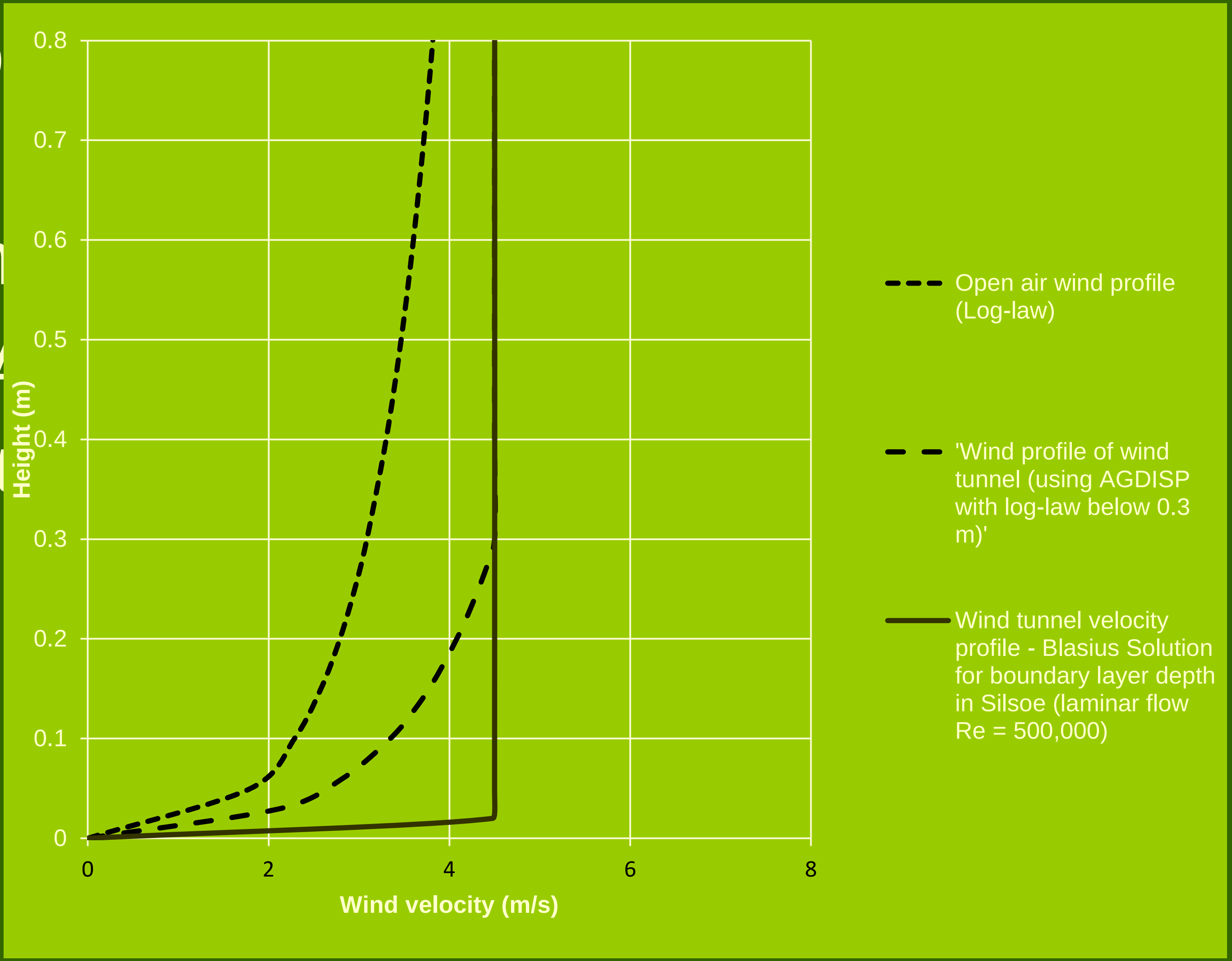
Analysis of wind tunnel data for field

- Wind tunnel measurements – stationary nozzle
  - Flux in µl/cm^2/s – flux (µl/s) per unit area
- Need how to use this result for moving sprayer
- This flux distributed over 358 cm in one second for the field trial
- Spray moving needs to be flux uniform at each height



