Bayer

Stone Environmental

Evaluation of AGDISPpro for Simulating Spray Drift from Unmanned Aerial System

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Modeling Spray Drift from UAS

- Spray drift characterization is required by risk assessment for pesticide registration
- Regulatory models, such as AgDrift and AGDISP, are for conventional applications
- UAS is a unique application platform compared to aircrafts
- AGDISPpro, a mechanistic model, has been developed based on AGDISP and CHARM

AGDISPpro

AGDISPpro

CHARM

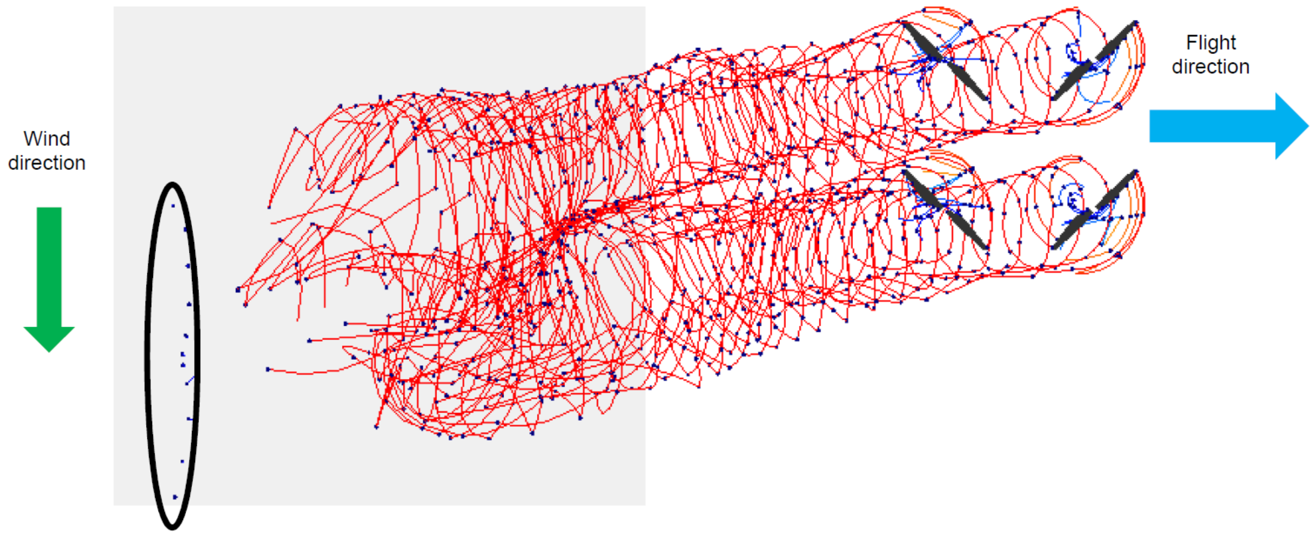
(Comprehensive Hierarchical Aeromechanics Rotorcraft Model)

- Develops the 3D velocity flow field, a library in AGDISPpro

AGDISP

(AGricultural DISPersal)

- Tracks the release of droplets through this field



Teske, M.E. et al. 2018, PREDICTION OF AERIAL SPRAY RELEASE FROM UAVS, Transaction of ASABE, Vol. 61(3): 909-918

Datasets used for AGDISPpro evaluations

Parameters	Dataset 1[a]	Dataset 2[b]	Dataset 3[c]	Dataset 4[d]	Dataset 5[d]
UAS type	PV 22	PV 35X	PV 35X	TTA M6E	TTA M8A
No. of rotors	4	6	6	6	8
No. of nozzles	4	6	4	4	6
Release height (m)	3	2 - 3	4.5	1.5	1.5
Spray quality	Medium; Extremely; Coarse	Fine; Ultra Coarse	Medium; Very Coarse; Extremely Coarse	Fine; Very Coarse	Fine; Very Coarse
Spray lines	1	4	1	3	3
Swath width (m)	1.5 to 4.1*	4.9	4 to 6*	2	3
Swath displacement (m)	0.5 to 1.8*	0	0 to 0.5*	0	0
No. of Samples collected for each spray	In-swath (n=15) off-target (n=33)	In-swath (n=7-19); off-target (n=27)	In-swath (n=17); off-target (n=19)	Off-target (n=5)	Off-target (n=5)

