Unmanned Aerial Pesticide Application System Task Force (UAPASTF).

Update on the database development and the refinement quality criteria for spray drift trials.

Ecological and Environmental Exposure

OTM DATABASE/QUALITY CRITERIA

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Database and Quality Criteria for UASS OTM Studies

- The ecological and environmental exposure (EEE) subgroup of the UAPASTF aims to update the information we currently have on off target movement (OTM) with unmanned aerial spray systems (UASS).
  - The EEE subgroup plan to update the off-site movement database that was developed for CropLife America (CLA) Drone Working Group (DWG).
    - The new data will be assimilated into the database to develop data summaries and visualizations.
  - The EEE subgroup will consider adapting the quality criteria for OTM studies to provide reliable exposure estimates suitable for use in model validation.
    - but is utilizing the quality criteria established for use in the OECD Working Party on Pesticides Drone / UASS Subgroup 'state of knowledge'.
  - The aim is also to create a document to guide spray drift studies for UASS to return better quality data: Data relevant and reliable for regulation.

Empirical Data

Off Site Movement Database

Database

Read Me: The various descriptive parameters.

Trial Info: Is a general description of the experiment and assigns a numerical descriptor.

Trial conduct: Provides detailed descriptions of the experimental set up and associated meteorological conditions for each trial.

Replicate data: Data is grouped into the shorter distance ISO method-based studies and 100m for the US and system evaluation studies.

Parameter	Units	Explanation
variant		serial number of tested variant
replicate		serial number of the replicate for each variant
Trial Information		**Basic informatio on the trial**
Principle investigator		primary contact for the conduct of the trial
Country		location by country
Date	mm/dd/yy	the date that the treatment was applied
Time	hh:mm	sampling time of the wind data
Description Notes		Identification of the primary treatment parameters
Location	decimal degrees	name of site or coordinates wher the tests were conducted
Trial Conduct		
Crop type		desription of the vegetation type present
Growth Stage	**BBCH**	average phenological stage of the vine canopy according to the BBCH scale
Crop Height cm	cm	average height from the ground to the top of the vines rows
Number of rows sprayed		number of flightlines
Sampler type		type of deposition sampler
Sampler height	cm	height of the deposition surface from the ground
Sampler size	cm2	size of the deposition sampler surface
Flight line direction		orientation of the flight lines relative to the orientation of the cropping stru
Equipment data		
Manufacturer		the name of the manufacturing company
UASS Name		Name of the version of UASS used
Rotor number		Number of rotors on the UASS
rotor width	cm	the diameter of the individual rotors
Total rotor width tip to tip	cm	the diameter of the rotor assembly on the UASS
Weight of the aircraft	kg	weight of UASS unloaded
Gross weight	kg	weight of UASS fully loaded
Nozzle type		manufacturer and type of the nozzle the UASS was equipped with
Nozzle number		number of nozzles at the UASS
Nozzle separation	cm	distance between each nozzle if it is the same
Nozzle location horizontal	cm	location of each nozzle on the boom if the nozzle spacing isnt equal
Nozzle location vertical	cm	distance of the nozzles or boom vertically from the centerline of the fusela
Boom width	cm	length of the boom

Read Me | Trial Info | Trial Conduct | Replicate data 20m | Replicate data 100m | Chart1 | Chart2 | Chart3 | Cha

