UAV / UASS for Pesticide Application

Overview of the Projects of the Unmanned Aerial Pesticide Application System Task Force (UAPASTF)

Greg Watson, PhD
Chair, Administrative Committee
UAPASTF

Global Crop Protection Regulatory Policy Lead
Bayer Crop Science

UAPASTF

Industry Response to Pesticide Regulators' "State of the Knowledge" Review of Unmanned Aerial Vehicle (UAV) Use for Pesticide Application

Unmanned Aerial Pesticide Application Task Force

(uapastf.com)

CEUREG Forum XXIV
Mojmfrovce, Slovak Republic
Virtual 9/23/2024

Unmanned Aerial Pesticide Application System Task Force (UAPASTF), LLC.

- Based in the US - but **global** in its work / focus
- UAPASTF global core mission is to supply regulatory data / information to inform the potential use of UAV-based pesticide application
  - Where appropriate, the UAPASTF will focus on generating data for submission to pesticide regulatory authorities to inform estimates for off-site movement, determine operator/handler exposure potential, and assess crop residue contribution to human dietary exposure in risk assessment and regulatory approval processes
- UAPASTF interacts with OECD Drone/UASS Subgroup of WPP, regional / national regulators, CropLife, & other stakeholders to develop & provide information / data
  - UAPASTF alignment with work of the OECD WPP Drone/UASS Subgroup critical to success
  - Established and seeking collaborative and confidentiality agreements with UAV-application companies and experts (e.g., additional UAV-application companies in other world areas, UAV manufacturers)
- UAV-based pesticide application a part of progression toward precision / digital agriculture with the potential for increasing sustainability

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Unmanned Aerial Pesticide Application Task Force (uapastf.com)

Member Company	*Administrative Committee*	*Technical Committee*
BASF Corporation	Rebecca Willis	**Frank Donaldson (Chair)**
Bayer CropScience LP	**Greg Watson (Chair)**	Jane Tang
Corteva Agriscience	**Travis Bui (Vice Chair)**	Rajeev Sinha
Gowan Company LLC	Raymond Layton	Jason A. McDonald
FMC Corporation	Hector Portillo	Roberto Barbosa
NuFarm Americas Inc.	Patti Turner	Tyler Gullen
Syngenta Crop Protection LLC	**Nestor Algarin (Treasurer)**	Jo Davies
Valent U.S.A. LLC	Robin Charlton	Christopher Read
Task force managers	*Rhonda Bichsel*	*Eric Bruce*

Parties interested in the work of, or registrants interested in joining the UAPASTF should contact:

Dr. Greg Watson,
Chair, UAPASTF Administrative Committee greg.watson@bayer.com
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OECD WPP Drone/UASS Subgroup – State of the Knowledge Report Recommendations

- The Subgroup has become an advisory body to provide expert input on how to fill knowledge gaps
  - Grouping of 'state of knowledge' recommendations needed to develop / implement
  - Workstreams Established, work in-progress

Work Package #1 – off-site exposure including exposure modeling (BIAC / Reg Agencies)

Work Package #2 – scanning / survey to stakeholders (Reg Agencies)

Work Package #3 – 'best practices' guidance (BIAC)

Work Package #5 – aware of ISO work (Research Institute / ISO representative)

Grouping of Recommendations from 'State of Knowledge' Report

#7. Develop an empirical database and standard drift curve or model to estimate off target exposure.

#9. Develop a useable publicly available model for predicting spray deposition and drift including parameters for static hovering, forward speed and spray equipment.

#1. Establish database to classify UASS into groups to reduce burden of testing each different platform/configuration.

#2. Survey manufacturers about future trend of UASS design/ use profiles to produce a benchmark platform as a common starting point for regulators (others may differ and need bespoke assessment but would cover most common uses).

#8. A data gathering exercise for operational practices mixing, loading, cleaning and transport scenarios.

#5. Develop and publish a user-friendly summary of best practice (including the essential nature of calibration), pitfalls and a trouble shooting guide (both for generating trials data and applying pesticides in practice), including preliminary recommendations for operational parameters (release height, application volumes, forward speed and spray quality).

#6. Promote the advice in Annex D recommendations for researchers conducting UASS drift studies.

