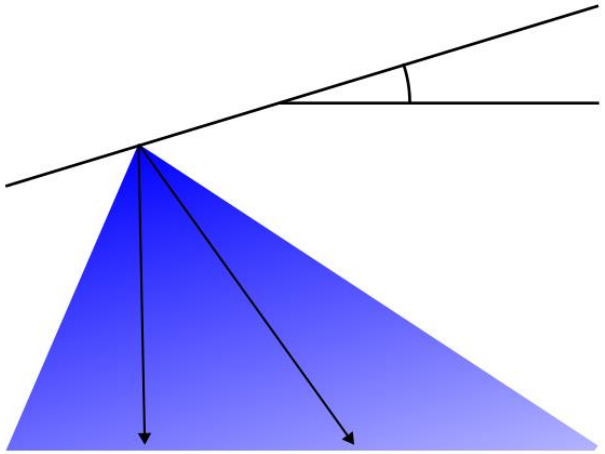

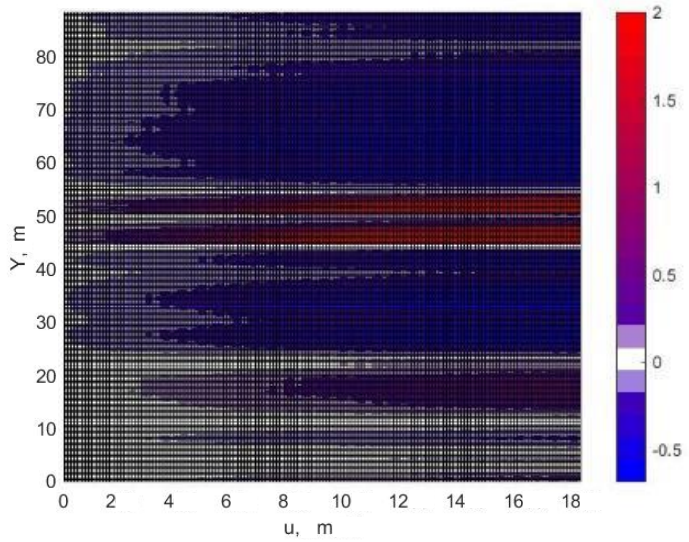

THE EFFECT OF BOOM LEVELING ON SPRAY DISPERSION

Travis Burgers [1,2], Miguel Bustamante [3], Juan F. Vivanco [3]

[1] Raven Industries, Sioux Falls, SD
[2] Department of Mechanical Engineering, South Dakota State University
[3] Universidad Adolfo Ibáñez, Viña del Mar, Chile

2023-02-07, SDSU Data Science Symposium

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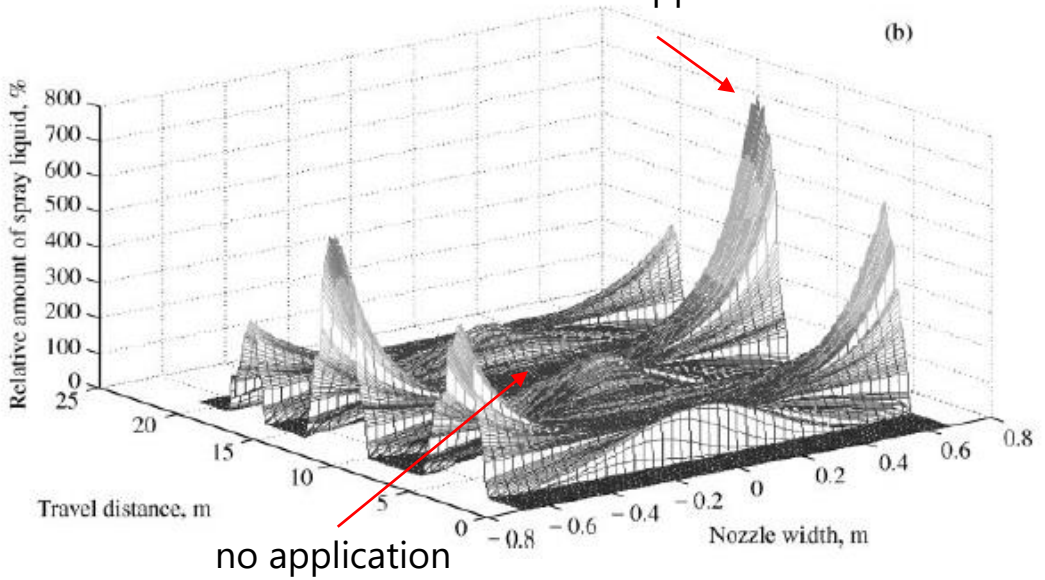
AGRICULTURAL SPRAYERS