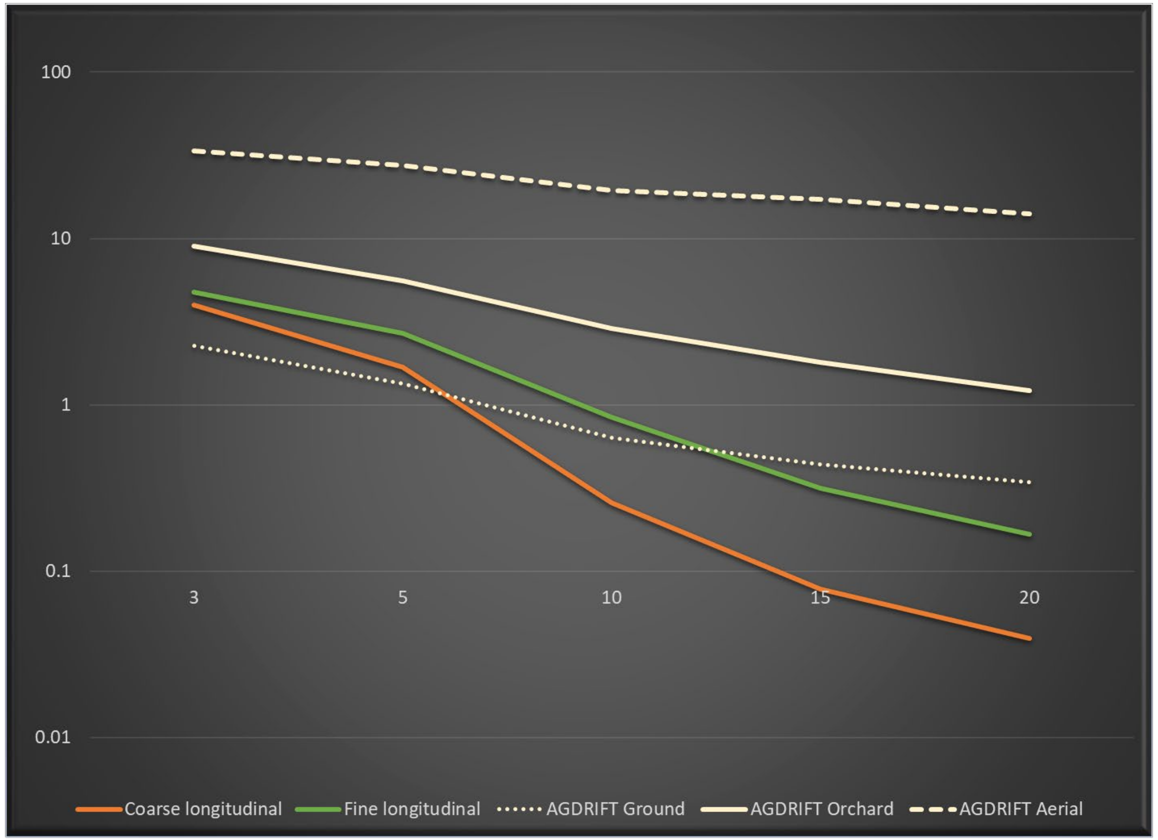
What is in the Database

- Herbst et al., and CAU data on simulated arable and vineyard, four platforms, and droplet size (20m).
- Herbst/Glasser et al., data on sloped vineyards with combinations of platform, flightline position, and droplet size (20m).
- Bonds/Fritz et al., bare ground data on three different platforms, flight altitude, boom position, and droplet size (40m and 100m).
- Goulet Fortin (BASF) has 114 different trials that we are still attempting to access (40 m).
- Martin/Tang (Bayer) UASS vs conventional arable, and droplet size (100m).