#4. Develop set of standard methodologies that will support regulatory decision making.

#3. Encourage manufacturers to develop improved spray systems including the pump systems, nozzle placement and closed transfer loading systems. * ISO standard project

Unmanned Aerial Pesticide Application System Task Force (UAPASTF)

- *Technical teams actively working*
  - **Off-site movement GLP study protocol & trials (Frank Donaldson, BASF)**
    - **Environmental / Ecological Exposure Subteam (Naresh Pai, Bayer Crop Science)**
  - **'Best practices' guidance (Hector Portillo, FMC)**
  - **Field crop residue project – Agriculture & AgriFood Canada (Greg Watson and Sheila Flack, Bayer Crop Science)**
  - **Occupational / Applicator / Non-dietary Exposure Subteam (Edgars Felkers, Bayer Crop Science)**

Updated off-site data generation plan

**note: pinned map locations indicate targeted regions, not specific field sites*

Location	Timing
USA (non GLP) (Robstown, Texas)	February 2023
Canada (GLP) (Saint-Jean-Sur-Richelieu, Quebec)	May 2023
Brazil #1 (GLP) (Santa Helena de Goiás, Goiás)	September 2023
Hungary (GLP) (Bugac)	October 2023
Spain (GLP) (Oropesa)	November 2023
USA (GLP) (Robstown, Texas)	December 2023
Brazil #2 (GLP) (Castro, Parana)	March 2024
Australia (GLP) (Clifton, Queensland)	April 2024
South Africa #1 (GLP) (Delmas, Mpumalanga)	September 2024
South Africa #2 (GLP) (Hertzogville, Free State)	September 2024

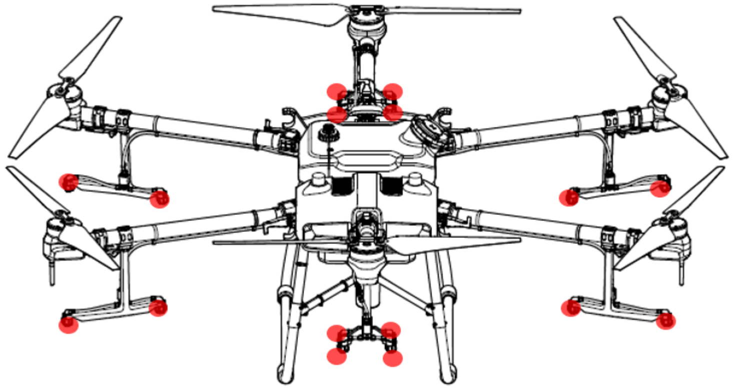
Globally focused Good Laboratory Practice (GLP) program

- Repeatable experiment to compare drift behavior across locations
- Enable data generation anywhere
- Single Contract Research Organization (CRO)
- UAV pilot/consultant at each field location
- Focus on single UASS platform (*i.e.*, establish a comparator / 'reference')
- Nozzles to produce three spray qualities (Fine, Medium, Coarse)
- Each UASS treatment followed by a ground sprayer (with same spray quality)
- Three treatments per nozzle ➔ 18 total treatments