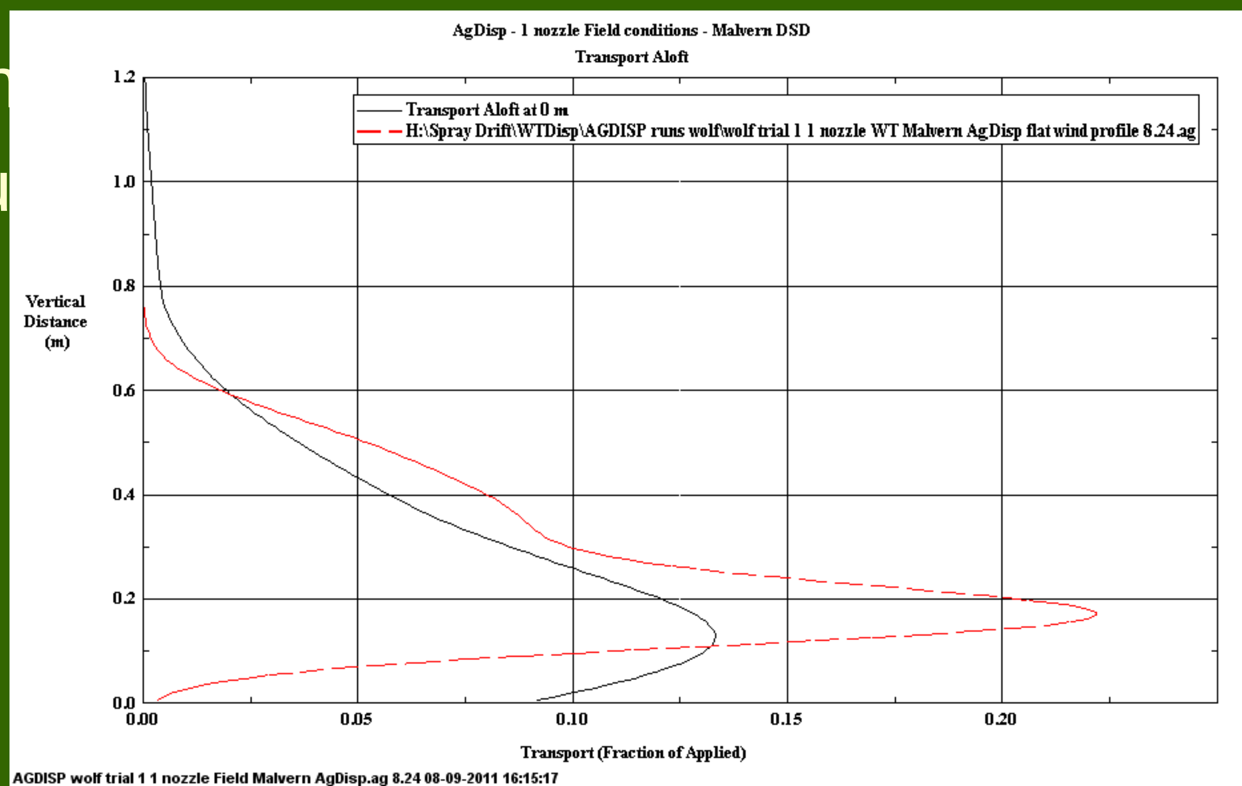
Adjust wind profile from wind tunnel profile to atmospheric profile

- Atmo
- Wind heigh
- Use A
  - Flat



Change in flux due to change in wind profile

- AGDISP 8.24 estimate changes in flux
- Incorrect turbulence description for wind tunnel
  - Lamin
  - Turbu %



