Atomization and Drift Models

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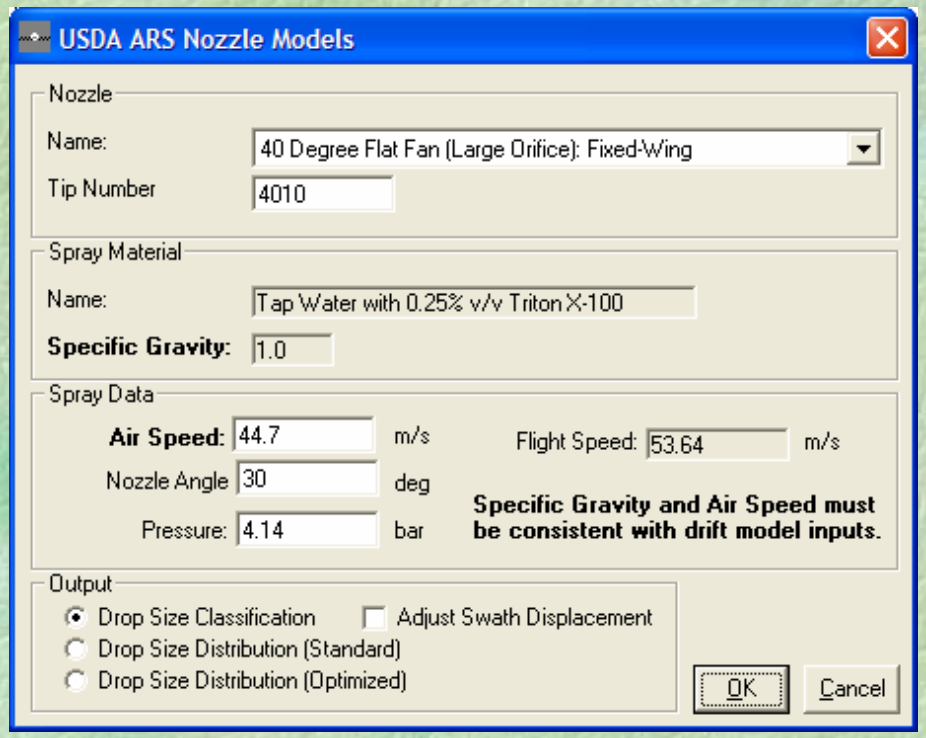
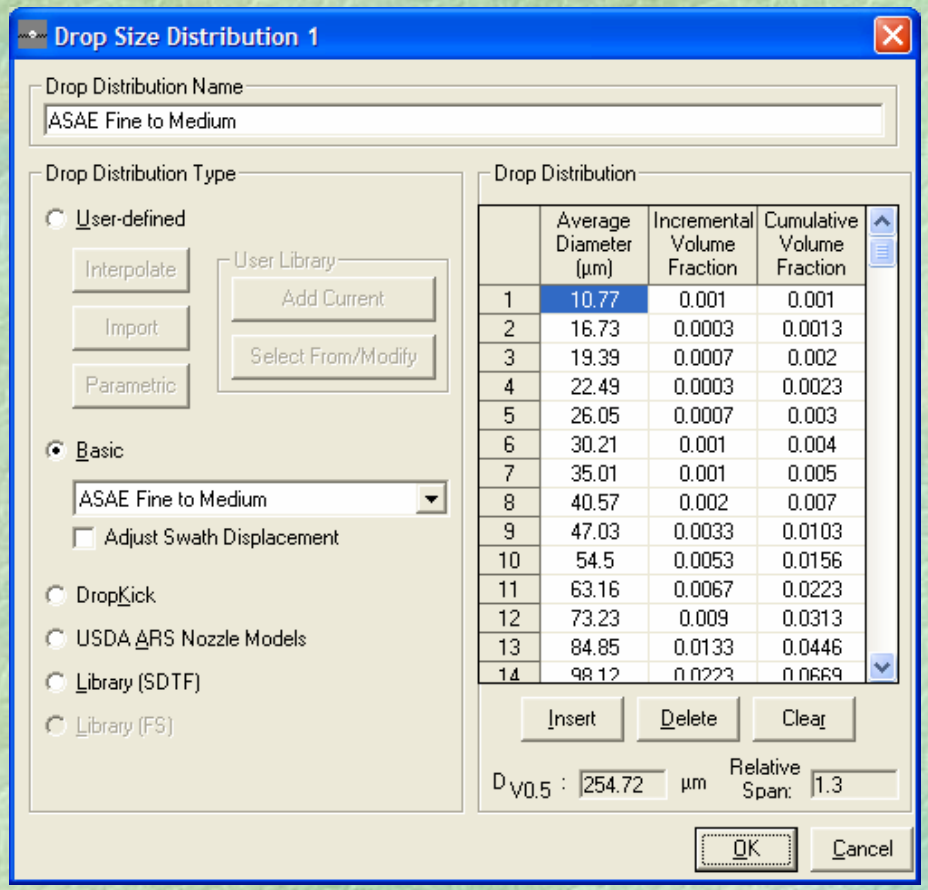
University of Queensland

Droplet Size Models

- USDA ARS – aerial models
- SDTF – DropKick within AgDRIFT
- UQ – developing models for specific atomizers and tank mixes
- Jones Air – JARBA
- Micronair models – SERG, Cotton Research Council, Micronair
- ASC models
- Unimiser model