UASS and Tractor

Equipment & Setup

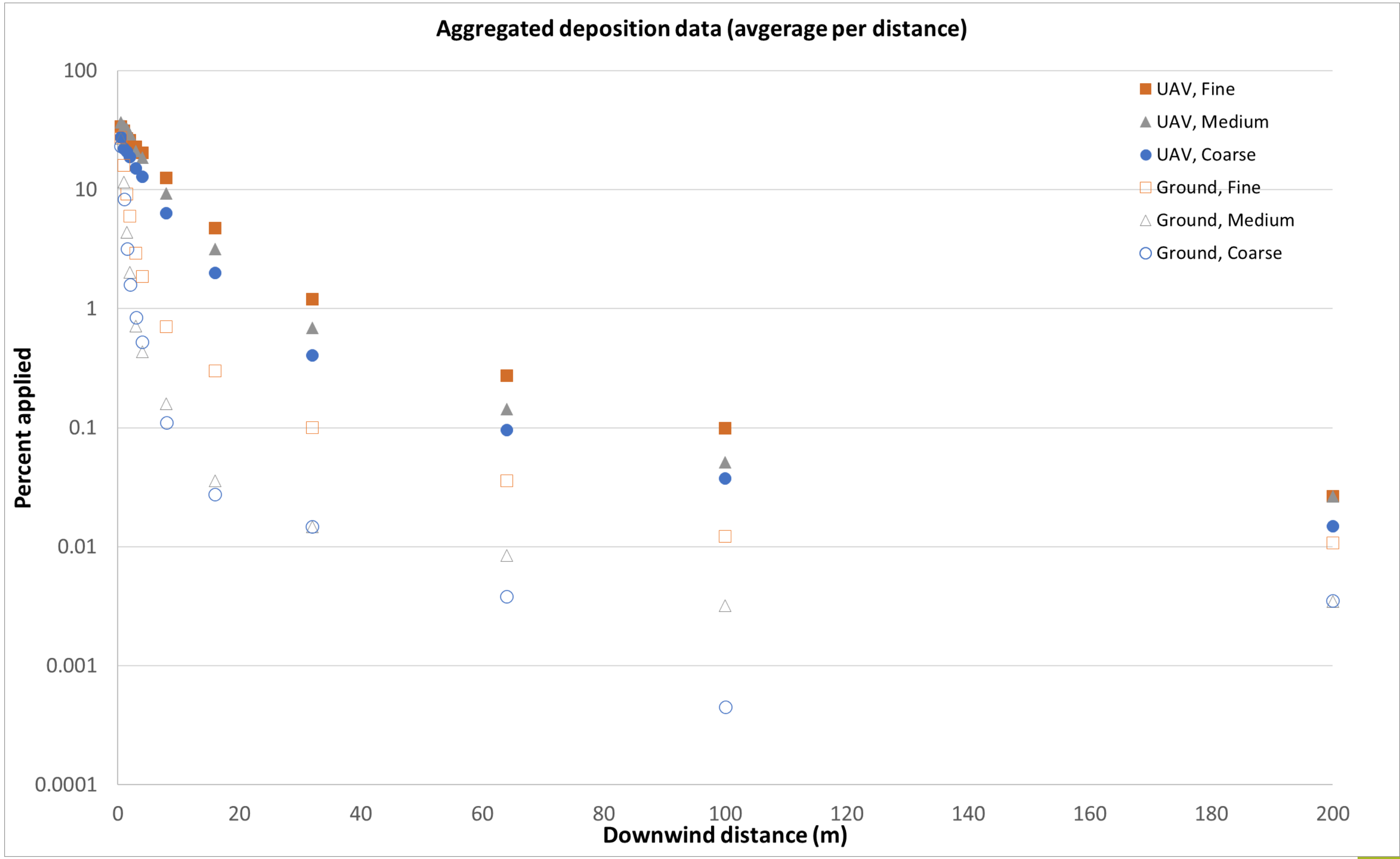
- DJI Agras T30
  - Six rotors, 16 hydraulic nozzles
  - 30L payload
  - Install pressure gauges in-line – confirms spray quality during applications
  - Nozzle release height 3m above ground
  - Bare (or near-bare) ground applications
  - Multiple passes (3-4) to match reference sprayer, depending on pattern test



- Tractor (reference sprayer)
  - Model depends on location
  - Three nozzles with same spray quality as the UAV it is paired with
  - Release height 20 inches (*ca.* 0.5m, 'low boom')

Downwind deposition data (aggregated)