a: Martin 2021; b: Rice 2022; c: Bonds 2020; d: Herbst et al 2019;
*Calculated

AGDISPpro – UAS library

// Custom UAS library were developed

PV 22

Weight: 15 kg, Payload: 9 kg

PV 35X

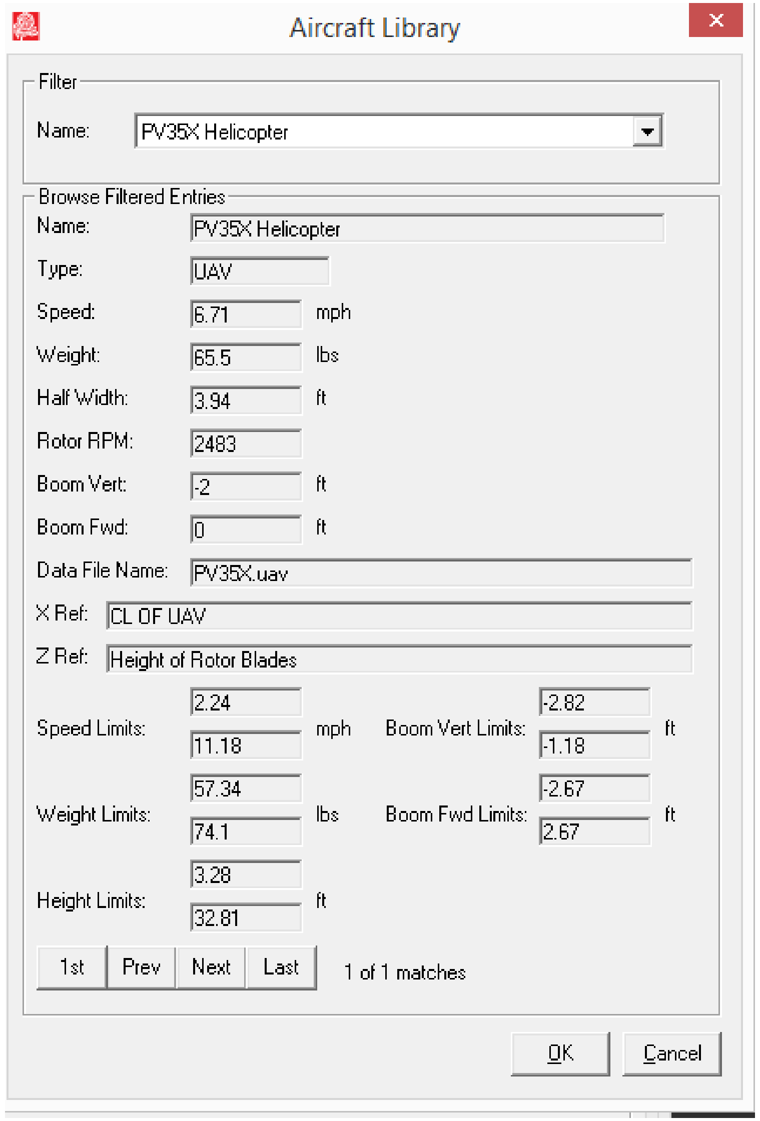
Weight: 22.2 kg, Payload: 11.3 kg

TTA6E*

Weight: 15.9 kg, Payload: 10 kg

TTA8A*

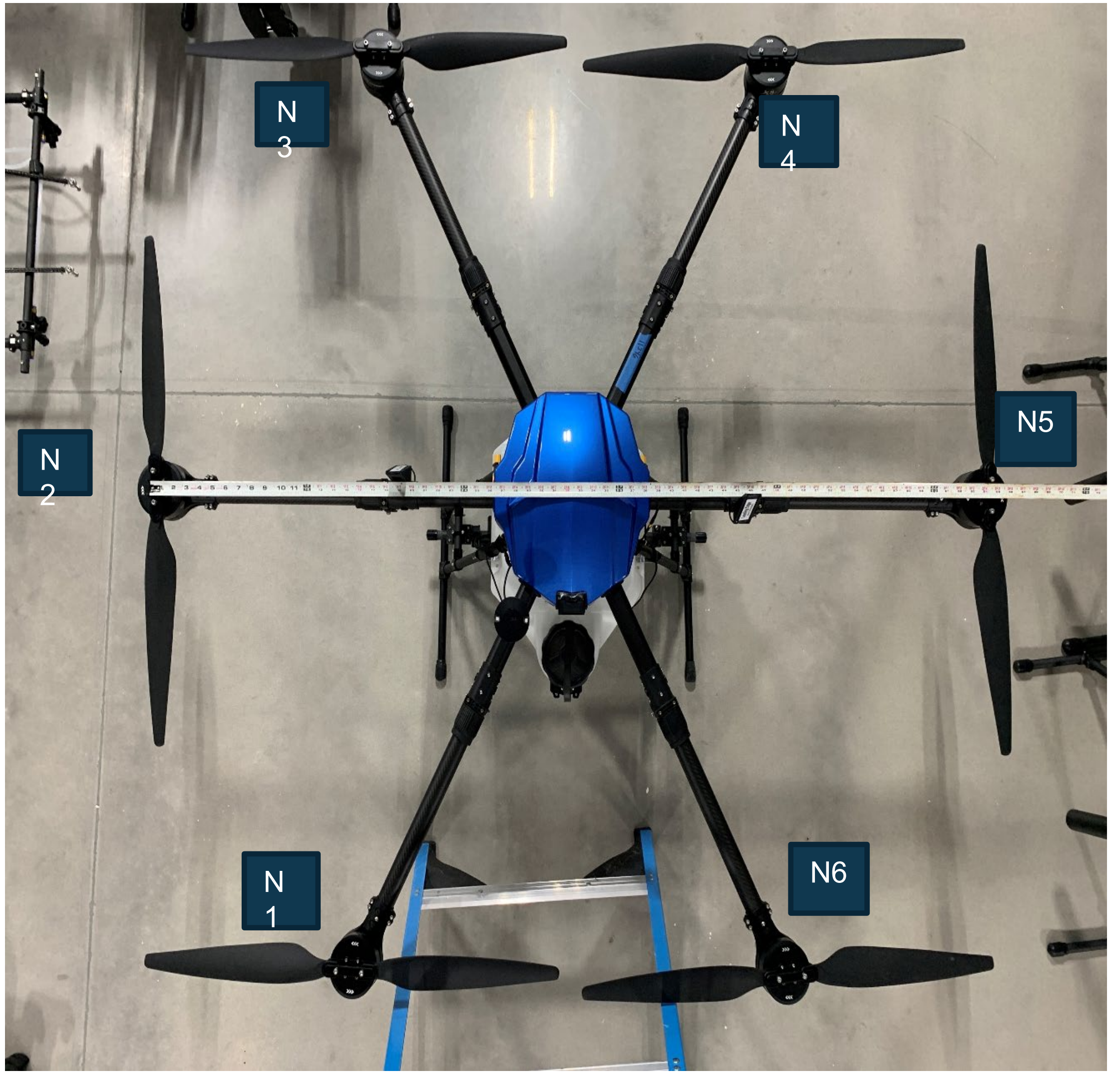
Weight: 22.1 kg, Payload: 23.9 kg



*Herbst 2018

Parameters for Modeling Customized UAS

- Aircraft layout
  - Number and location of wings, rotors, and propellers
  - Direction of rotation for rotors and propellers
- Geometry of each wing, rotor, and propeller
- Information about how the aircraft is controlled/trimmed
- Flight information: weight of the UAS+ payload, spraying height and application velocity