Many Models Included in AGDISP/ AgDRIFT



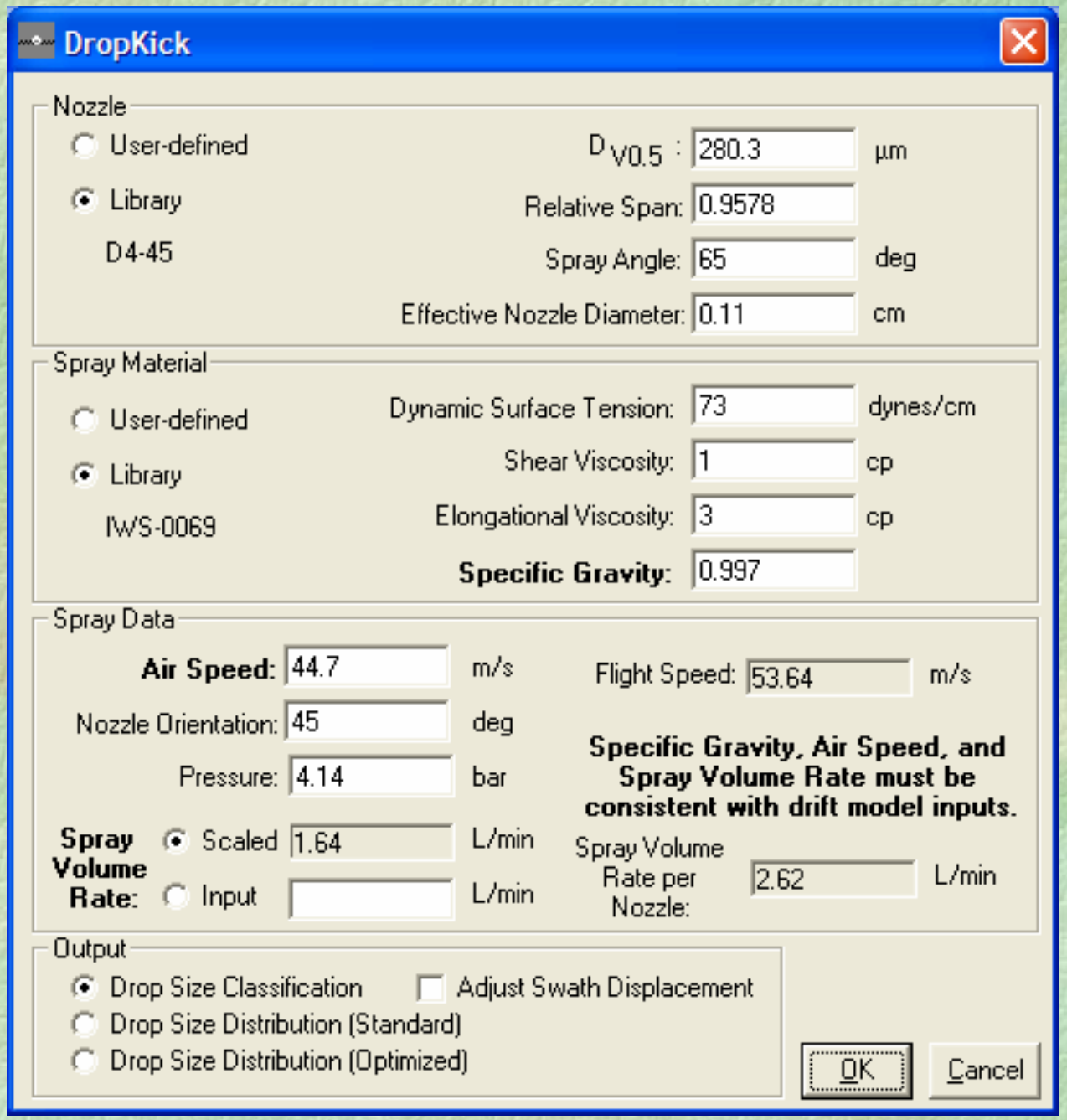


USDA Models

- Models for specific nozzle types in aerial applications with water+surfactant for PMS data
- **http://apmru.usda.gov** Downloads
- Additional models being developed for all major nozzle types
- Also included in AgDRIFT and AGDISP

DropKick

- Included in AgDRIFT (but not AGDISP)
- Covers wide range of hydraulic nozzles and tank mixes, but needs complete validation still and comparison with other models
- Provides estimate only, for approximate “ballpark” idea of droplet size spectrum


DropKick
Nozzle
User-defined
Library
D4-45
D V0.5 : 280.3 µm
Relative Span: 0.9578
Spray Angle: 65 deg
Effective Nozzle Diameter: 0.11 cm
Spray Material
User-defined
Library
IWS-0069
Dynamic Surface Tension: 73 dynes/cm
Shear Viscosity: 1 cp
Elongational Viscosity: 3 cp
Specific Gravity: 0.997
Spray Data
Air Speed: 44.7 m/s
Nozzle Orientation: 45 deg
Pressure: 4.14 bar
Spray Volume Rate:
Scaled 1.64 L/min
Input L/min
Flight Speed: 53.64 m/s
Specific Gravity, Air Speed, and Spray Volume Rate must be consistent with drift model inputs.
Spray Volume Rate per Nozzle: 2.62 L/min
Output
Drop Size Classification
Adjust Swath Displacement
Drop Size Distribution (Standard)
Drop Size Distribution (Optimized)
OK
Cancel

DropKick Nozzle Library

Filter

Nozzle: ASAE Fine

Browse Filtered Entries

Nozzle:	ASAE Fine
Type:	
Manufacturer:	
$D_{V0.5}$ (µm):	150
Relative Span:	1.1
Spray Angle (deg):	0
Effective Nozzle Diameter:	0.05 cm

1st | Prev | Next | Last | 1 of 1

OK | Cancel

DropKick Material Library

Filter

Component: Any

Substance: Minimum

Browse Filtered Entries

Substance:	Minimum
Dynamic Surface Tension: (dynes/cm)	25
Shear Viscosity (cp):	0.9
Elongational Viscosity (cp):	0.9
Specific Gravity:	0.78

Components:

1st | Prev | Next | Last | 1 of 1

OK | Cancel

Drop Distribution

	Average Diameter (µm)	Incremental Volume Fraction	Cumulative Volume Fraction
1	10.77	0.0017	0.0017
2	16.73	0.0013	0.003
3	19.39	0.0017	0.0047
4	22.49	0.0027	0.0074
5	26.05	0.0043	0.0117
6	30.21	0.006	0.0177
7	35.01	0.007	0.0247
8	40.57	0.0077	0.0324
9	47.03	0.013	0.0454
10	54.5	0.0227	0.0681
11	63.16	0.0353	0.1034
12	73.23	0.0487	0.1521
13	84.85	0.059	0.2111
14	98.12	0.0717	0.2828

Insert | Delete | Clear

$D_{V0.5}$: 137.21 µm Relative Span: 1.27

CP Nozzles

- http://www.cpproductsinc.com/dropletcalc.htm
- http://www.cpproductsinc.com/dropletcalc2.htm

THE CP PRODUCTS® COMPANY, INC.

APPLICATION PARAMATERS FOR CP NOZZLES

ASAE AA97-006
I. W. Kirk, ARS, USDA, College Station, Texas

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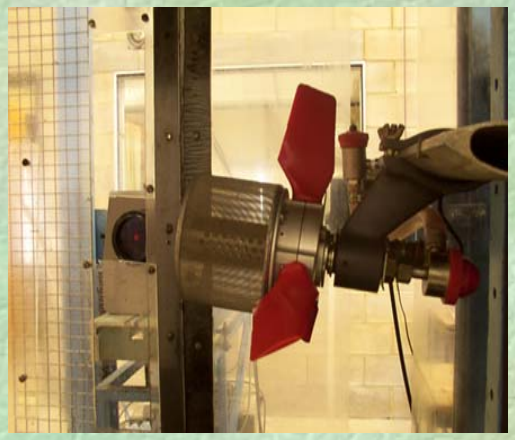
ASAE, 2950 Niles Rd., St. Joseph, MI 49085-9659 USA
Voice: 616.429.0300 FAX: 616.429.3852

Directions: Enter CP nozzle parameters, pressure, and airspeed in the fields below.