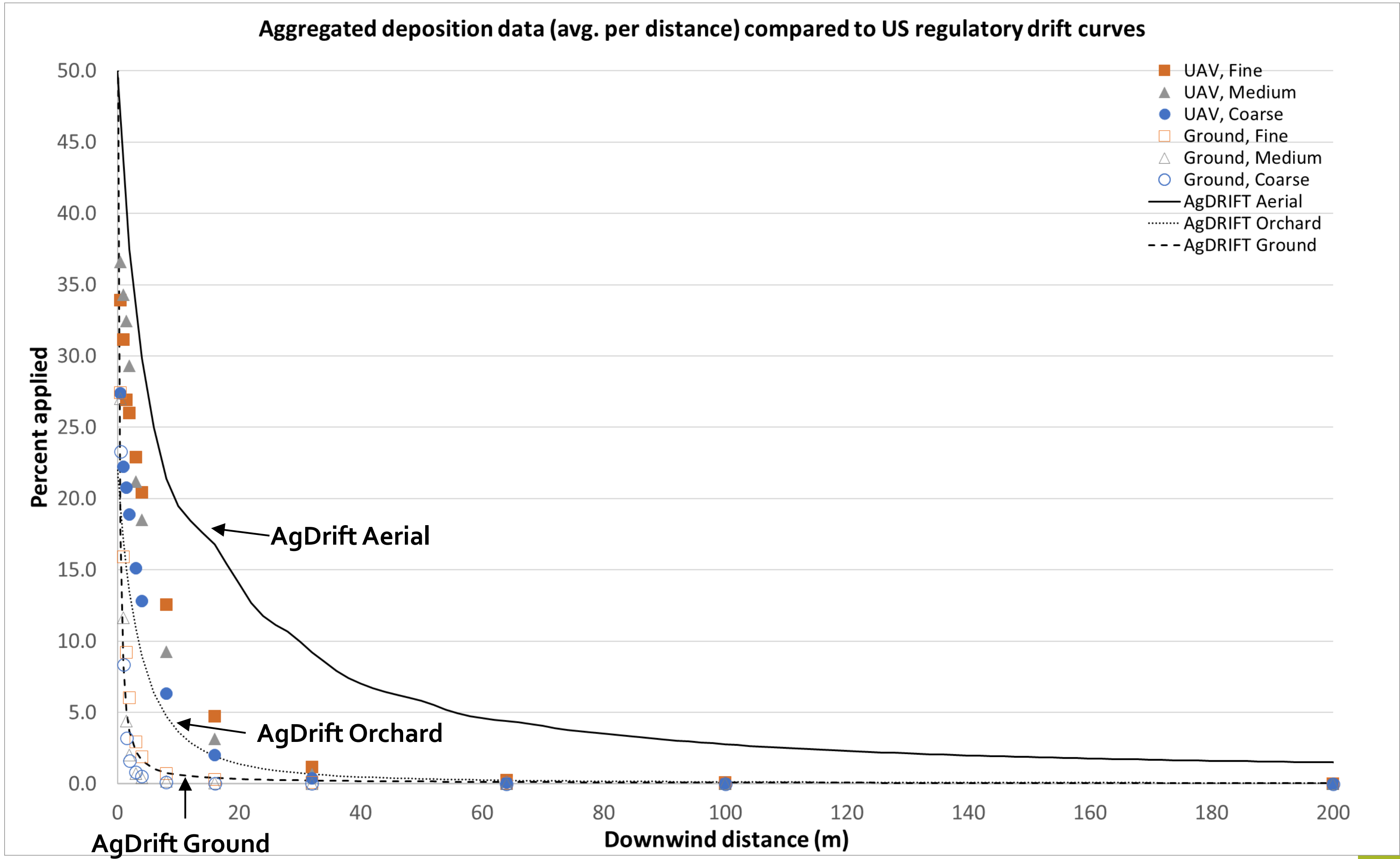
- UAV: 3m release height, bare ground
- Aggregated by spray quality (F-M-C)
- Three downwind transects, three spray events per nozzle, six GLP studies (n=54)
- UAV: 90% deposition within 16 m
  99% deposition within 32 m
  (> 99.9% by 100 m)
- Ground: 99% deposition within 16 m (> 99.9% by 32 m)
- Follows expected pattern based on droplet size
- Work ongoing to evaluate weather effects, covariate analysis approach



Note: y-axis is logarithmic

Downwind deposition data (aggregated, US drift curves)

- 3m release height, bare ground
- Aggregated by spray quality (F-M-C)
- US Regulatory Drift curves
  - Tier 1 Aerial, Fine-Medium
  - Tier 1 Orchard Airblast
  - Tier 1 Ground, 50th percentile, low boom, fine-medium coarse
- Data falls within ground and aerial drift curves, and generally below Tier 1 airblast by 32 m