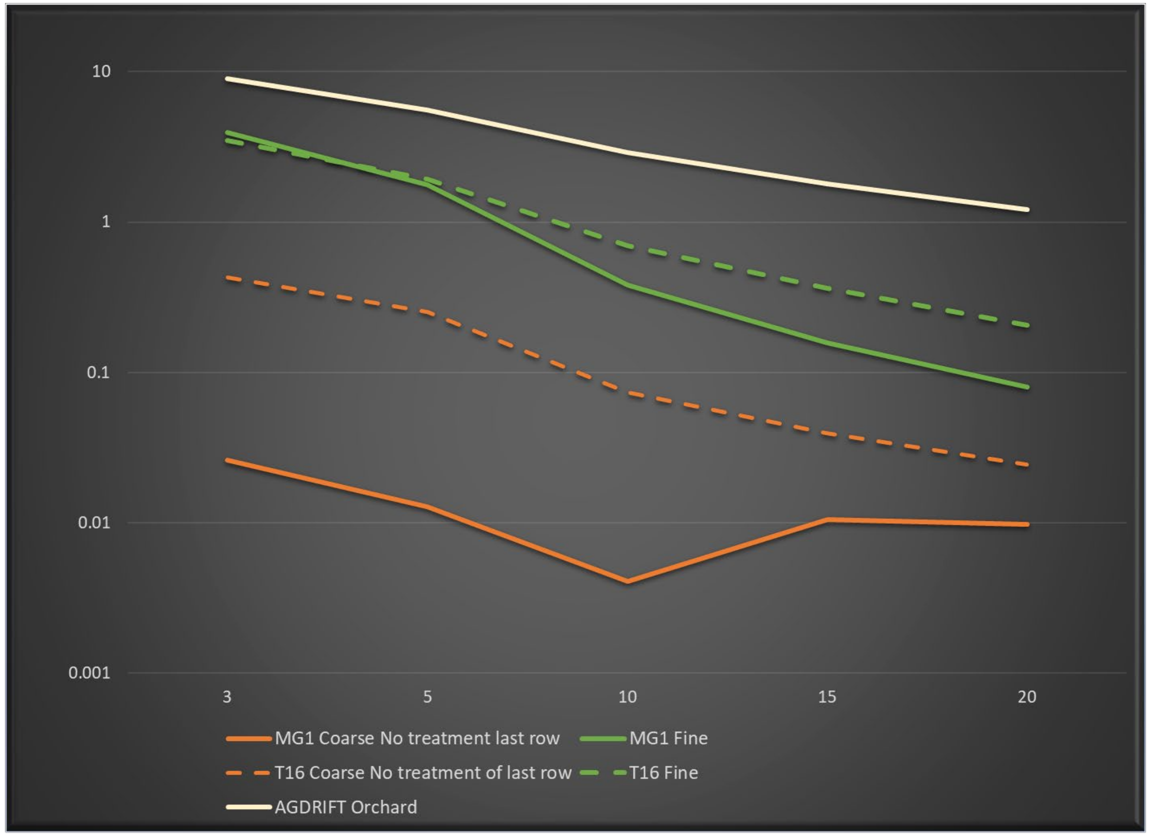
Herbst data previously provided information on simulated arable and vineyard: More recent studies added to the DB are in a sloped vineyard

All graphs are compared to AgDRIFT standard curves

AgDRIFT for arable orchard and aerial compared to fine and coarse sprays in a sloped vineyard.