	Orifice Size, Inches	Deflector Angle, Degrees	Pressure, PSI	Airspeed, MPH
Acceptable Range:	.061 to .171	30 to 90	20 to 60	100 to 160

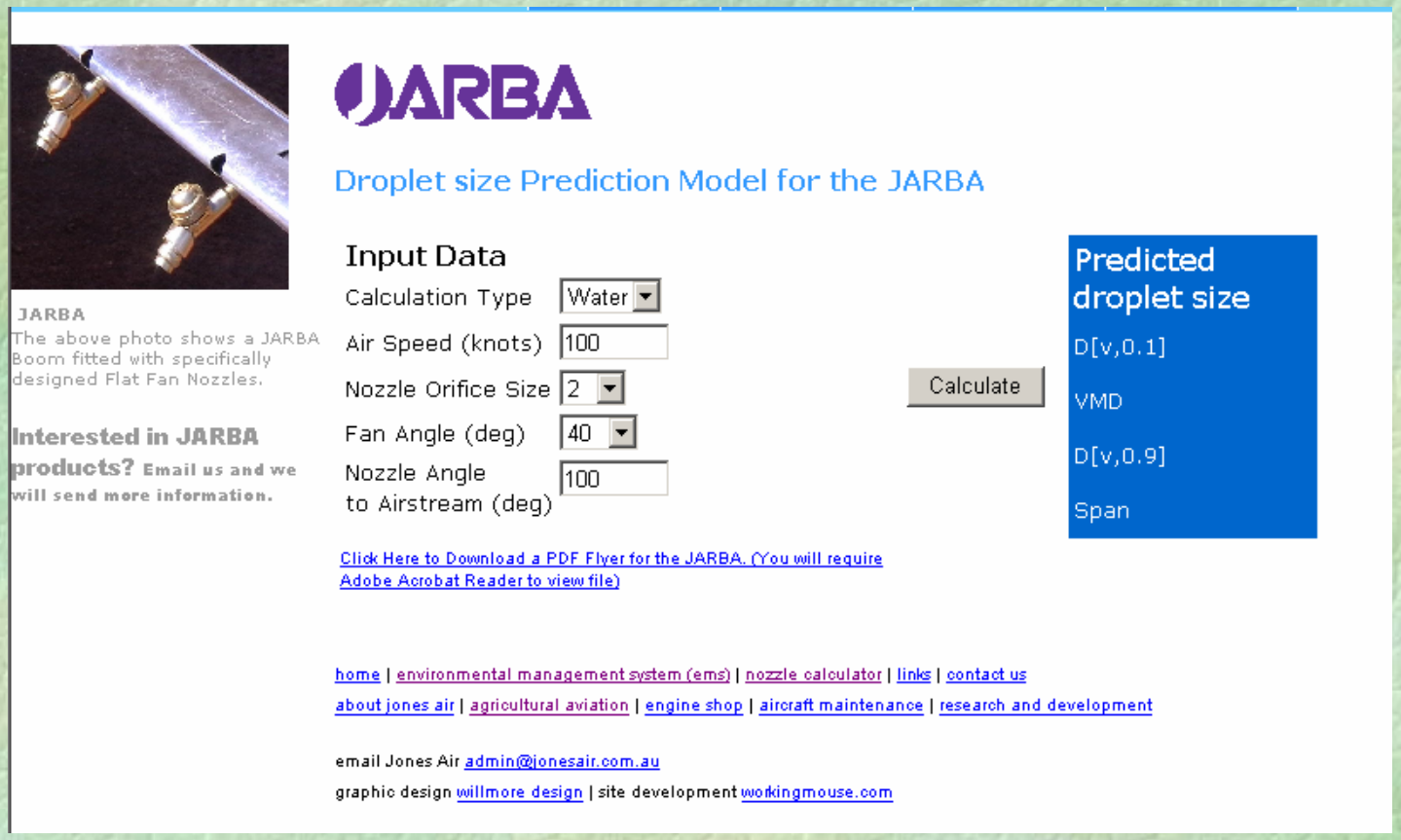
UQ Atomization Models

- Wind tunnel data being used to develop increasing range of atomization models compatible with other droplet size data from SDTF etc (Malvern, same wind tunnel, etc)
- Extensive rotary atomizer and active tank mix/ adjuvant modeling



JARBA Rotating Boom

- http://www.jonesair.com.au/Nozzlecalc
- Only system currently offering means to control droplet size in-flight to insure meeting label requirements as conditions change



Unimiser Rotary Screen Atomizer

Cotton Research & Development

Unispray Pty Ltd.

Droplet Size Prediction Model for the UNIMISER Nozzle

Results Based on Water

Input data	
Air Speed (knots)	75
Flowrate (L/min/nozzle)	10
Wet Nozzle Rotational Speed (rpm)	4800

Predicted droplet size	
D[v,0.1]	158
VMD	240
D[v,0.9]	350
Span	0.80
Spray Quality	Medium

The University of Queensland

The Centre for Pesticide Application and Safety

".....for a safer environment"

Micronair Rotary Cage Atomizers

MICRONAIR

AU5000 ATOMISER
Droplet Size Prediction Model

THE UNIVERSITY OF QUEENSLAND

The Centre for Pesticide Application and Safety
"...for a safer environment"

Formulation	ULV	
Air speed	100	MPH
Flow rate per atomiser	2	US gal/min
Is RPM transducer fitted?	No	
Blade angle	45	degrees
Blade type	EX6353 Short	
Atomiser rotational speed (spraying)	4,252	RPM

Predicted droplet size (µm)	
D[v,0.1]	25
VMD	84
D[v,0.9]	77
Span	0.61
Spray quality	Very Fine

Select options in yellow cells

Enter data in grey cells

ASC Rotary Drum Atomizers

Droplet Size Prediction Model for the ASC A-10 Nozzle

CURTIS DYNA-FOG Ltd
Innovators of Spraying and Fogging Technology Since 1947

	Input data
Formulation	Water
Air Speed (knots)	120
Flowrate (L/min/nozzle)	8
Blade setting	4
Dry Nozzle Rotational Speed (rpm)	5022

Predicted droplet size	
D[v,0.1]	54
VMD	140
D[v,0.9]	234
Span	1.28
Spray Quality	Fine

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AgDBAIS: Drift Mitigation Database

- Thanks to numerous database owners
- BBA
- AAFC
- IMAG
- (SDTF)
- (UK)
- ECPA funding

Co-Operators

- Drift study databases from North America, Europe, Australia, New Zealand
- AgDBAIS named after the main databases for initial work: DEFRA (UK), BBA (Germany), AAFC (Canada), IMAG (Netherlands), SDTF (US)

Input Fields for Database Search Variables

agDBAIS

Home
Search Trials
Contributors
Contact Us

Application Method: -all- Sprayer Type: -all- Atomizer: -all-

Pressure: to (bar) Application Volume: to (L/ha)

Boom Height: to (cm) Travel Speed: to (km/h)

Surface cover/crop: -all- Barrier: -all- Topography: -all-

Windspeed: to (km/h) Temperature: to (C°)

Relative Humidity: to (%) Atmospheric Stability: -all-

Adjuvant: -all- Active Ingredients: -all- Carrier: -all-

Distance Off-swath: in progres to in progres (m) Drift: in progres to in progres (%of emitted)

Search

Details/Export

Conduct Search and Reveal Matching Studies

agDBAIS

Home
Search Trials
Contributors
Contact Us

Application Method: -all- Sprayer Type: -all- Atomizer: Air Induced Flat Fan

Pressure: to (bar) Application Volume: to (L/ha)

Boom Height: to (cm) Travel Speed: to (km/h)

Surface cover/crop: -all- Barrier: -all- Topography: -all-

Windspeed: to (km/h) Temperature: to (C°)

Relative Humidity: to (%) Atmospheric Stability: -all-

Adjuvant: -all- Active Ingredients: -all- Carrier: -all-

Distance Off-swath: in progres to in progres (m) Drift: in progres to in progres (%of emitted)