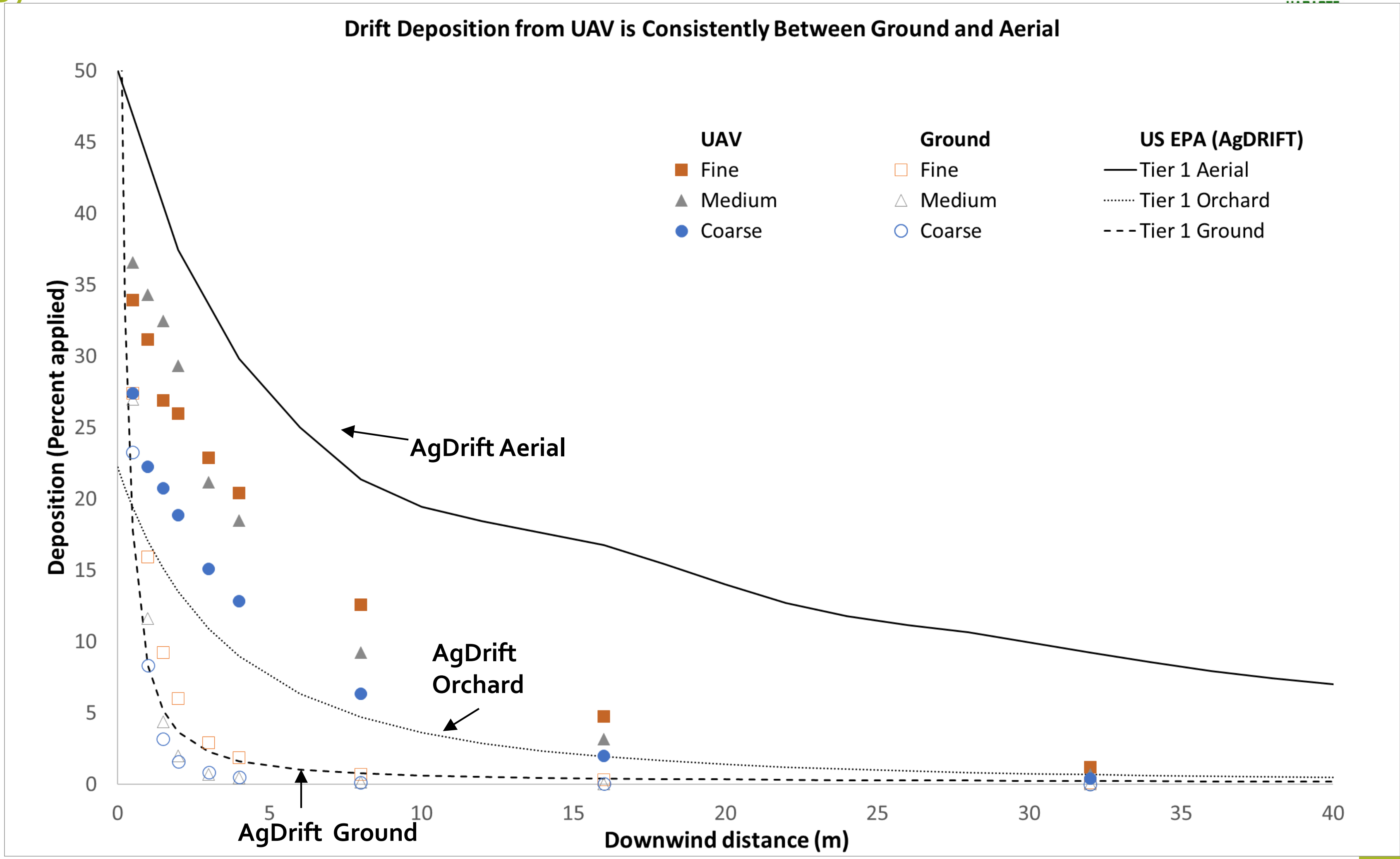
Downwind deposition data

(aggregated, 40m, US drift curves)

- Deposition similarity Fine and Medium nozzles at near-edge-of-field

Next steps

- Further investigation into prevailing weather conditions, site-by-site evaluation
- Pattern test data
- Principle component analysis
- Integrate reference sprayer results
- Vertical sampler results