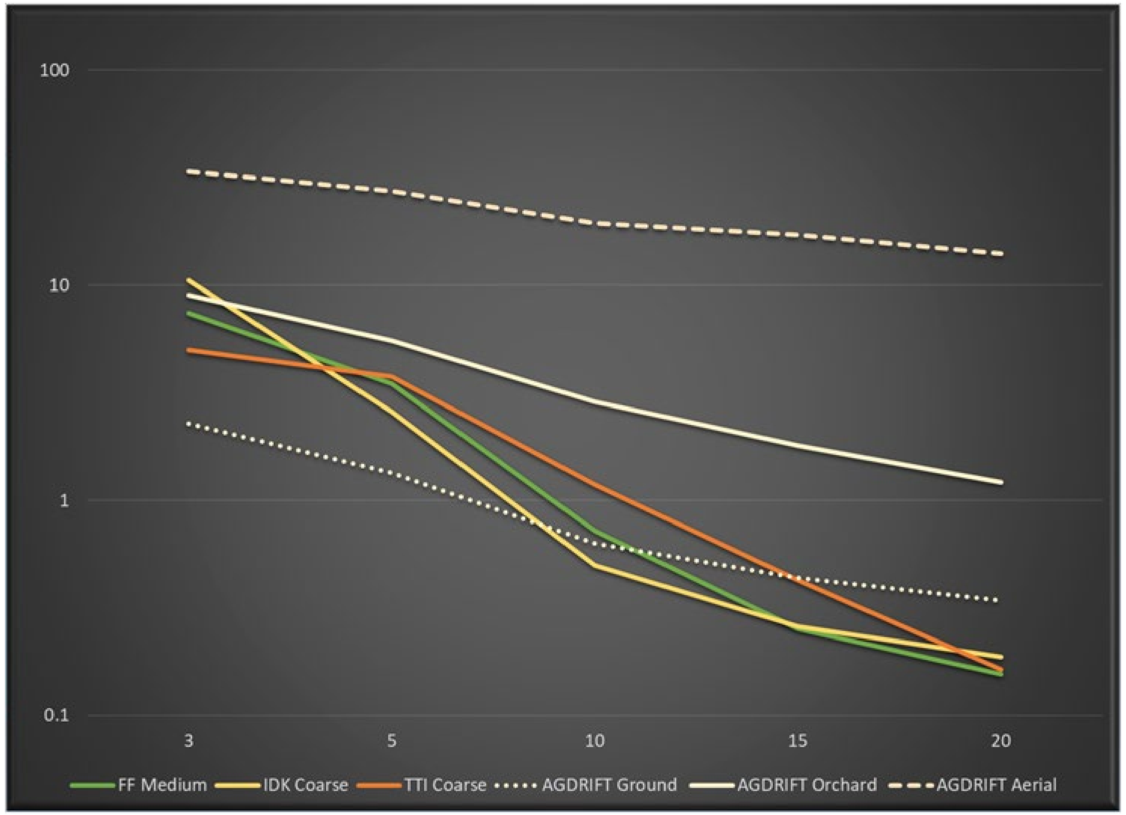


AgDRIFT for orchard compared to the two different platforms, standard fine spray, and the coarse spray not spraying the last row.

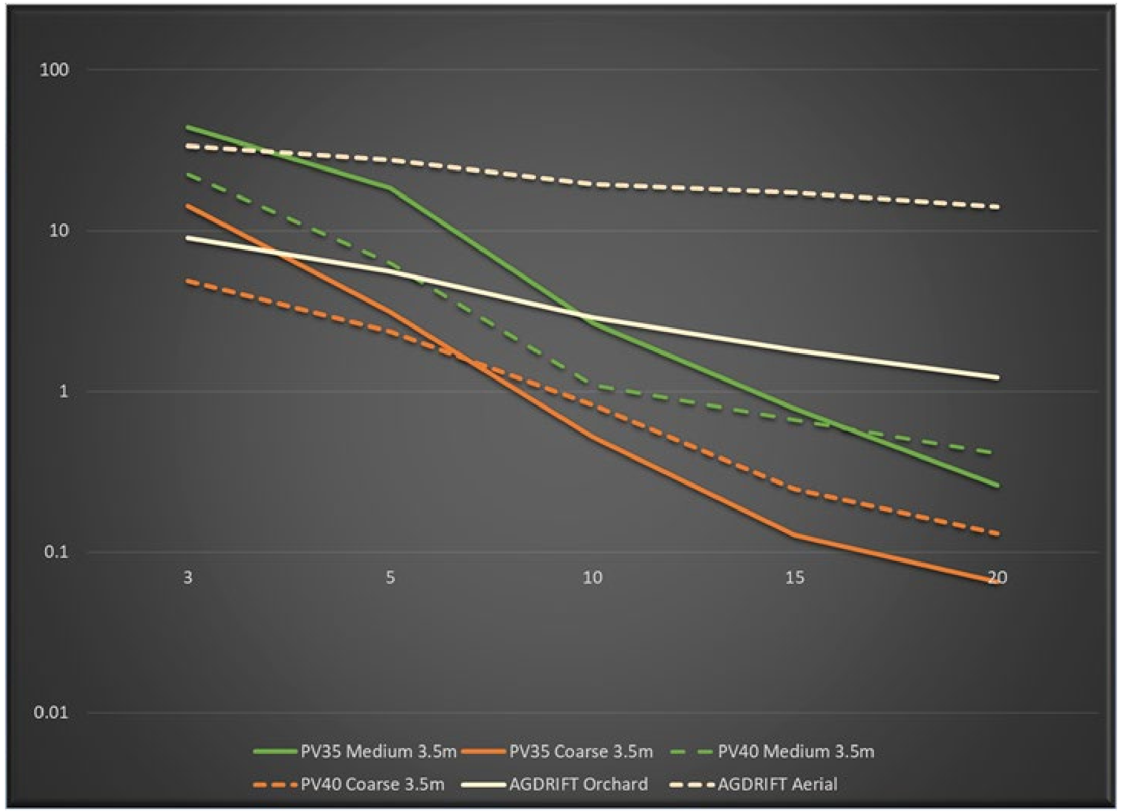


Bonds and Fritz et al., 18 separate trials are in the database transects run from up wind -5 m through to 10m downwind with 0.5m resolution with lower resolution out to 40 and 100m. Designed to measure both the swath, the offset thereof and the down wind drift.