Search

```
na na - BBA <> Experiment ID: Trial ID:84F0925S
na na - BBA <> Experiment ID: Trial ID:84F1039S
na na - BBA <> Experiment ID: Trial ID:94F0922S
na na - BBA <> Experiment ID: Trial ID:94F1030S
na na - BBA <> Experiment ID: Trial ID:94F1128S
na na - BBA <> Experiment ID: Trial ID:94F4020H
na na - BBA <> Experiment ID: Trial ID:94F4120H
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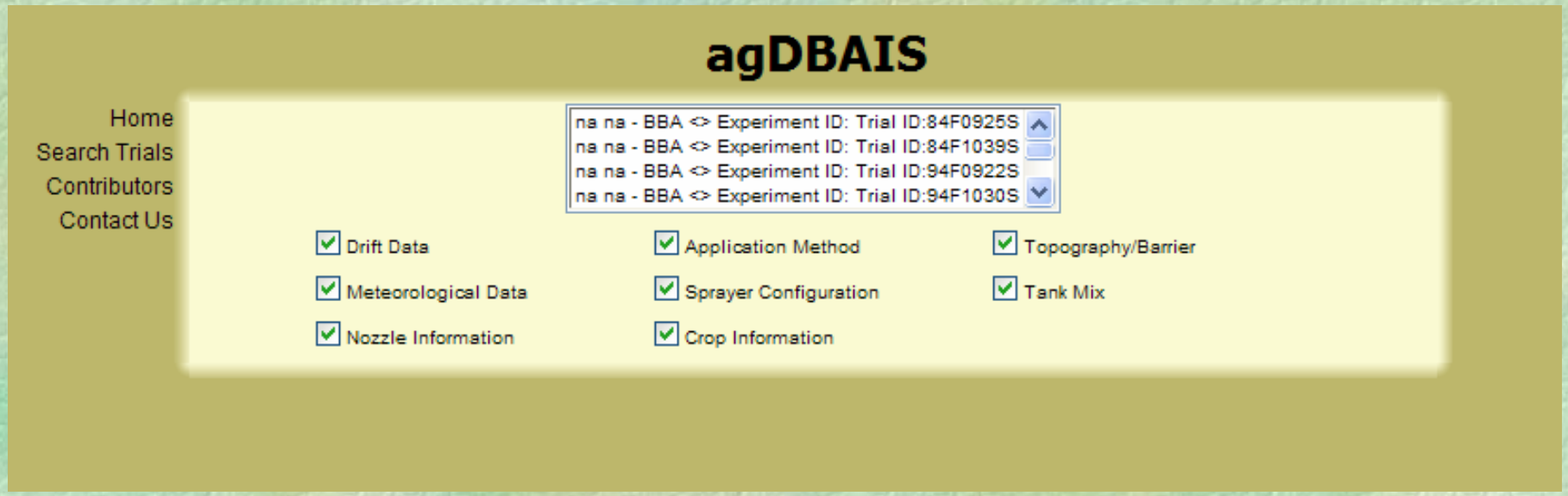
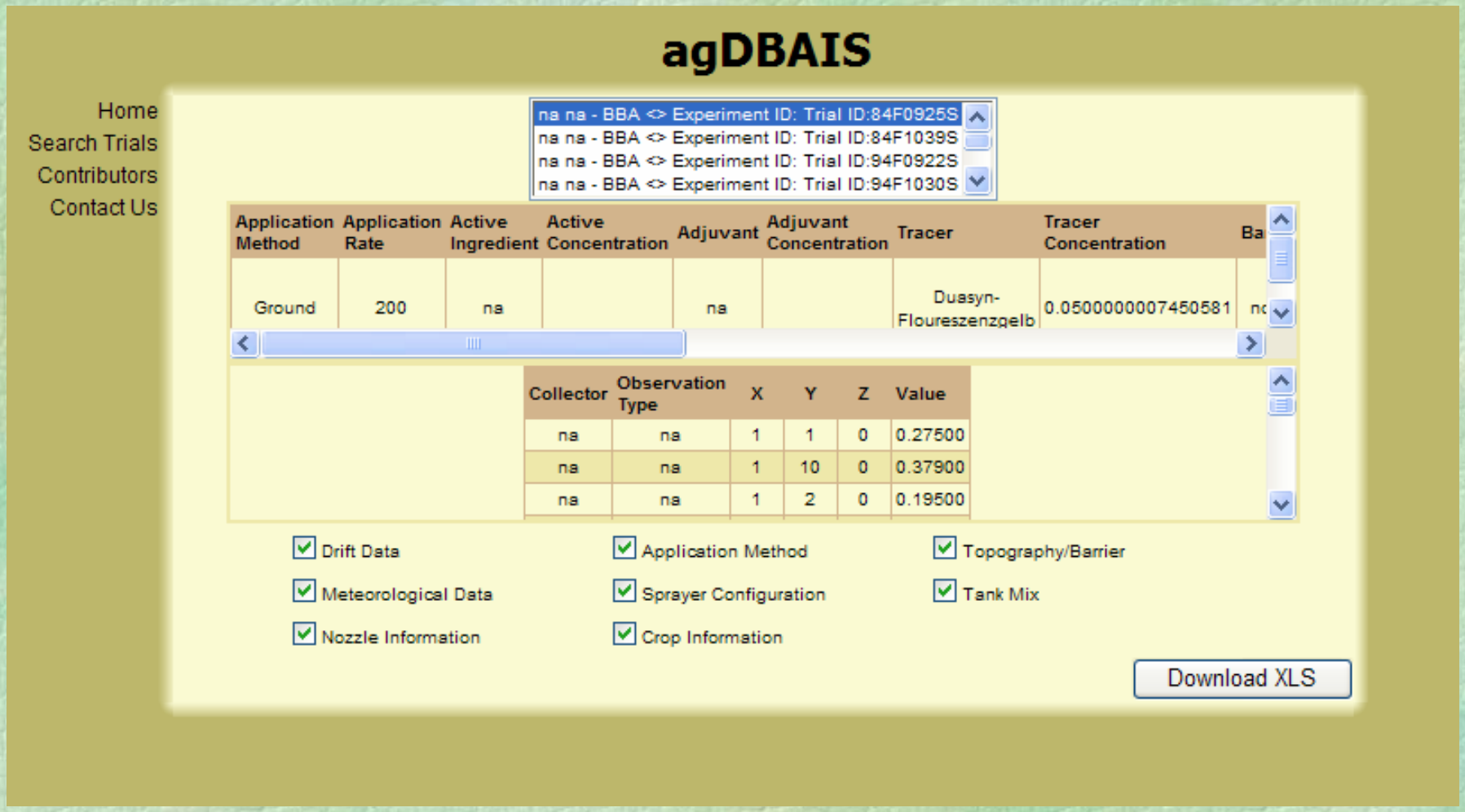
Details/Export

Select Data Fields to Export



Export Data to EXCEL® File



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
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2	na	84F0925S	Ground	200	na	0	na	0	Duasyn-Floureszenzgelb	0.050000001	none	level	Holder	ES3	0	7.8	3
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4	na	84F0925S	Ground	200	na	0	na	0	Duasyn-Floureszenzgelb	0.050000001	none	level	Holder	ES3	0	7.8	3
5	na	84F0925S	Ground	200	na	0	na	0	Duasyn-Floureszenzgelb	0.050000001	none	level	Holder	ES3	0	7.8	3
6	na	84F0925S	Ground	200	na	0	na	0	Duasyn-Floureszenzgelb	0.050000001	none	level	Holder	ES3	0	7.8	3
7	na	84F0925S	Ground	200	na	0	na	0	Duasyn-Floureszenzgelb	0.050000001	none	level	Holder	ES3	0	7.8	3
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32	na	84F0925S	Ground	200	na	0	na	0	Duasyn-Floureszenzgelb	0.050000001	none	level	Holder	ES3	0	7.8	3

Sheet1 / Sheet2 / Sheet3

	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	Boom Width	Boom Height	Crop	Crop Height	Crop Stage	Wind Speed	Temp.	Relative Humidity	Atmospheric Stability	Nozzle Type	Nozzle Model	Collector	Observation Type	X	Y	Z	Value
2	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	1	0	0.275
3	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	10	0	0.379
4	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	2	0	0.195
5	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	3	0	0.217
6	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	4	0	0.154