Concluding remarks – Off-site Movement

- UAPASTF Technical Committee making steady progress toward stated goals
  - Five GLP studies completed in 2023, four GLP studies in 2024 (*two planned for completion in Sep 2024*)
  - Collaboration with key drift experts in different areas
    - Efforts to intensify moving forward
  - Data analysis ongoing
    - Data organization and analysis plan developed, shared with regulators

- UASS deposition results
  - Follow expected trend by droplet size
  - 90% ground deposition within 16 m
    - 99% ground deposition observed by 32 m
  - Data fall between regulatory drift curves for ground and aerial applications

DATABASE DEVELOPMENT

UAPASTF

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

Jane Bonds

ACS FALL 2024 AUGUST 18-22 DENVER, CO

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Spray Drift, Operator Exposure, Crop Residue and Efficacy: Early Indications for Equivalency of Uncrewed Aerial Spray Systems with Conventional Application Techniques

Bonds et. al. 2024.

Journal of the ASABE. 67(1): 27-41. (doi: 10.13031/ja.15646) Bonds et al ASABE

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.

Manned Aerial AGDRIFT Significantly Overpredicts UAV Exposure

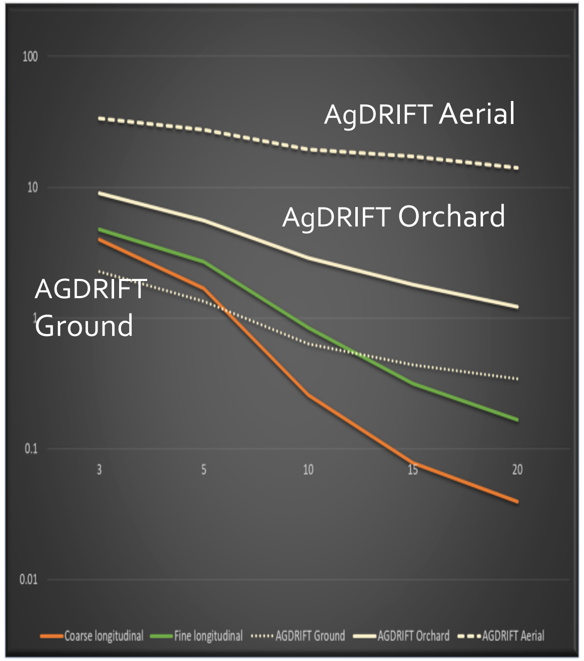
(Off-site Movement Publications)

Goulet Fortin, et. al. Evaluating spray drift from Uncrewed Aerial Spray Systems: A machine learning and variance-based sensitivity analysis of environmental and spray system parameters. Sci Total Environ. 2024 doi: 10.1016/j.scitotenv.2024.173213

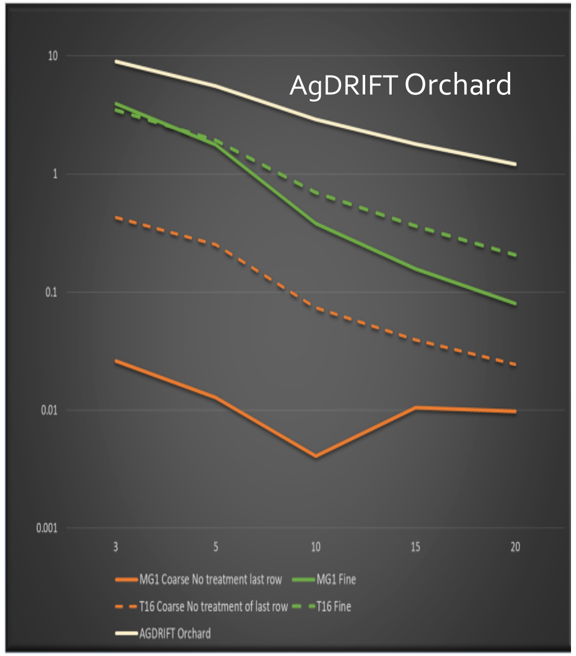
Herbst data previously provided information on simulated arable and vineyard: More recent studies added to the DB are in a sloped vineyard

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.