Early studies in CA had consistent wind providing data that sat well with the data generated by Herbst et al., but without the distinction between nozzles. Medium and coarse over fine and coarse.



Later studies in FL had very gusty winds which significantly effect the offsetting of the spray deposition, not just wind driven off sets but also tilt.



Goulet Fortin et al., have 114 studies

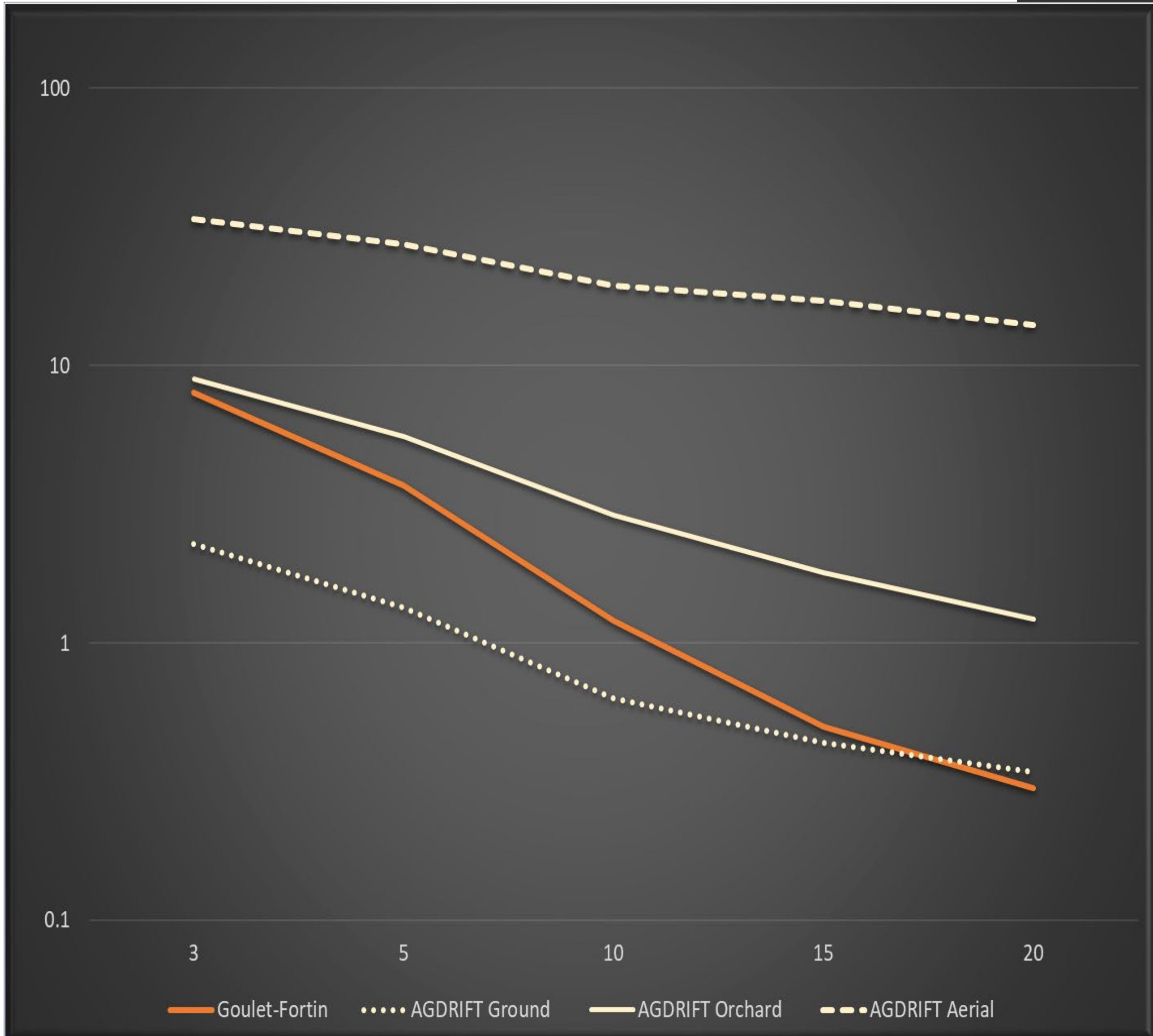
A recent paper has analyzed these data where this graph was presented.