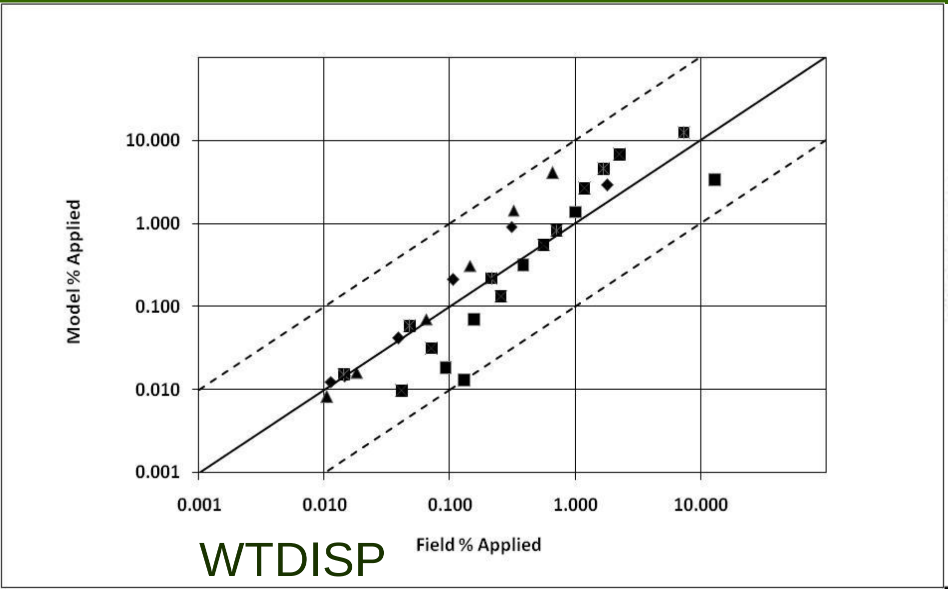
Analysis continued

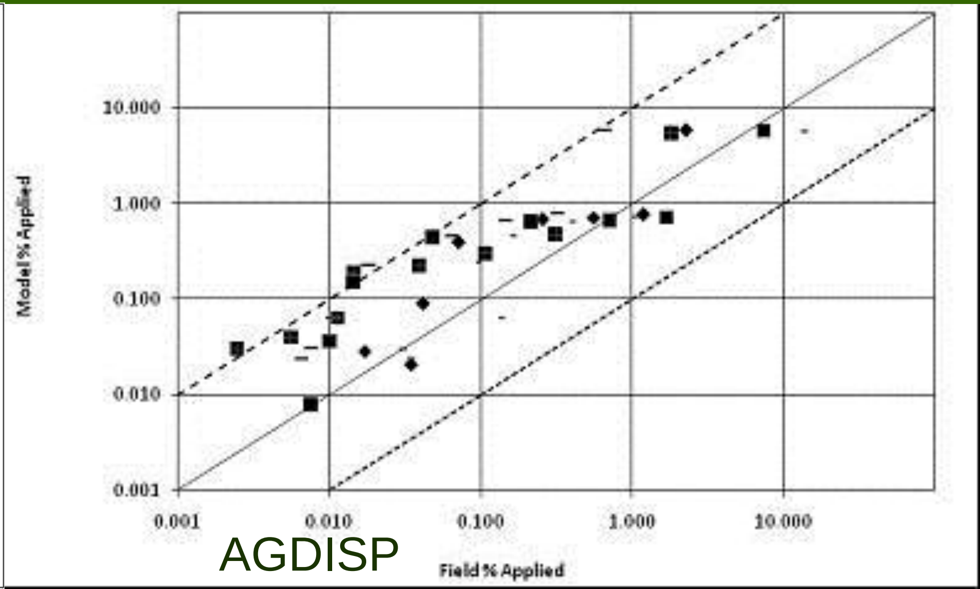
- Run WTDisp with the calculated fluxes
  - Calculates Deposition Profile downwind for one nozzle
- Add results using 36 nozzles with 0.5 m offsets due to nozzle spacing on boom
- Compare results with field data