Goulet Fortin et al., have 114 studies

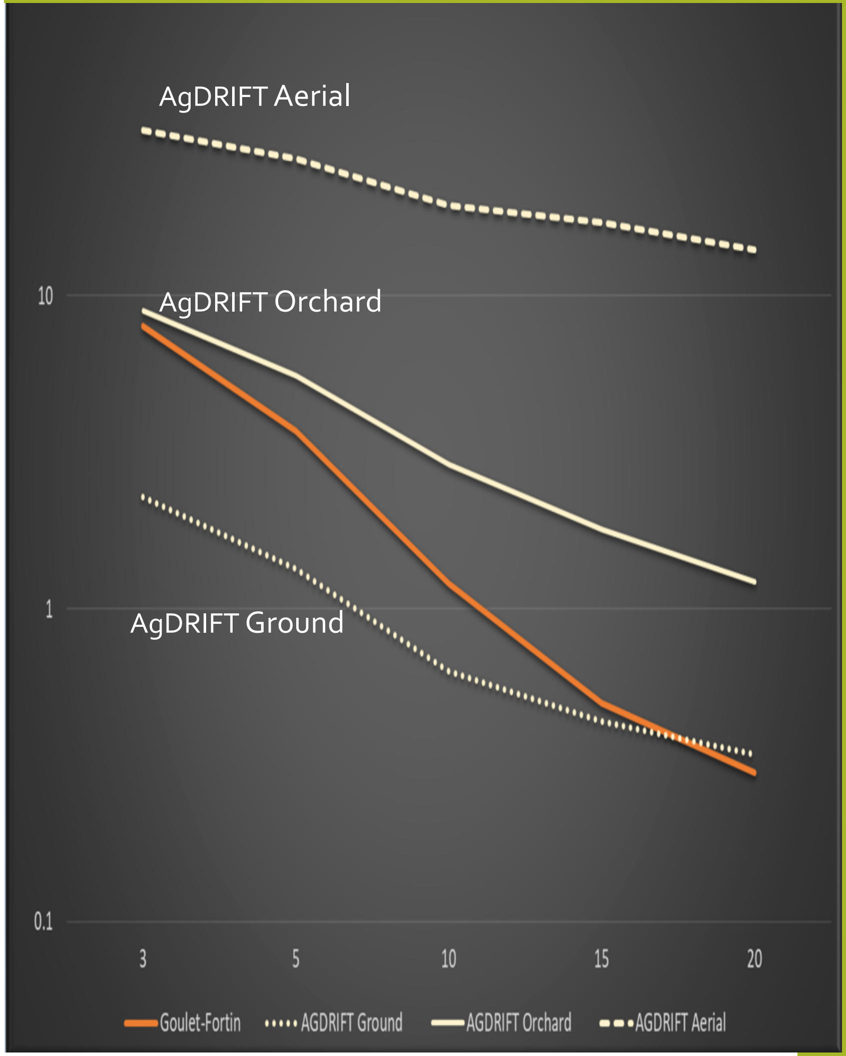
A recent paper has analyzed these data where this graph was presented.

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).



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

BEST MANAGEMENT PRACTICES

Unmanned Aerial Pesticide Application System Task Force (UAPASTF) update on best management practice development for safe and effective application of pesticides using unmanned aerial spray systems (UASS)

UAPASTF

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‘Best practices’ guidance (Hector Portillo, FMC)

Cycles of incorporating feedback

- Preparation of draft completed by UAPASTF 4th Q '22
- Shared with UAPASTF external experts & collaborators 1st Q '23
- Final initial draft sent for broad expert review Apr-May '23
- OECD Cooperative Research Program funded workshop, in-person, May 23rd & 24th, 2023, York, UK
- Request review & input of updated draft from key UAPASTF external experts, collaborators, and member companies by Jan '24
- Request review & input of updated “final” draft from OECD Drone/UASS Subgroup by May '24
- “Version 1.0” of *Best Management Practices for Safe and Effective Application of Pesticides Using Unmanned Aerial Spray Systems (UASS)* to be posted to the UAPASTF Website **coming soon** Sept '24