The studies followed ISO 22866:2005 and SETAC DRAW protocols and measured downwind deposition out to 40 m.

We are waiting to see what can be shared with the database.

The data sits well with the EU data.

Figure represents 50th percentile of all data (3 & 5 m flight heights, 3 & 5m/s flight speed).



An update to the table showing a breakdown of the literature reporting the downwind distance to 90% spray accountancy.

Author	Altitude (m)	UASS speed (m/s)	Droplet size	Rotor	Wind speed (m/s)	Distance to 90% (m)
J. Wang 2018	1.5	3	Medium	1	0.7	6.9
	1.5	3	Medium	1	2.2	3.9
	2.5	3	Medium	1	1.8	3.7
	2.5	3	Medium	1	4.7	10.1
	3.5	3	Medium	1	1.8	33.5
	3.5	3	Medium	1	3.7	46.5
Xue 2014	5	3	Medium		3	8
Brown 2018*	4.6	5.4	Fine	1	3	7.5
G. Wang 2020	4	5	Fine 100	4	2.8	20
	4	5	Fine 150	4	2.9	13
	4	5	Fine 200	4	2.0	12
X. Wang 2018	2	5	Medium	1	6.3	10
	2	5	Medium	1	7.3	6.4

Off Target Measures

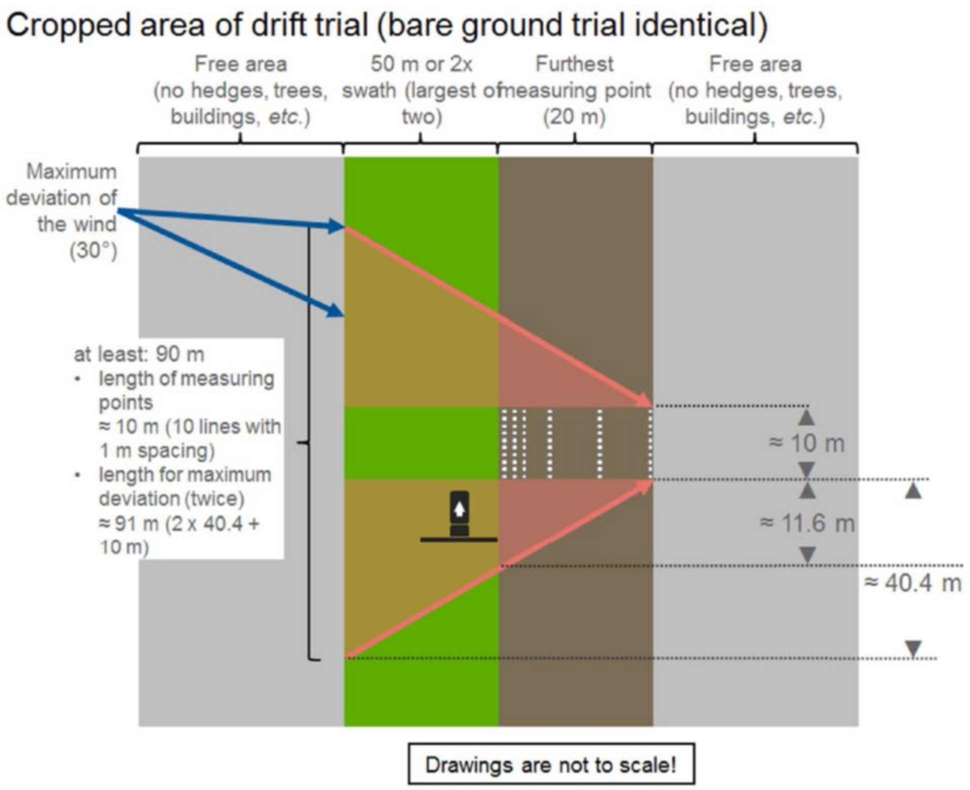
Methods Development for UASS

Spray Drift Trial Methods

- Within the methods document each section is introduced using examples from ISO, ASABE, EPA, and SETAC DRAW standard documents. These provide a framework and a range for various aspects to be considered in a drift method.
- Once framed from standards for conventional systems, examples are taken from the literature where UASS studies typically deviate.
- Solutions are provided to avoid pitfalls and define how unknowns should be addressed to fill in information gaps.