Results – All trials with AI110025 nozzle

- Ratio of modelled to measured Deposition

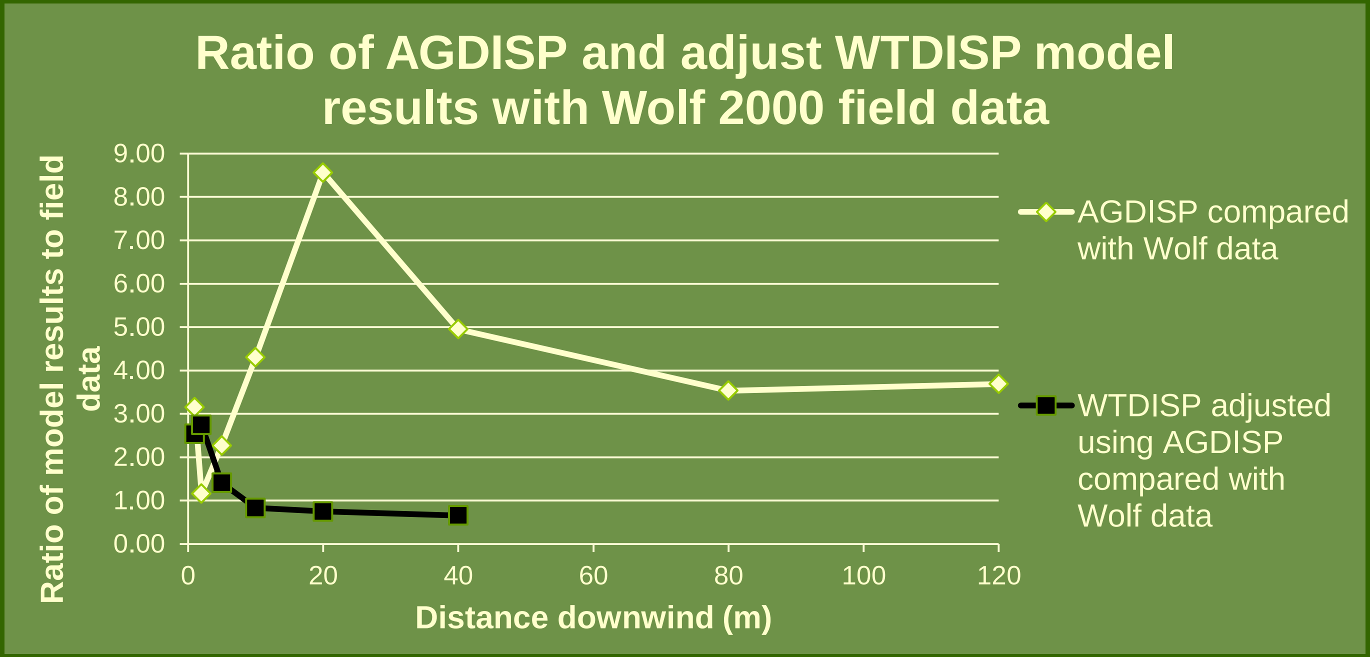
AI110025 nozzles	Mean	StDev	Maximum	Minimum
WTDISP mean result with fluxes adjusted using adjusted wind profile using AGDISP 8.24 – mean	1.49	1.32	6.16	0.10
WTDISP – mean (unadjusted fluxes)	2.03	1.87	8.92	0.13
AGDISP - mean	3.95	3.60	12.94	0.43