PrecisionVision 35X by Leading Edge

AGDISPpro Parameterization

Meteorology
- Wind speed
- Wind direction
- Temp.
- Rel. humidity

Application method
- UAS type
- Release height
- Spray line

Application technique
- Number of nozzles
- Droplet Size Distribution

Spray Material
- Spray volume
- Active and Nonvol. fraction

Swath
- Width
- Displace-ment

Field study

Field study or Calculated from field data

Statistical Analysis

- **The index of agreement (*r index*):** to evaluate agreement between modeled and the measured disposition, range 0-1

$$r = 1 - \frac{\Sigma(P_i - O_i)^2}{\Sigma(|P_i - O| + |O_i - O|)^2}$$

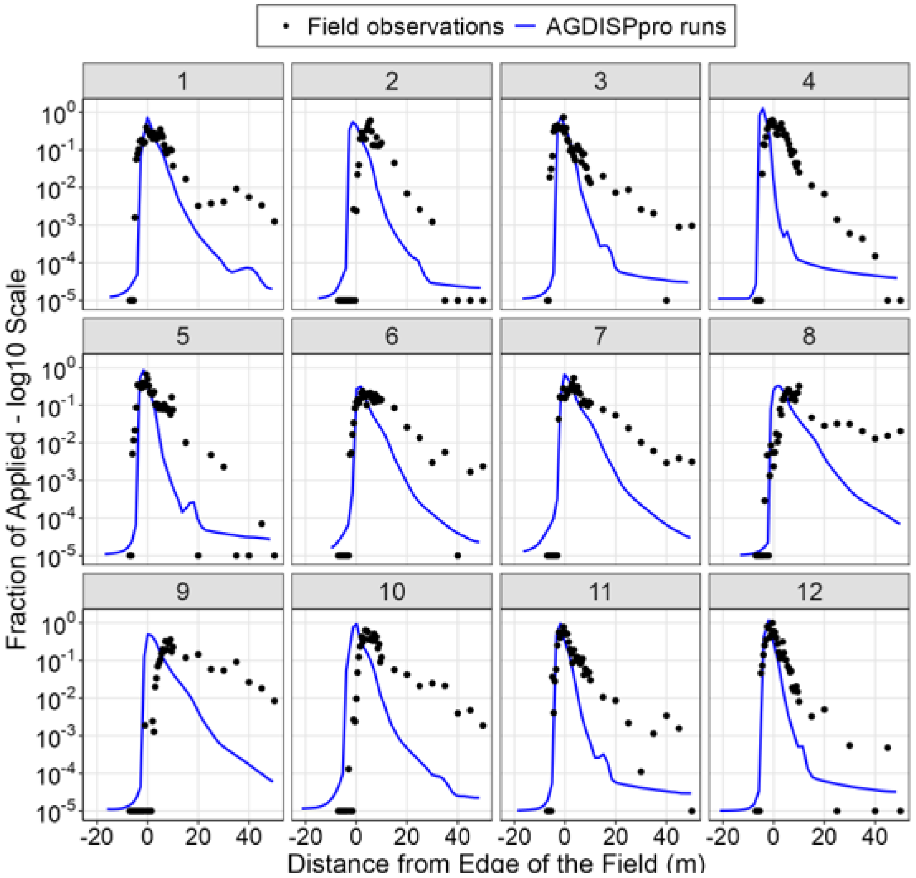
- **Mean bias error (*d*):** to assess whether the model was under predicting (a negative value) or overpredicting (a positive value)

$$d = \frac{\sum(P_i - O_i)}{n}$$

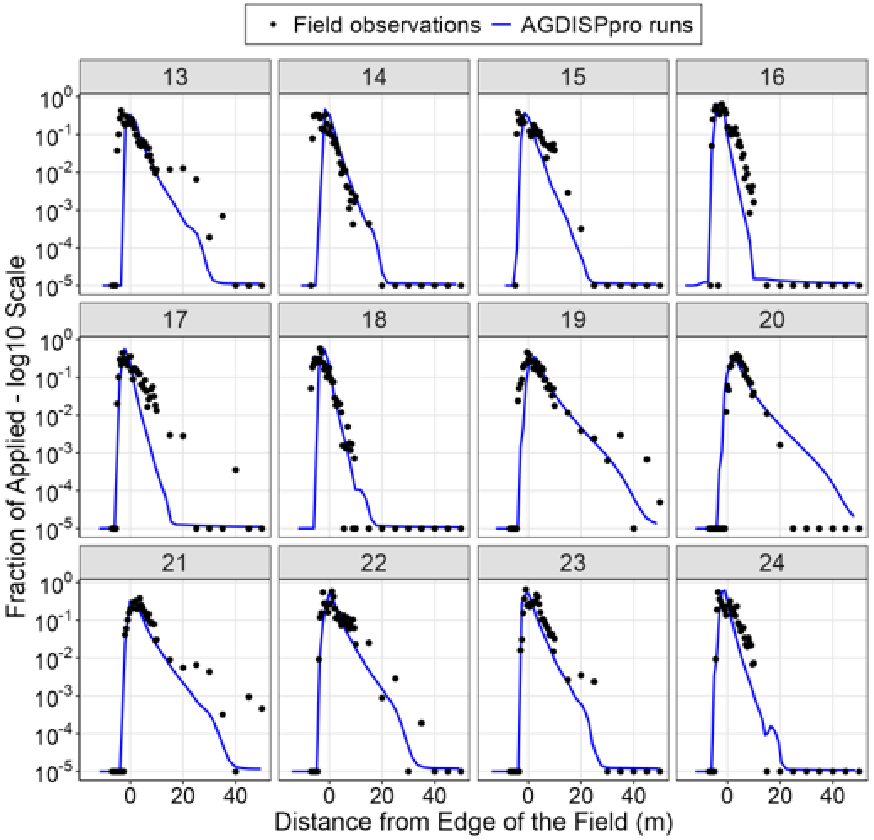
- **One sample t-test**: to evaluate the percent difference between the modeled and the measured total drift deposition.