- Agricultural sprayers
  - commonly used in agriculture to disperse herbicides, pesticides and fertilizers
  - generally consist of a centrally-located, self-propelled tractor and two boom wings
    - total sprayer width up to 48 m (158 ft)
  - have numerous nozzles over the length of the boom
    - commonly 51-cm (20-in) spacing

AUTOMATIC BOOM HEIGHT LEVELING

- Automatic boom height systems reduce the variability in boom height
- Problems if boom is too low
  - Uneven spray dispersion can occur
    - Streaking: a complete lack of application can occur near severe overapplication
      - up to six times the target rate (Lardoux et al. 2007, Clijmans et al. 2000)
    - Weeds can develop resistance to herbicides when they receive sublethal doses (Tehranchian et al. 2017)

6x overapplication



no application

Clijmans et al. 2000

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COMPARISON OF BOOM LEVELING SYSTEMS

- JD R4045
  - JD BoomTrac Pro (BT) versus Raven AutoBoom XRT
- RoGator 1100C
  - Norac UC5 Passive Roll versus Raven AutoBoom XRT
- 3 replicates x 3 speeds x 3 courses for each boom leveling system (Burgers et al. 2021)

WheelsAge

Ziegler CAT

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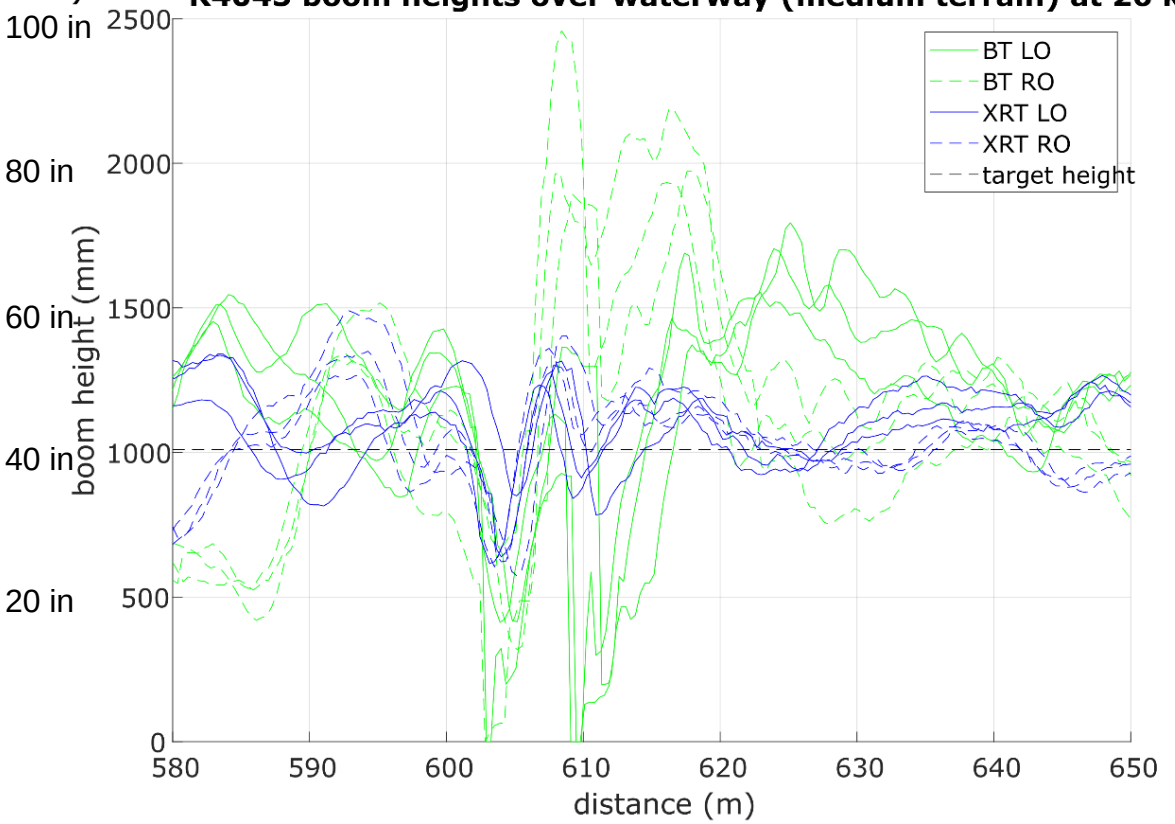
BOOM HEIGHTS OVER THE WATERWAY AT 26 KPH (16 MPH)