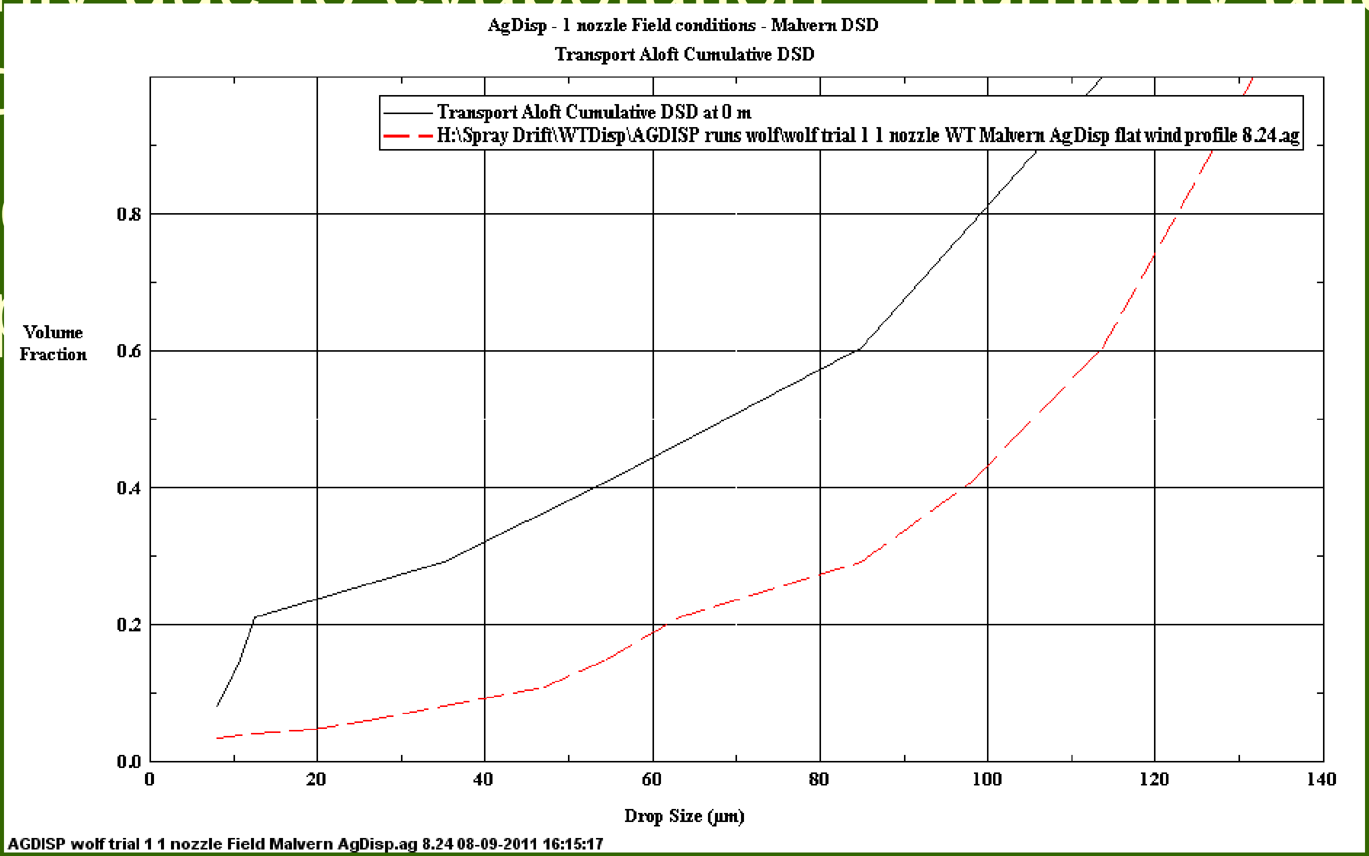
Results with distance downwind

- AGDISP over estimates with a peak
- Adjusted WTDISP decreases with distance



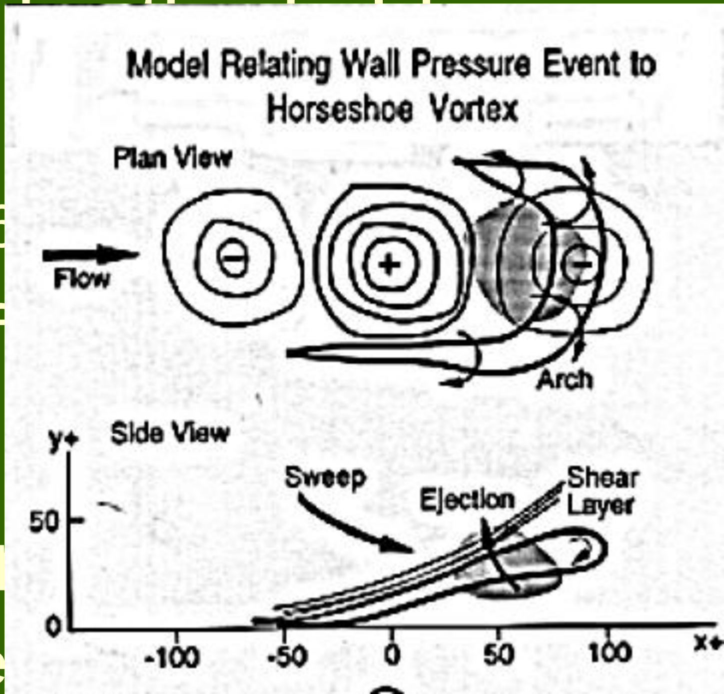
Change in droplet size

- AGDISP 8.24 shows a large differences mainly due to evaporation – humidity and wind
- Exp to evap



Turbulence scaling effects

- Wind tunnel – laminar flow
- Field – Fully turbulent flow
- Turbulent Structures – Sweeps and bursts
- Each last about 4 seconds
  conditions of trial 1
  - Hogstrom and Bergstrom (1996
- Reason for large range of f
  measurements
- Assess differences field/wi
  - CFD models & sonic anemome



Droplet size and flux in the field

- Measure droplet size and flux in the field
- With sonic anemometer data
- Improved model
- Field Phase Doppler Interferometry

Conclusions

- WTDISP results improve on AGDISP
- Adjusted flux using AGDISP 8.24 improves results
- Droplet spectrum different compared to AGDISP – evaporation rate
- Droplet size and flux measurement in the field – Field phase doppler interferometry
- Assess effect of turbulent processes on results – CFD models/sonic anemometers

Conclusions