Unmanned Aerial Spray System (UASS) Best Practices Components

UAPASTF

Spray Equipment Calibration Is Critical –
Not well Understood for UASS

Calibration ensures:

- Delivery of <u>accurate amount of product</u> as label rate
- <u>Uniform distribution of active ingredients</u> over the field or to the targets
- Three major factors influence sprayer calibration:
  - Ground speed, i.e., flight speed (km/h, miles/h)
  - Swath width (meters or feet) – Impacted by flight height, nozzle/boom configuration
  - Flow rate (L/min or g/min)

UAPASTF Best Management Practices for Safe and Effective Application of Pesticides Using Unmanned Aerial Spray Systems (UASS)

- Not our intention to make this a standard (for example ASAE or ISO) but the UAPASTF BMPs could be utilized in works towards standards
- Because standards haven't yet fully captured best practices for evolving UASS uses (e.g. models, countries, and uses) these BMPs are general and meant to be a starting point
- Meant to be a starting point to then guide towards local resources
- Higher-level sections (check list) and detailed sections

Draft communication

QR Code Coming Soon

Unmanned Aerial Spray Systems (UASS):

Start Here for Best Practice Resources

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Drone Pesticide Application is Unique and Growing in Popularity

- Changes in UASS technology and regulations are happening rapidly.
- UASS has broad global appeal, with uptake examples in all four regions of the world.
- Regulatory frameworks and best practices are available and will differ based on the local situation.

Best Management Practices (BMPs) and UASS

- Pesticide application requires expertise and stewardship for proper use and safe handling, especially with a new technology like UASS.
- BMPs increase the likelihood of good environmental and operator practices while considering economic factors, availability, technical feasibility, and effectiveness.
- The BMPs provided here are intended to supplement information on the local product label. The registered and current product label should ultimately be followed above any other source of information. Readers should therefore ensure that this guidance is adapted or supplemented by other country/state/region specific needs, conditions, laws, and regulations, as relevant, including official and required aviation training, to ensure safe operations, which may not be explicitly mentioned on pesticide labels.

Purpose and Scope

- This BMP document intends to provide general guidance on best practices for the safe and effective application of pesticides when using UASS primarily for agriculture. The following areas are discussed:
  - **Current licensing regulations in key UASS markets**
  - **User safety in the context of pesticide handling**
  - **Equipment set up and calibration parameters that impact spray deposition while reducing off target movement (drift), including impact of equipment selection and environmental conditions**
- Because changes in UASS technology and regulations are happening rapidly, this document is intended to be updated regularly to ensuring the guidance and references within stay relevant.

While this is an exciting space, it should also be noted that in many geographies, UASS represent a complementary application technique to existing methods, and further understanding of their unique value and best local practices will help position their use appropriately and more effectively.

The Unmanned Aerial Pesticide Application System Task Force (UAPASTF) consists of the pesticide member companies: BASF Corporation, Bayer CropScience LP, Corteva Agriscience LLC., FMC Corporation, Gowan Company LLC, Nufarm Americas, Inc., Syngenta Crop Protection LLC, and Valent U.S.A. LLC. The UAPASTF, convened by industry, generates, submits, and/or shares/provides access to information and data to governmental agencies to address limitations in available regulatory information and to support risk assessment.

UAPASTF making progress toward stated goals

- 'Recommendations for conducting UAV off-site movement studies' released ((uapastf.com))
- Nine GLP off-site movement studies in 7 countries on 5 continents
- Building an off-site movement database
- Data analysis from UAPASTF field study program / database ongoing – looking for tripartite opportunities to develop empirical / mechanistic exposure models for regulatory exposure / risk assessment
- **Best Management Practices for Safe and Effective Application of Pesticides Using Unmanned Aerial Spray Systems (UASS) [*Version 1.0*] *Coming soon Sept 2024***

- Work on nondietary / occupational exposure has been initiated
  - in dialogue with regulatory agencies on goals / questions for 'job steps' survey
- Field crop residue program (*within input from* PMRA & *UAPASTF on study protocol*) implemented by Ag and AgriFood Canada & PMC
  - Bayer Crop Science provided the GLP test material & completed the analytical phase
  - Preliminary review of results demonstrate equivalency of ground & UAV applications