ALL MEASURED WITH XRT SENSORS

a)



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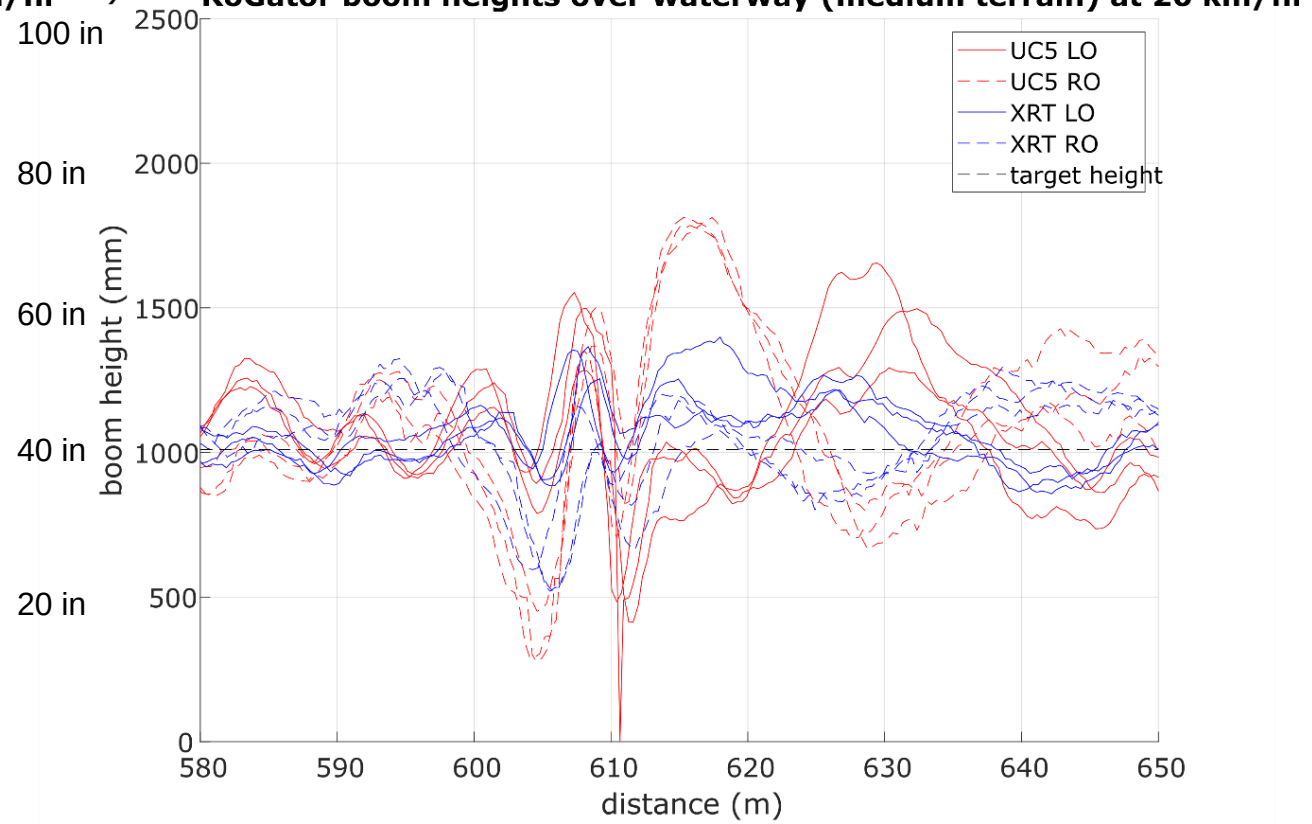