Dataset 1 – Model Simulation v.s. Field Measurement

Medium DSD



Extremely Coarse DSD



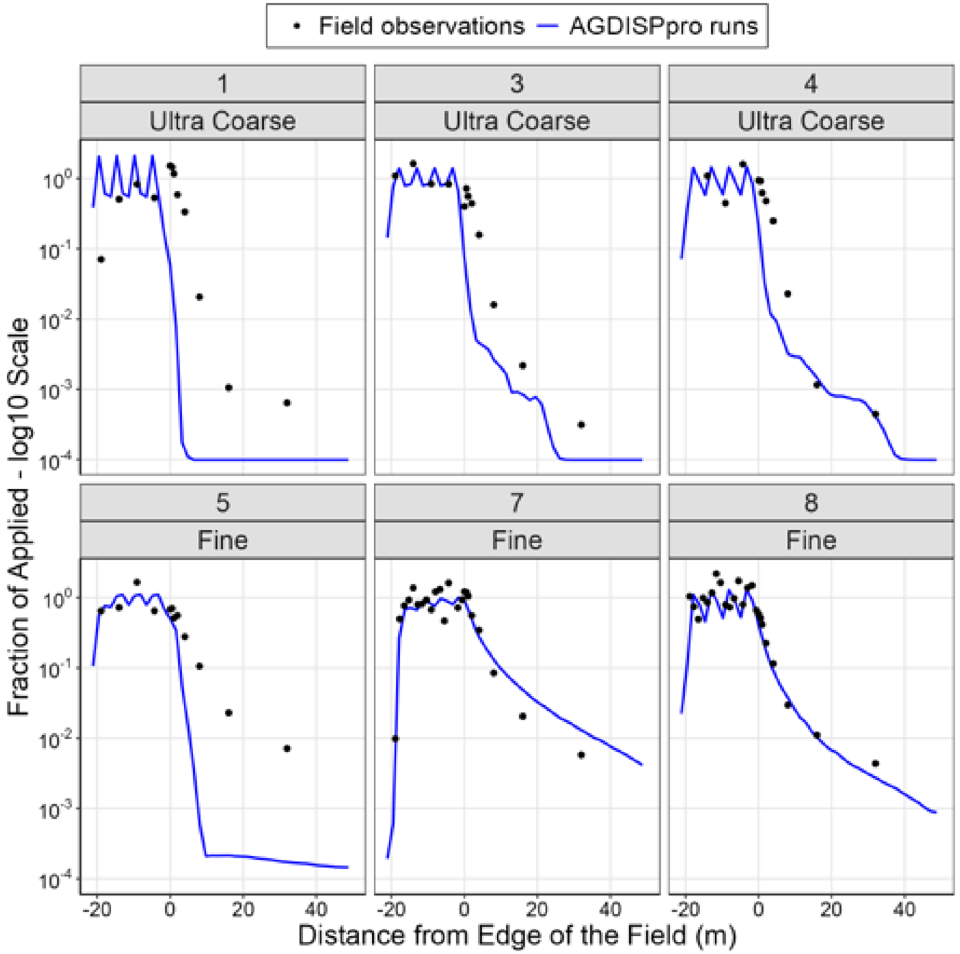
In-Field Deposition & Off-Target Drift		Off-Target Drift	
r index	*d*	r index	*d*
0.7	-0.003	0.7	-0.043

t test -significant difference

In-Field Deposition & Off-Target Drift		Off-Target Drift	
r index	*d*	r index	*d*
0.8	-0.010	0.9	-0.014

t test –no significant difference

Dataset 2 – Model Simulation v.s. Field Measurement



In-Field Deposition & Off-Target Drift		Off-Target Drift	
r index	*d*	r index	*d*
0.6	-0.18	0.5	-0.35

t test -significant difference

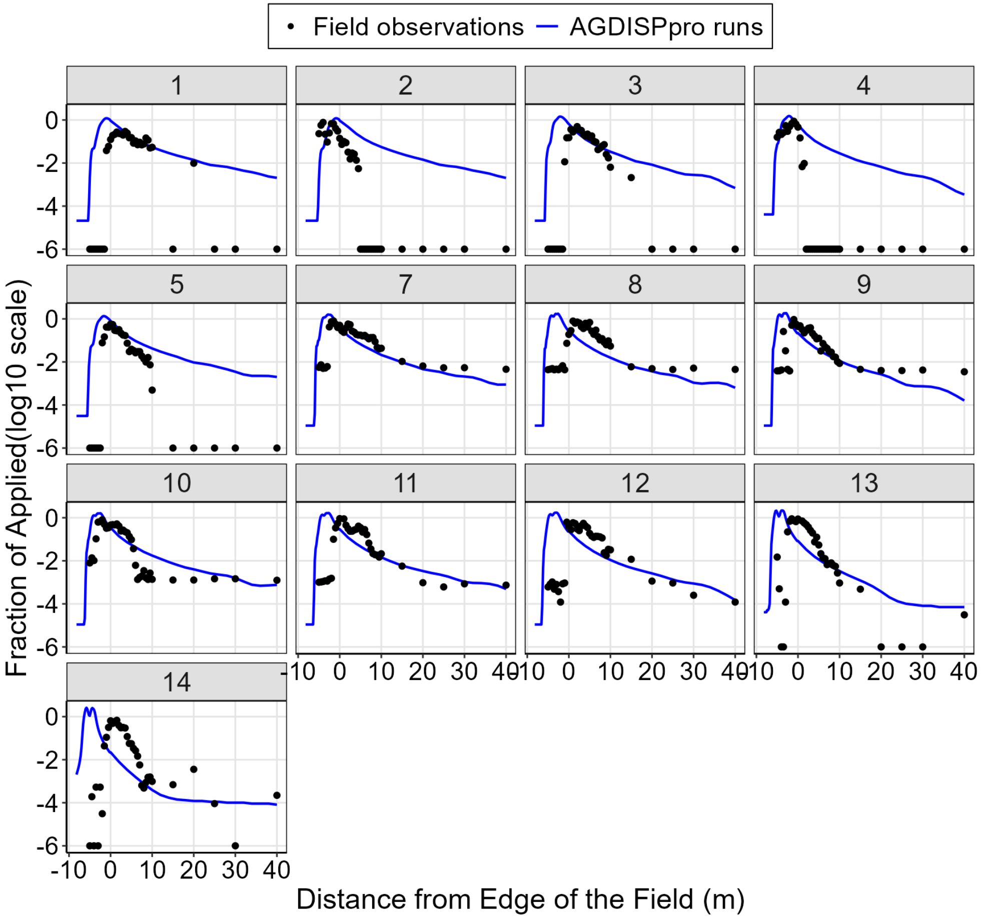
In-Field Deposition & Off-Target Drift		Off-Target Drift	
r index	*d*	r index	*d*
0.8	-0.14	0.9	-0.10