Trial site and layout

- Width
  - ISO 20 m or the swath width of the sprayer (20 m typical boom width).
  - SETAC 50 m or 2 x the swath whichever is larger.
- Length
  - The length of the spray line be such that the most distant downwind collection devices with a tolerance of a deviation of 30° in wind direction. The standards agree but deviate in the detail of this description.
- UASS
  - The length of the spray line should be minimally 2x the length of the sample line **plus the width of the subsample array**.
  - A length of 20 m is too short: **minimum of 40 ideal 100 m.**
  - The site can be designed with an assumed swath width and edge of field, but in-swath and upwind measures should be taken for post application confirmation of these application inputs.



Ground Deposition Samplers

- The SETAC DRAW working group looked closely at the different samplers there is currently no way to decide which is the more appropriate for the purpose of developing a risk assessment.
  - I prefer Mylar cards; easy to wash and no lip effect like petri dish, but at high volumes runoff is possible.
- Final decisions erred toward petri dish for their ease of use and low detection limits.
- Analytical technique: Fluorescent tracers would be preferred over HPLC for simplicity and cost and over colorimetry for sensitivity.

Vertical Detectors

- 2 mm lines are considered optimal due to their small, well defined surface area.
- These have been accepted by many researchers, but the distances need to be explained.
- The Herbst trials introduced this method to many, but as an edge of field (1-2m) potential drift measure as opposed to a measure of drift for off target data (bystander / hedgerow).
- ISO states 5 meters for boom sprayers and 5 or 10 meters for sprayers operating in Bush and Tree crops.
- UASS: A standard of 5 m should be applied to span between arable and orchard drift trials, with additional distances optional.

Replication and Pseudo Replication

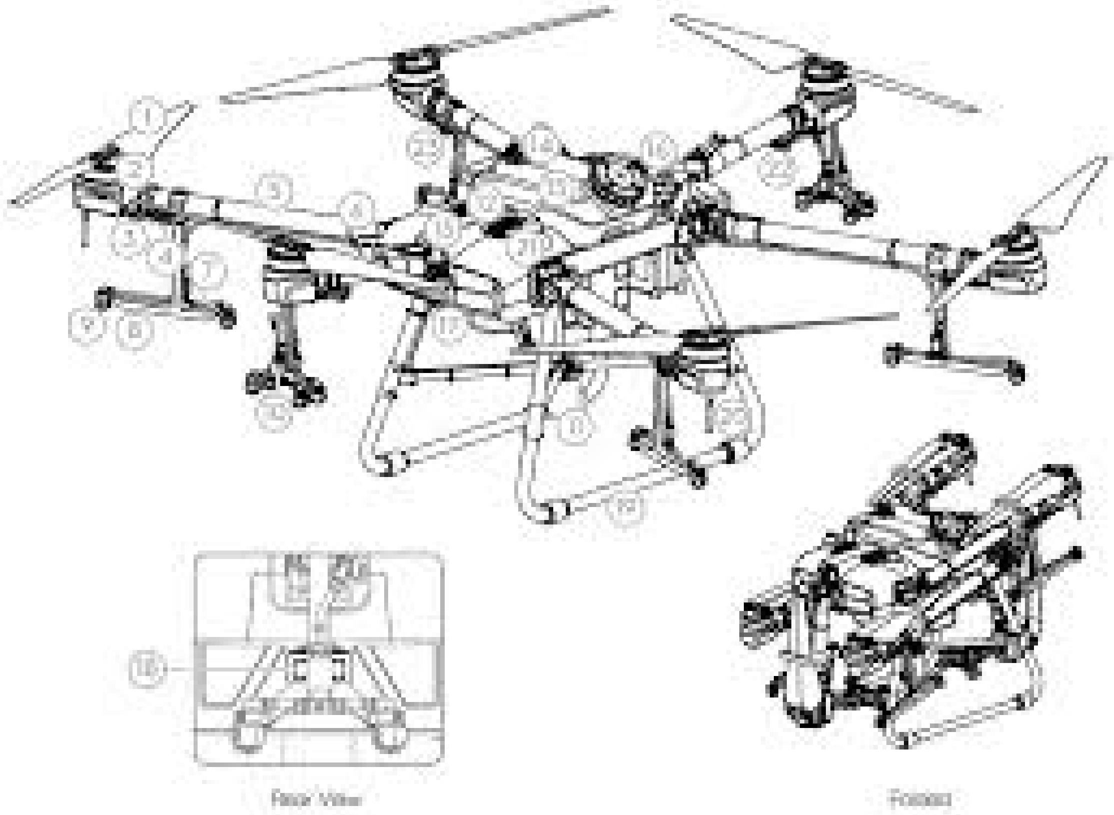
- Replication is a big issue in UASS drift studies. We must put a stop to the 1 rep and three subsamples. Within this table there are so far nine published studies that have one replicate.