7	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	5	0	0.136
8	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	6	0	0.102
9	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	7	0	0.16
10	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	8	0	0.164
11	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	1	9	0	0.314
12	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	3	1	0	0.101
13	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	3	10	0	0.1
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20	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	3	8	0	0.111
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27	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	5	5	0	0.026
28	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	5	6	0	0.052
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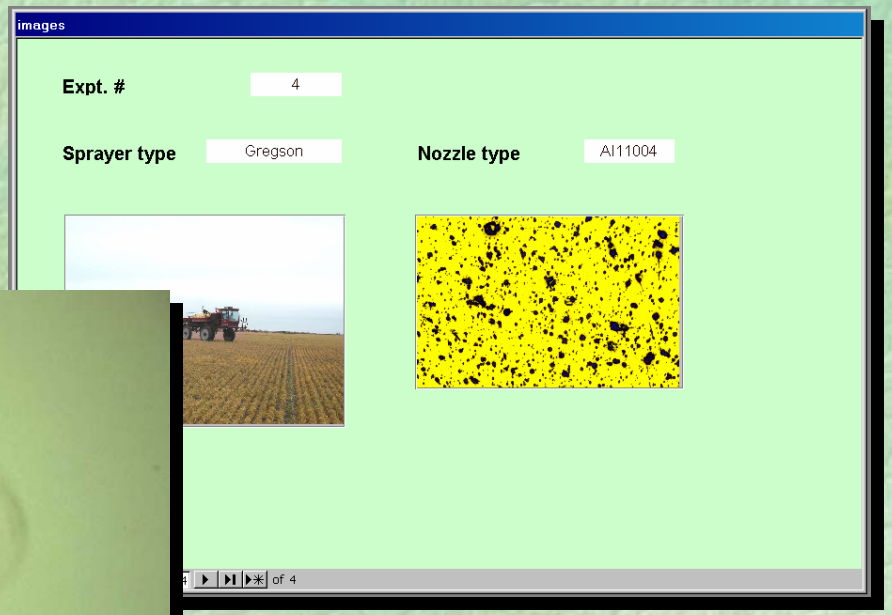
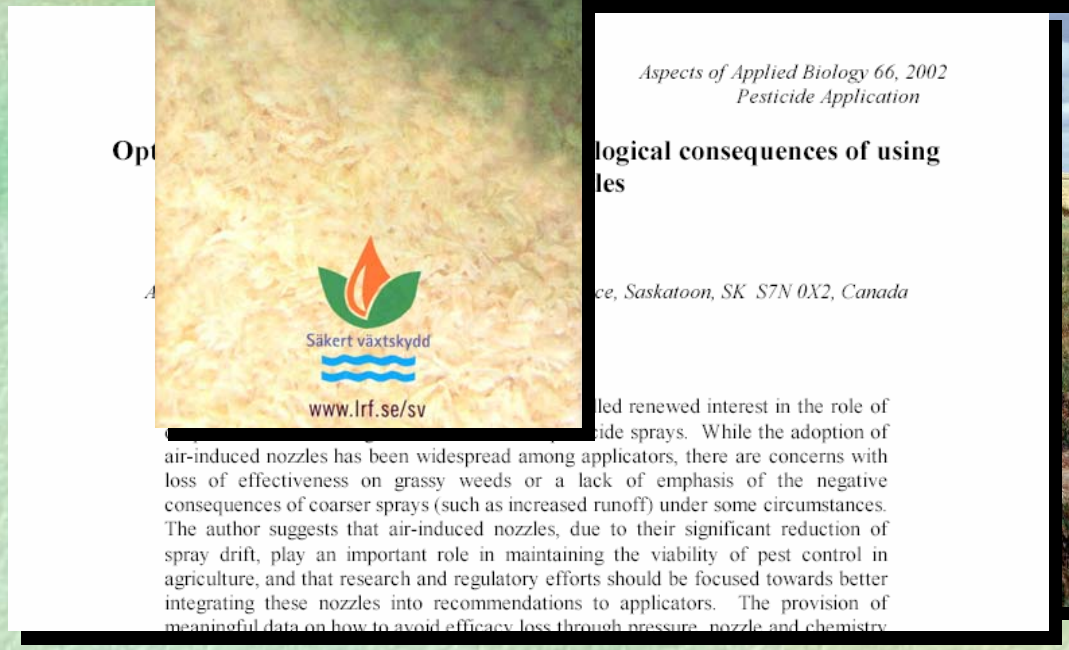
32	10	50	meadow	5	0	2.6	17.275	52.5	0	Air Induced Flat Fan	ID120-03	na	na	10	1	0	0.013

Sheet1 / Sheet2 / Sheet3





Aspects of Applied Biology 66, 2002
Pesticide Application

Opt **logical consequences of using les**

A ce, Saskatoon, SK S7N 0X2, Canada

led renewed interest in the role of ide sprays. While the adoption of air-induced nozzles has been widespread among applicators, there are concerns with loss of effectiveness on grassy weeds or a lack of emphasis of the negative consequences of coarser sprays (such as increased runoff) under some circumstances. The author suggests that air-induced nozzles, due to their significant reduction of spray drift, play an important role in maintaining the viability of pest control in agriculture, and that research and regulatory efforts should be focused towards better integrating these nozzles into recommendations to applicators. The provision of meaningful data on how to avoid efficacy loss through pressure, nozzle and chemistry

Drift Models

- AGDISP and AgDRIFT similar, and yield same result for same inputs