Burgers et al. 2021

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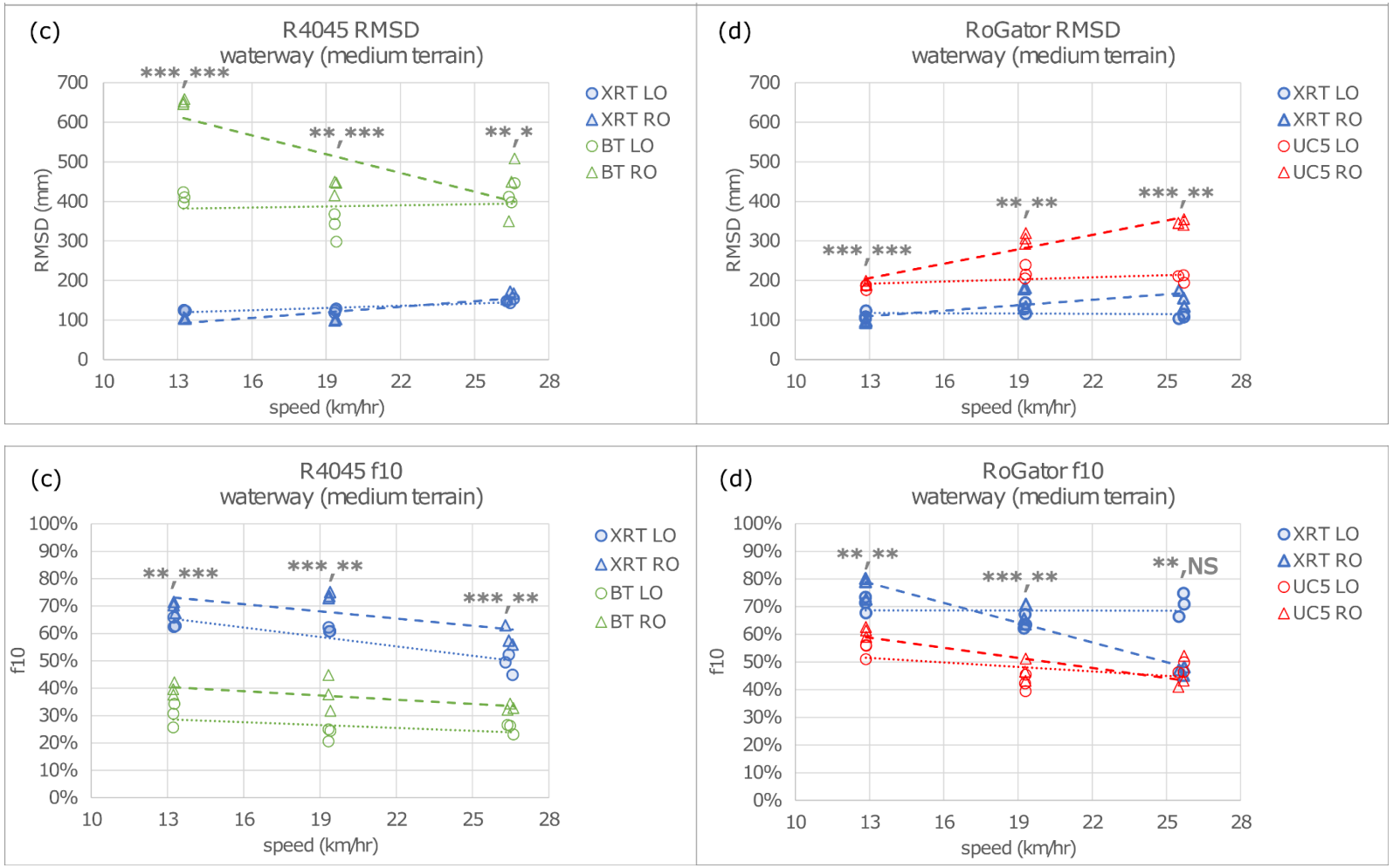
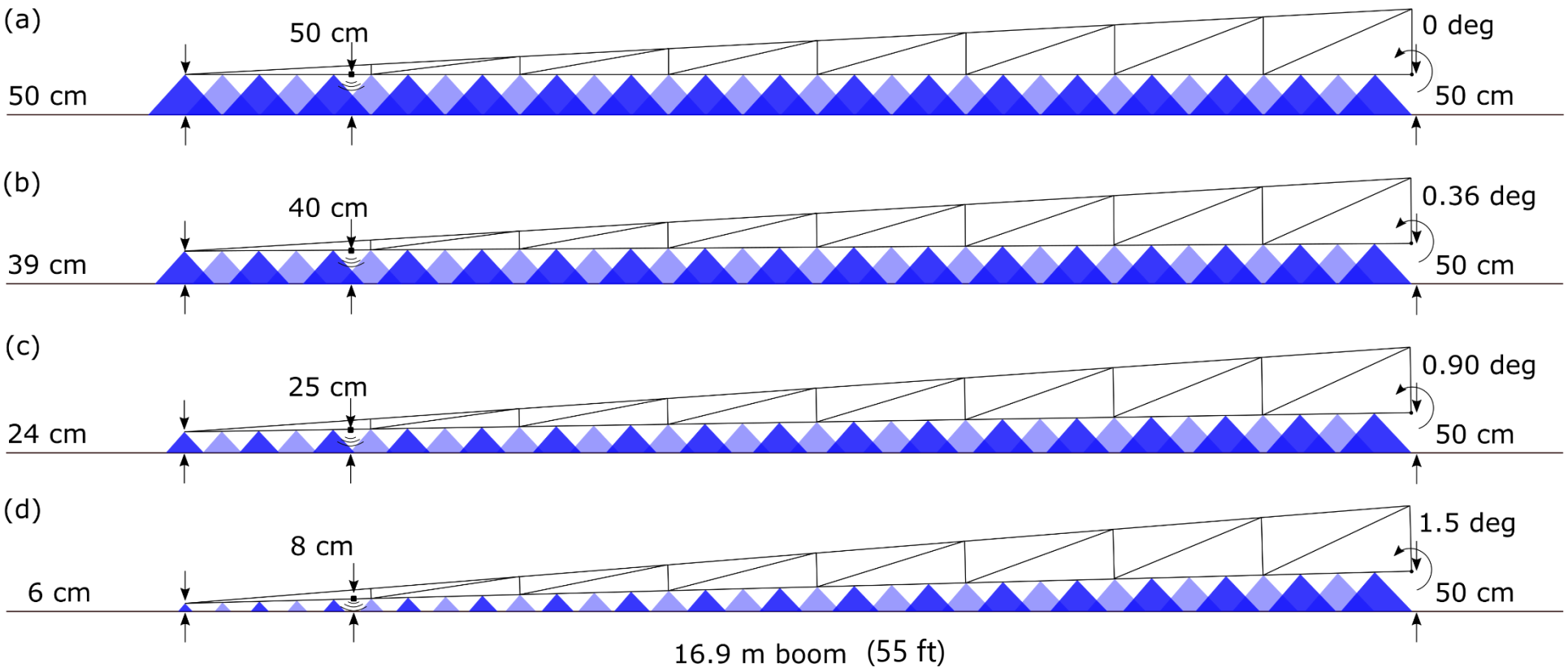
XRT IS LESS VARIABLE AND KEEPS BOOM CLOSER TO TARGET

- On all terrains at all speeds
  - XRT is less variable than BT and UC5
  - XRT keeps the boom closer to target than BT and UC5



Burgers et al. 2021

IMPLICATIONS: BOOM HEIGHT AFFECTS SPRAY DISPERSION



Raises question: how does boom leveling affect the spray coverage map?