t test –no significant difference

Dataset 3 – Model Simulation v.s. Field Measurement

Medium DSD

Bonds2020-PV35X

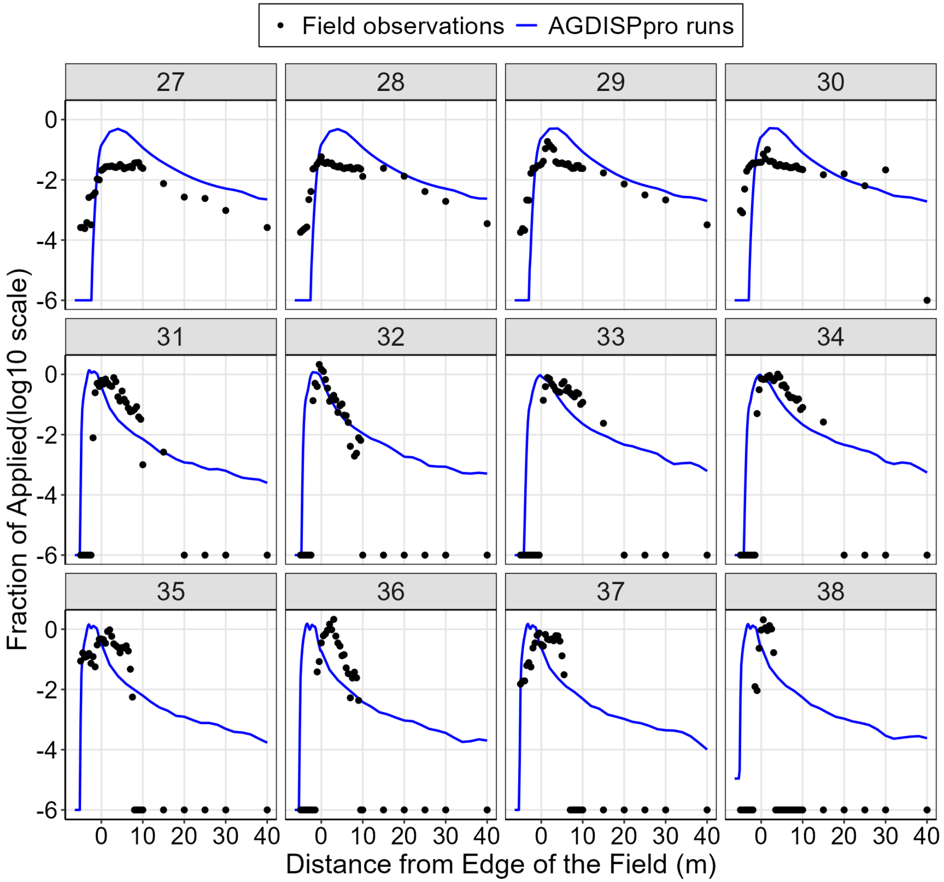


In-Field Deposition & Off-Target Drift		Off-Target Drift	
r index	*d*	r index	*d*
0.3	0.16	0.5	-0.04

t test –no significant difference

Very Coarse DSD

Bonds2020-PV35X

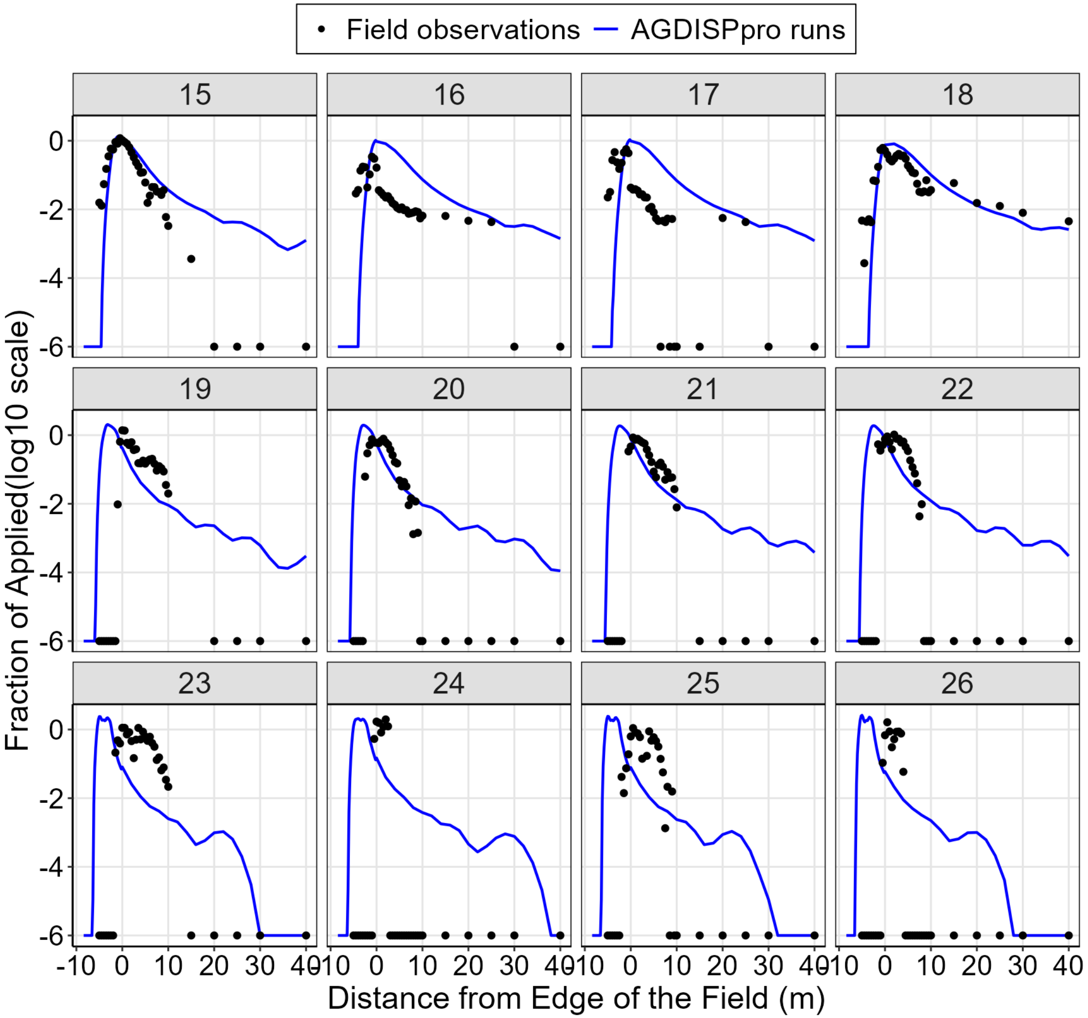


In-Field Deposition & Off-Target Drift		Off-Target Drift	
r index	*d*	r index	*d*
0.4	0.07	0.4	-0.04