- AGDISP includes some useful features not included in AgDRIFT (but does not include ground and orchard applications), plus 101 more aircraft types, dry materials, sloping terrain, predictive ground model, plans for hedgerow/ buffer interception models
- Comparison conducted between models using AGDISP refinements such as Gaussian extension, atmospheric stability, etc to reduce far-field drift values and provide better fit to SDTF data (AgDRIFT over-predicts 4x at far-field)

Tier III AgDRIFT Agricultural

AgDRIFT - [*]

File Edit Tier View Run Toolbox Help

Title: Untitled

Aircraft: Aircraft — Type: Basic (Air Tractor AT-401)

Nozzles and DSD

Boom Height: 3.05 m

Flight Lines: 20

Swath

Swath Width Definition: Fixed Width

Swath Width: 18.29 m

Swath Displacement Definition: Fraction of Swath Width

Fraction: 0.6506

Half Boom Effect

Spray Material: Material — Type: Basic (Water)

Meteorology

Wind Speed: 4.47 m/s

Wind Direction: -90 deg

Temperature: 30 deg C

Rel. Humidity: 50 %

Advanced Settings: Edit

Transport: Flux Plane: 0 m

Terrain: Surface Roughness: 0.0075 m

AgDRIFT®

Single Tier in AGDISP

AGDISP

File Edit View Run Toolbox Help

Title: Untitled

Aircraft: Aircraft — Air Tractor AT-401 (Library)

Release Height: 30.48 m

Flight Lines: 20 Reps

Application Technique

Liquid

Nozzles — 42 nozzles

DSD — ASAE Fine to Medium (Reference)

Dry

Details — Venturi Spreader

Spray Material: Material — Water (Reference)

Meteorology

Wind Speed: 2.24 m/s

Wind Direction: -90 deg

Temperature: 18.33 deg C

Rel. Humidity: 50 %

Atmospheric Stability: Stability — Overcast

Canopy: Canopy (Height)

Canopy Roughness: 2.99 m

Canopy Displacement: 14.94 m

Terrain

Surface Roughness: 0.0075 m

Show Cover Types

Upslope Angle: 0 deg

Sideslope Angle: 0 deg

Transport: Flux Plane Distance: 0 m

Advanced Settings: Advanced

Swath

Swath Width: 18.29 m

Swath Displacement: 0 m

AGDISP

Dry Delivery Details

Particle Distribution Name