Burgers et al. 2021

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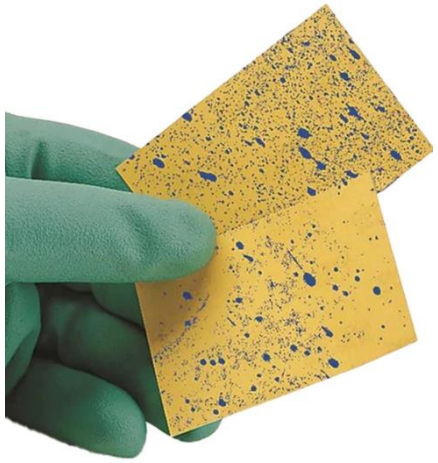
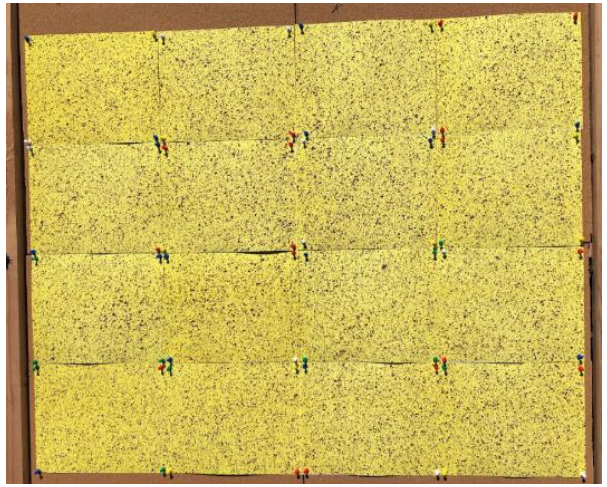
COVERAGE MEASUREMENT WITH WATER SENSITIVE PAPER

- Spray coverage can be measured with water sensitive paper
  - Cards are 2 x 3 in (5 x 8 cm)
  - Sheets are 9.5 x 11.75 in (24 x 30 cm)
- Expensive
  - $1–2 per 2 x 3 in card
- Requires post-processing to quantify results
- Not practical over a large area



gemplers.com



Ajay Sharda, KSU

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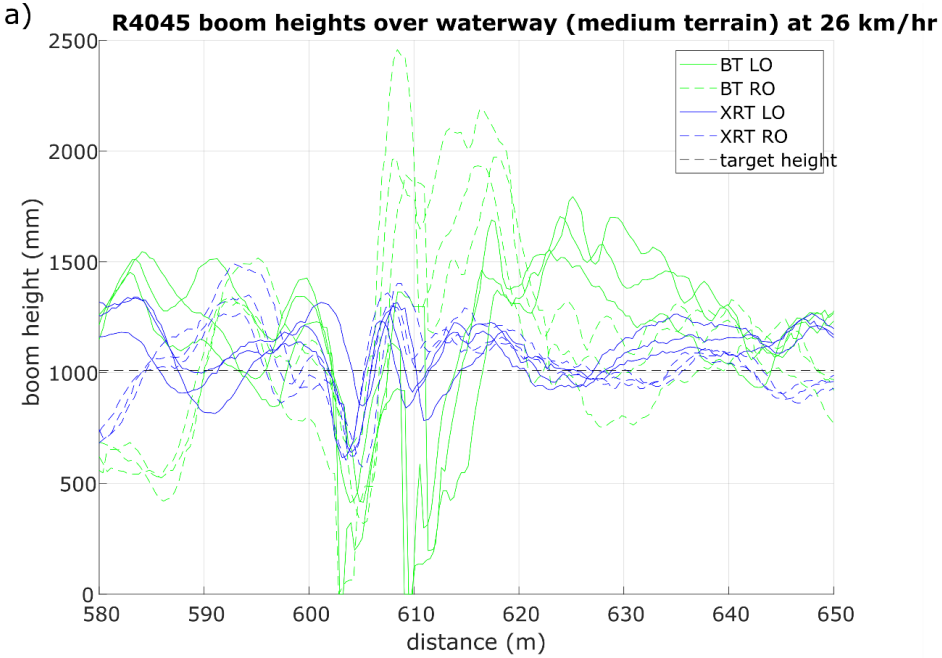
HYPOTHESIS