Table 1 Description of treatments sampler distances and replication from a number of different UASS trials.

Citation	Treatment	Sampling	Replication
(Sánchez-Fernández *et al.*, 2023)	A mist blower 800 l/ha was compared to a UASS at 45 l/ha	Filter paper 5.5 × 80 cm (120 cm^2) at 1, 2, 3, 5, 7.5, 10, 12.5, 15, 17.5, 20, 25, 30 and 40 m	Sub samples 3 Replicates 3
(Herbst *et al.*, 2023)	TeeJet XR 110- 015 Albuz ATR brown, Agrotop Airmix 110-015 and Lechler IDK 90-025	Petri dishes 14.5 cm (1,651 cm^2) at 3, 5, 10, 15 and 20 m	Sub samples 10 Replicates > 3
(Wang *et al.*, 2020a)	Three types of UAV sprayers, equipped with AIN IDK 120-015 and HCN TR 80-0067,	Petri dish 15 cm (1,760 cm^2) were placed at 3, 5, 10, 15 and 20 m. Airborne, horizontal lines 3 x 5 m frame at 2 m, and two rotary samplers were placed at each deposition distance	Sub samples 10 Replicates >3 goal 6
(Dubuis *et al.*, 2023)	Early BBCH 67 and Late BBCH 91	Petri dish x 8.8 cm 0, 1, 3, 5, 10, 15, 20, 30 and 50 m (304 cm^2). Airborne collected 5 m using a 6m tower with three vertical lines 2.5 mm, each string was cut 1m long sections. Manikins at 3, 5 and 10 m	Sub samples 5 Replicates 4
(Li *et al.*, 2022)	UASS velocity 1, 2, 3 m/s	Mylar cards at 1, 3, 5, 10, 20, 50 m (8.5 x 5.4 cm (230 cm^2)), and airborne (from 2-10m every 1 m at 100 m downwind)	Sub samples 5 Replicates 1

Equipment descriptions

- This section of the paper will discuss some of the primary mechanical issues with UASS studies.
- For example, many UASS do not have pressure gages or flow meters, and the swath width is difficult to properly determine, meaning special attention needs to be spent on calibration.
- Flight settings also need to be carefully defined with descriptions of how to take the measure, what is the altitude, ground/crop/nozzle/landing gear?
- We are also working with DJI to prepare a simpler schematic of the reference sprayer (AGRAS T30) so that we can define key platform parameters to be measured and reported.



In this effort we are gathering additional data to continue to build the empirical database as we are bound by the range in information available. Please share your data if you can.

With the methods documents the aim is to define a typical structure of a Drift Methods Document.

Design issues are being highlighted from the literature to show where clarification is needed for UASS studies.

Also issues unique to UASS are being outlined and deviations to typical design suggested to respond to pifalls and information gaps.

Any Questions

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