t test –no significant difference

Dataset 3 – Model Simulation v.s. Field Measurement

Extremely Coarse DSD [Bonds2020-PV35X]



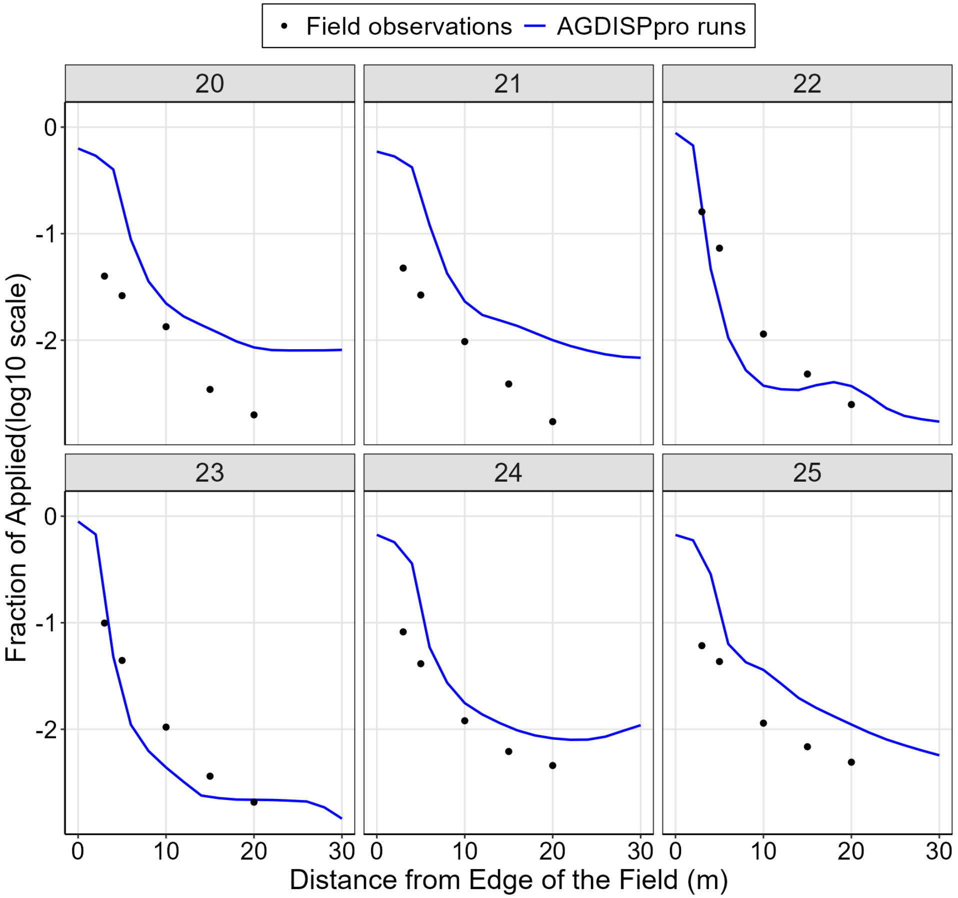
In-Field Deposition & Off-Target Drift		Off-Target Drift	
r index	*d*	r index	*d*
0.3	0.16	0.5	-0.06