ASAE Fine to Medium

Material Property

Particle Sphericity: 1

Application Type

- (•) Venturi Spreader
  - Exit Width: 4 m
  - Edge Angle: 30 deg
  - Exit Speed: 10 m/s
- ( ) Radial Spreader
  - Disc Radius: 0.35 m
  - Rotation Rate: 500 rpm
- ( ) Bucket Spreader
  - Swing Distance: 6 m

Spreader Location

Vertical: -0.3505 m

Forward: -0.254 m

Values may be changed via Aircraft

Equivalent Particle Distribution

	Average Diameter (µm)	Incremental Volume Fraction	Cumulative Volume Fraction
1	10.77	0.001	0.001
2	16.73	0.0003	0.0013
3	19.39	0.0007	0.002
4	22.49	0.0003	0.0023
5	26.05	0.0007	0.003
6	30.21	0.001	0.004
7	35.01	0.001	0.005
8	40.57	0.002	0.007
9	47.03	0.0033	0.0103
10	54.5	0.0053	0.0156
11	63.16	0.0067	0.0223
12	73.23	0.009	0.0313
13	84.85	0.0133	0.0446
14	98.12	0.0223	0.0669

Insert | Delete | Clear | Import

$D_{V0.5}$: 254.72 µm Relative Span: 1.3

OK | Cancel

Gaussian Far-Field Extension

Handoff Options
- (•) Automatic
- ( ) Specified at [ ] m

Spray Line Length Options
- (•) Infinite
- ( ) Specified at [ ] m

Surface Layer Mixing Height Options
- (•) Automatic
- ( ) Specified at [ ] m

Deposition Assessment | Plot | Export | Calc | Close

Upslope Angle: 0 deg
Sideslope Angle: 0 deg

Atmospheric Stability

- ( ) Day (1 hr after sunrise to sunset)
  - Solar Insolation: Strong
- (•) Night (sunset to 1 hr after sunrise)
  - Cloud Cover: Overcast

OK | Cancel

Canopy

Canopy Name
GENERIC CONIFER

Canopy Type
( ) None ( ) Height ( ) Story (•) Optical

Optical Canopy Properties
(•) Library: GENERIC CONIFER

			Library Defaults
Height:	24.32	m	30.4
LAI:	2.57		7.2

<-

( ) User-Defined

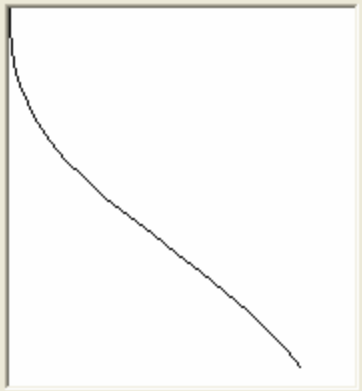
Leaf Area Index Envelope

	Tree Height (m)	Cumulative LAI
1		
2		
3		
4		
5		
6		

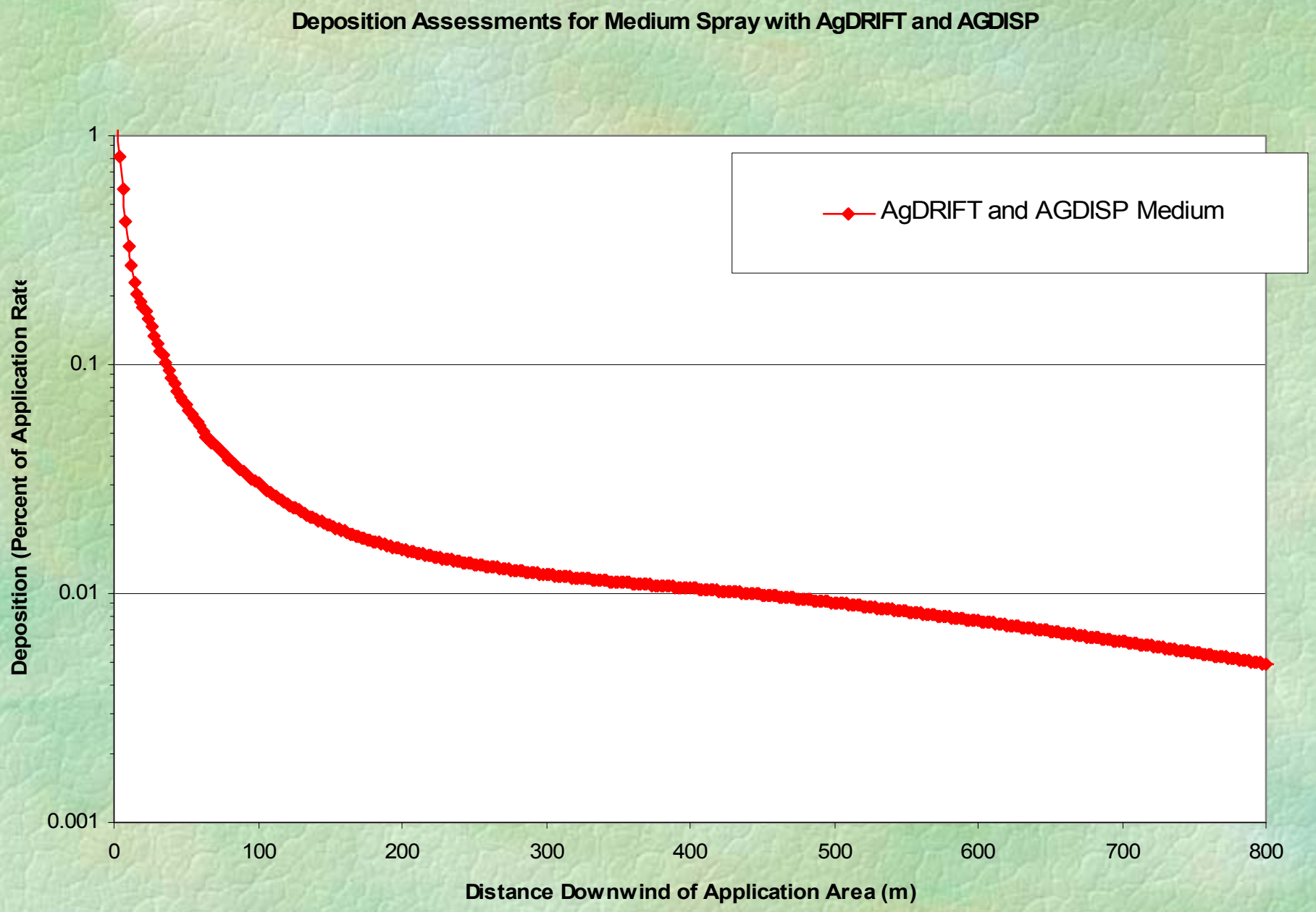
Insert | Delete | Clear

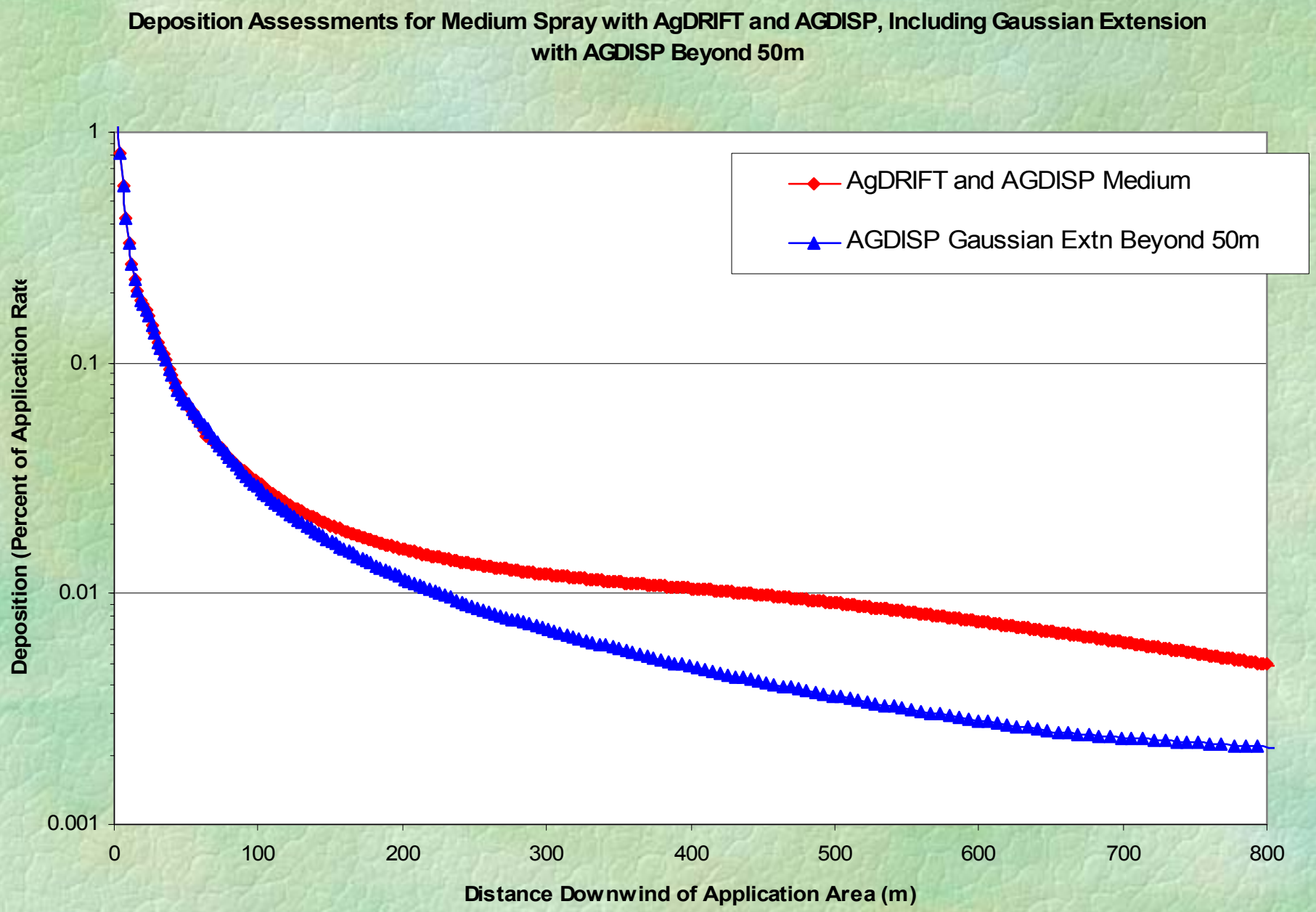
Properties
- Element Size: 2 cm
- Element Type: Flat Plate
- Temperature: 18.33 deg C
- Relative Humidity: 50 %