t test –no significant difference

Dataset 4 – Model Simulation v.s. Field Measurement

Fine DSD

Herbst2018-M6E

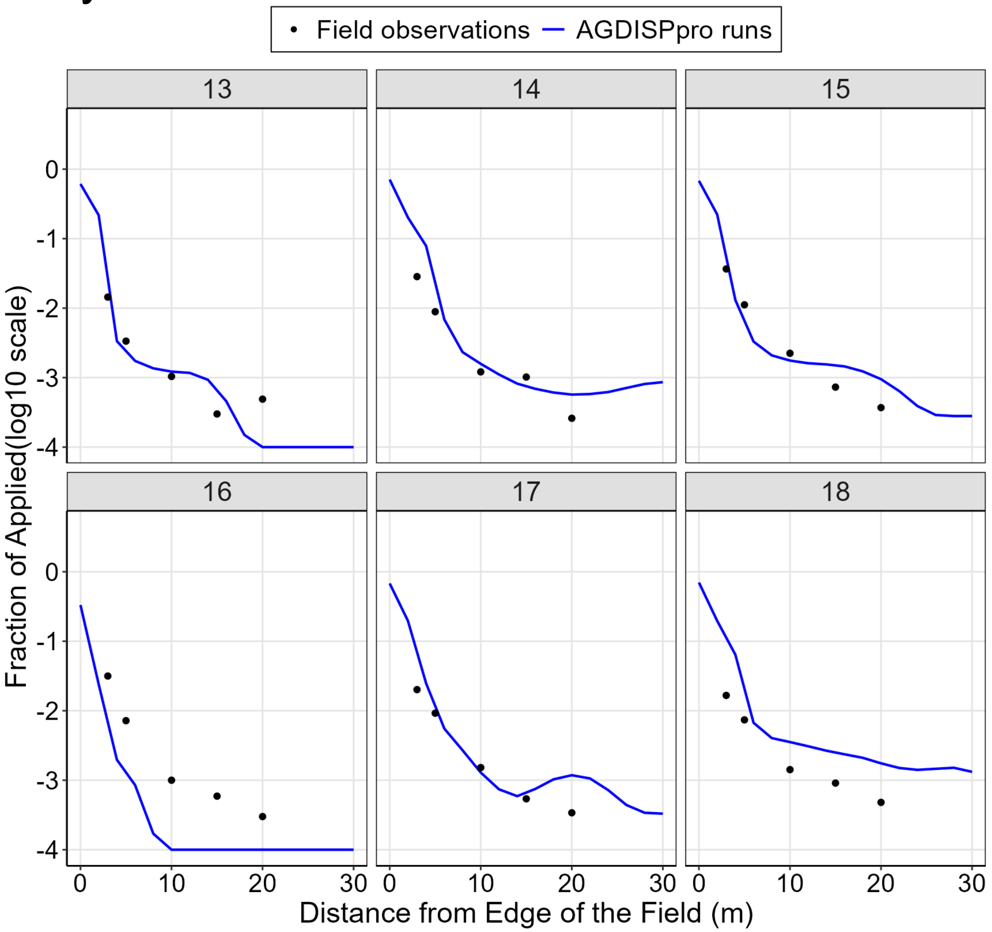


Off-Target Drift	
r index	*d*
0.4	0.10

t test –no significant difference

Very Coarse DSD

Herbst2018-M6E

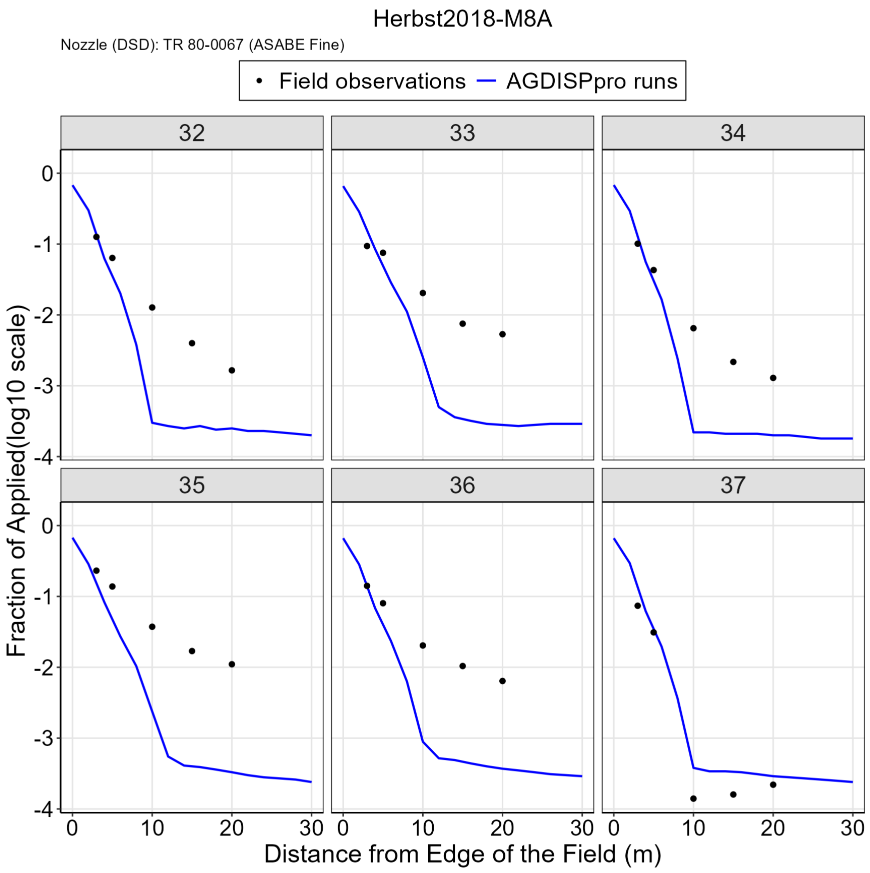


Off-Target Drift	
r index	*d*
0.4	0.02

t test –no significant difference

Dataset 5 – Model Simulation v.s. Field Measurement

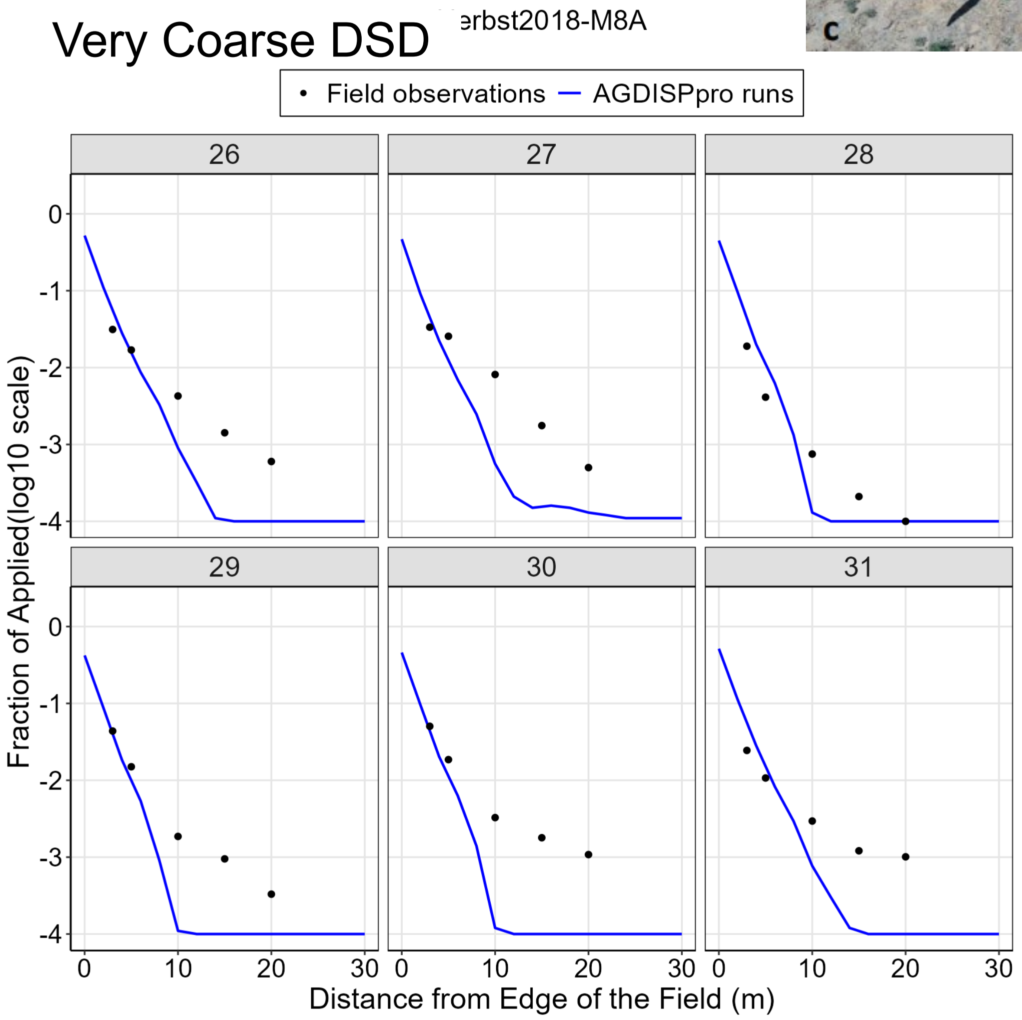
Fine DSD



Off-Target Drift	
r index	*d*
0.9	2E-04

t test –no significant difference

Very Coarse DSD

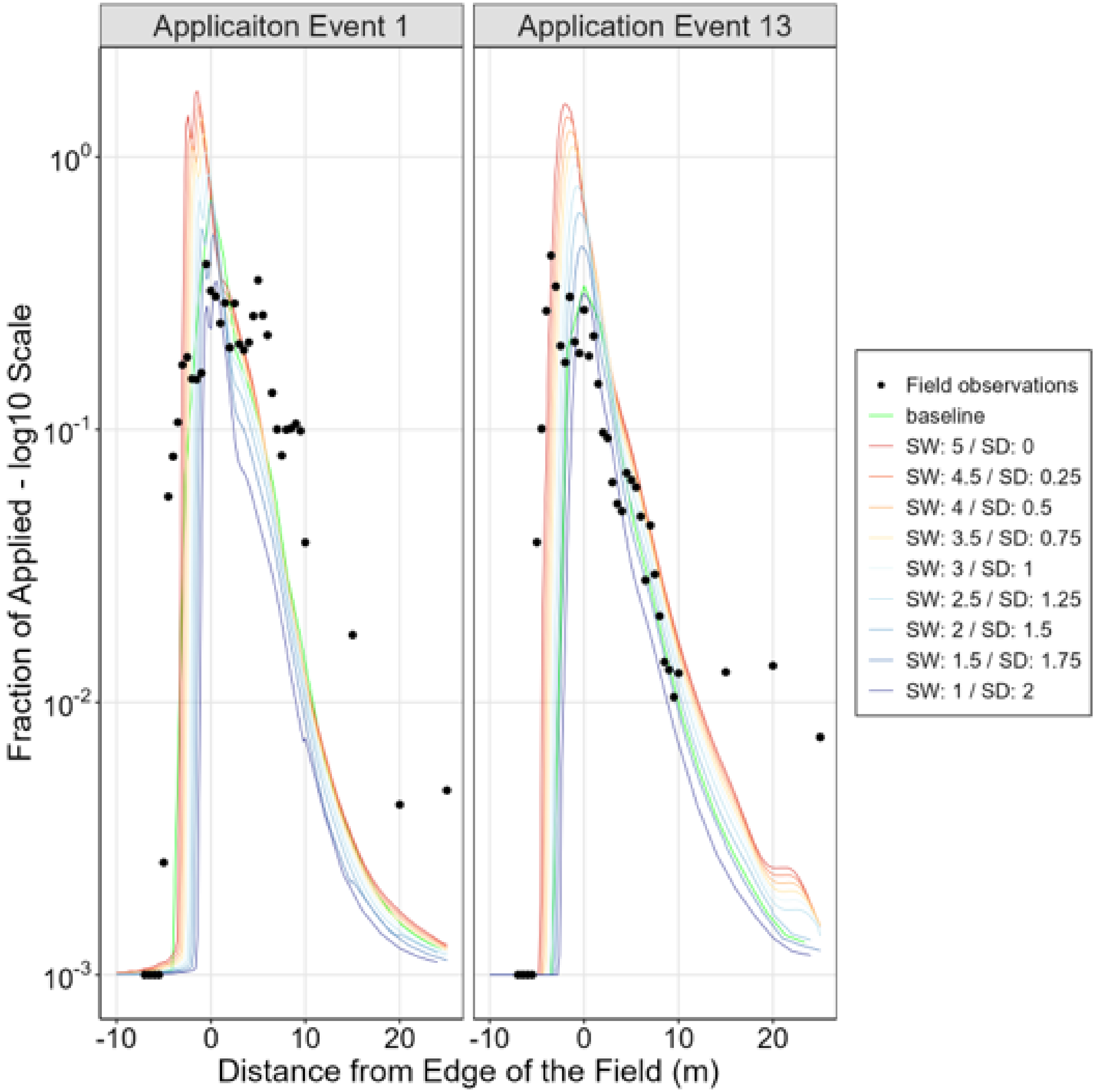


Off-Target Drift	
r index	*d*
0.8	4.5E-03

t test –no significant difference

Sensitivity analysis of swath width

- Swath width is a very sensitive parameter in AGDISPpro
  - Changing from 1 to 5 meters, resulting in a 3-to-5-fold increase in the magnitude of the deposition peaks
- Pattern testing is important to reduce the uncertainty
- Calibration of AGDISPpro can improve model performance



Dataset 1

Summary

- When customized UASs are modeled, AGDISPpro performs well in simulating spray drift deposition without calibrations
  - Different types of drones
  - Varied spray quality
- Swath width and displacement are sensitive parameters for AGDISPpro
- The evaluation demonstrates that AGDISPpro is very promising in predicting spray drift from UAS for regulatory use

Acknowledgement: authors of datasets used in this study

Thank You

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Contact Jane Tang for any questions

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