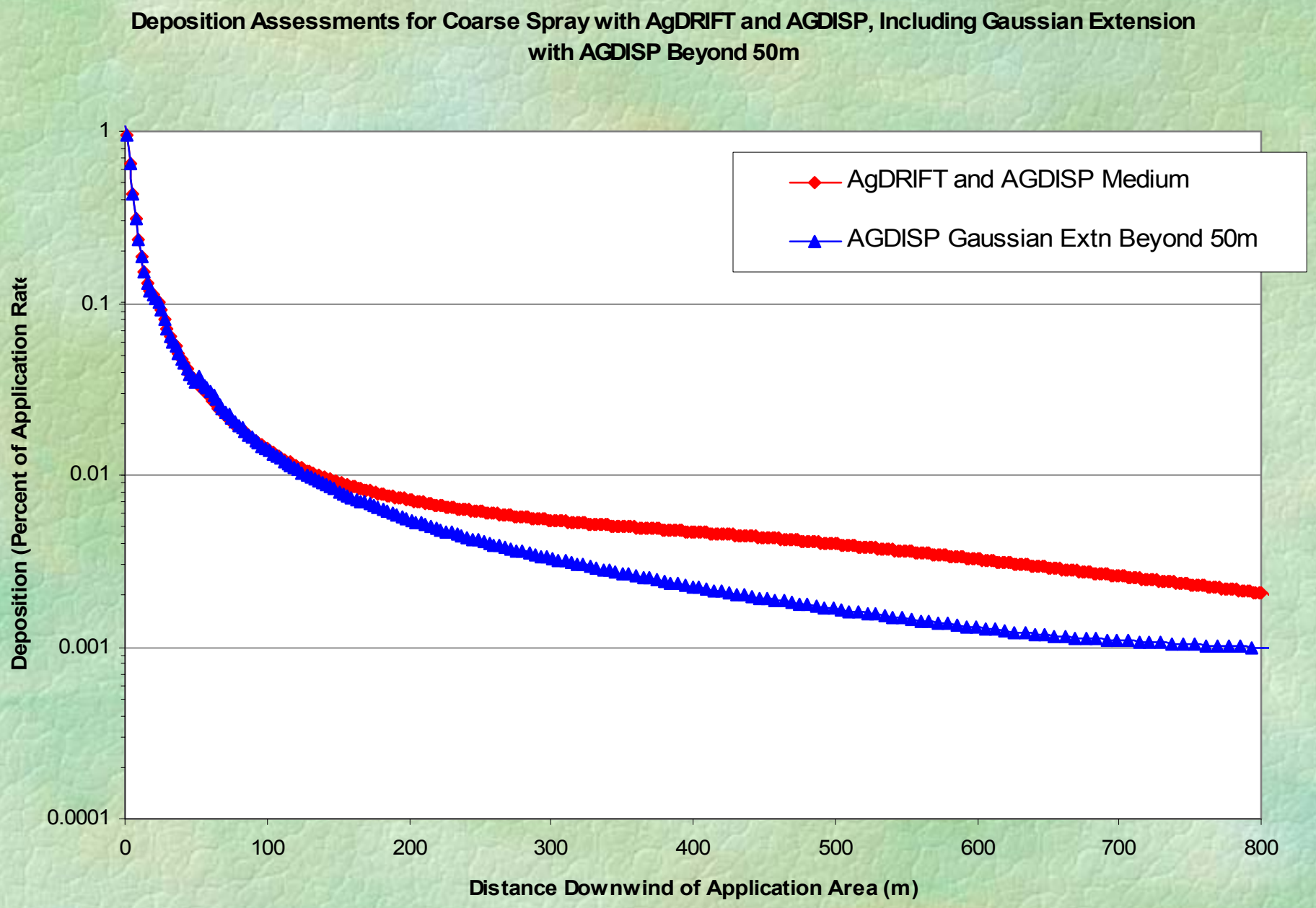
Preview

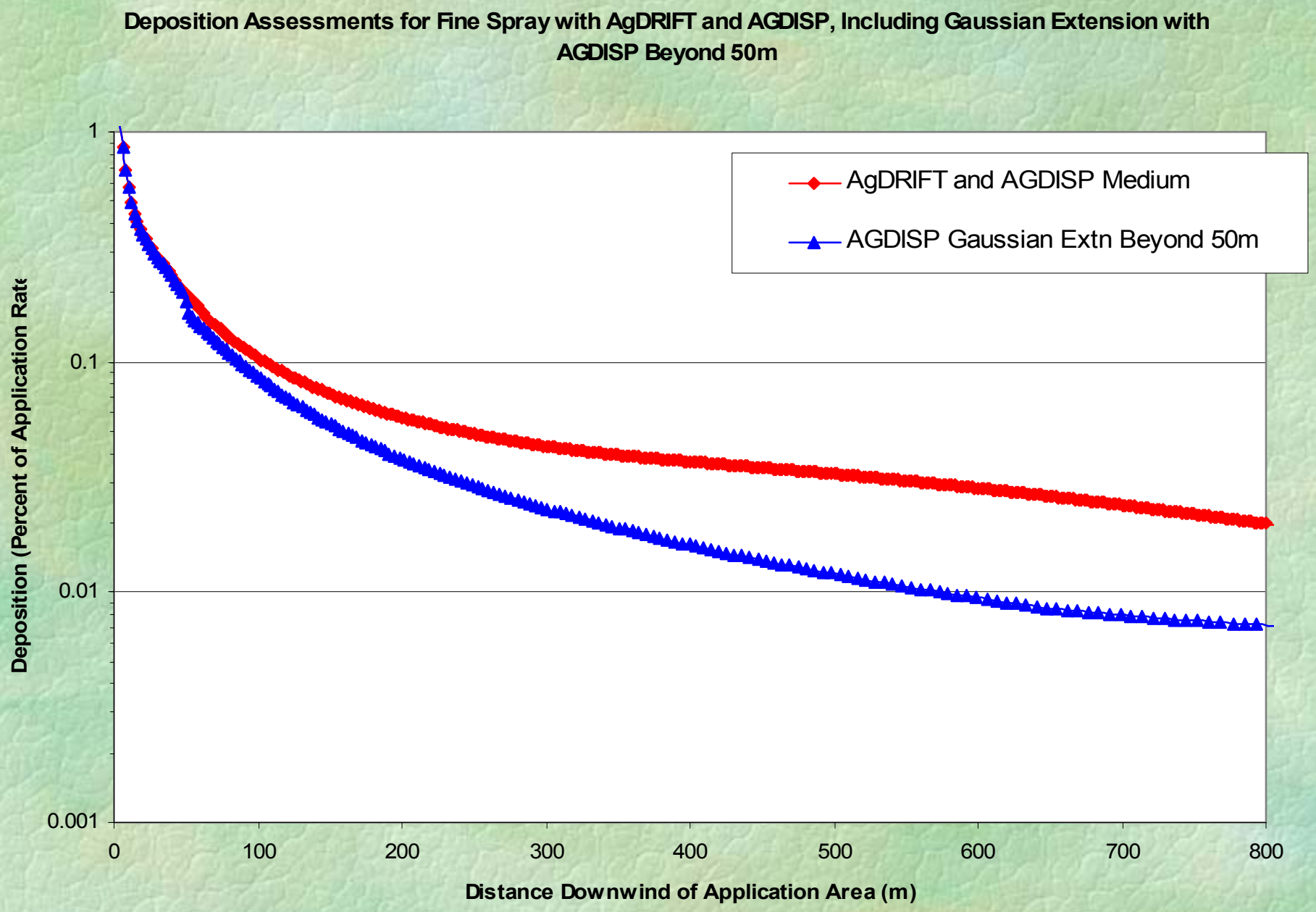


OK | Cancel


Deposition Assessments for Medium Spray with AgDRIFT and AGDISP
AgDRIFT and AGDISP Medium
Deposition (Percent of Application Rate
1
0.1
0.01
0.001
0
100
200
300
400
500
600
700
800
Distance Downwind of Application Area (m)


Deposition Assessments for Medium Spray with AgDRIFT and AGDISP, Including Gaussian Extension with AGDISP Beyond 50m
AgDRIFT and AGDISP Medium
AGDISP Gaussian Extn Beyond 50m
Deposition (Percent of Application Rate
1
0.1
0.01
0.001
0
100
200
300
400
500
600
700
800
Distance Downwind of Application Area (m)


Deposition Assessments for Coarse Spray with AgDRIFT and AGDISP, Including Gaussian Extension with AGDISP Beyond 50m
AgDRIFT and AGDISP Medium
AGDISP Gaussian Extn Beyond 50m
Deposition (Percent of Application Rate
1
0.1
0.01
0.001
0.0001
0
100
200
300
400
500
600
700
800
Distance Downwind of Application Area (m)


Deposition Assessments for Fine Spray with AgDRIFT and AGDISP, Including Gaussian Extension with AGDISP Beyond 50m
AgDRIFT and AGDISP Medium
AGDISP Gaussian Extn Beyond 50m
Deposition (Percent of Application Rate
1
0.1
0.01
0.001
0
100
200
300
400
500
600
700
800
Distance Downwind of Application Area (m)

Effect of Atmospheric Stability

- AGDISP default is “Overcast”, where “Strong” is often more common
- Spray deposition rates at 800m (g/ha):

	Overcast	**Strong**
Fine Spray	5.23	4.35
Medium Spray	1.38	1.10

Conclusions

- Many droplet size models available, and many under development
- Need to standardize outputs for input to AGDISP and other models
- Classification of droplet size spectra offers one solution to different measurement systems, but not perfect for all tank mixes, nor for some narrow droplet size spectra or sprays
- Discussions continue on future of AgDRIFT and AGDISP models, and need to maintain regulatory and research modeling tools as “evergreen”
- Please provide comments on modeling needs