- **Limitation**: only have the *implication* that boom leveling improves consistency of spray dispersion
- **Objective**: create a computational model
  - Inputs: boom heights and sprayer position in time
  - Output: spray coverage maps
- **Hypothesis**: automatic boom height leveling systems that control height better will have more consistent spray coverage

a)



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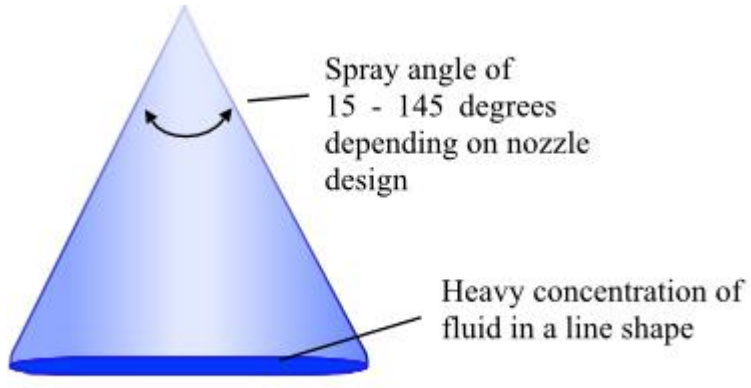
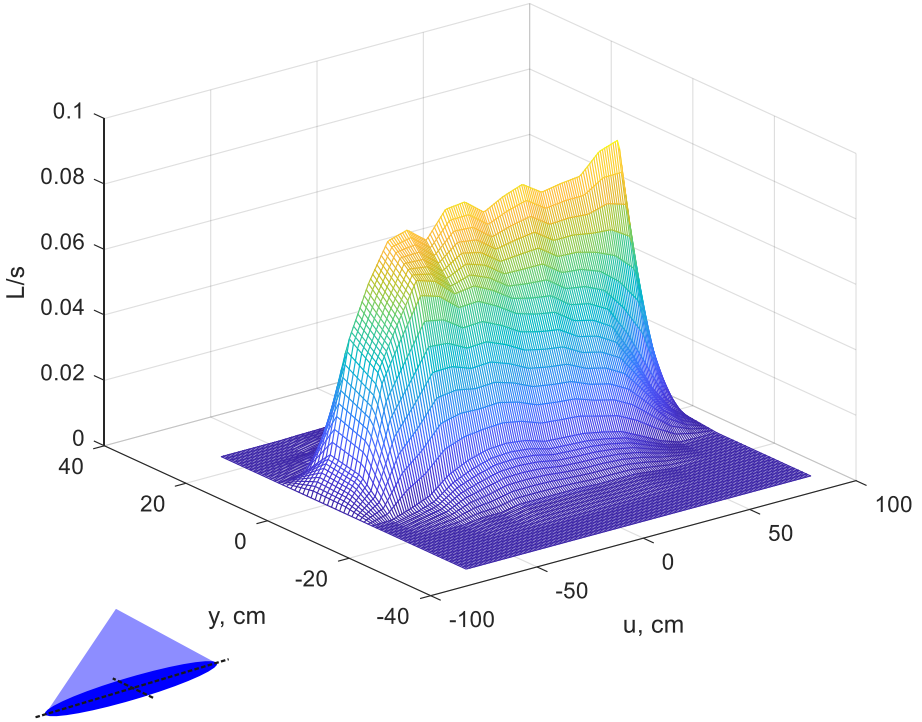
MEASURED SPRAY DISTRIBUTION FROM ONE NOZZLE

- Sprayed water from a flat fan nozzle at 20 in (50 cm) height
- Caught water in cups over a surface
- Weighed cup and calculated volume of water in each cup
- Calculated flow rate over surface

Jeff Doom, SDSU; Chapman and Doom (2021)

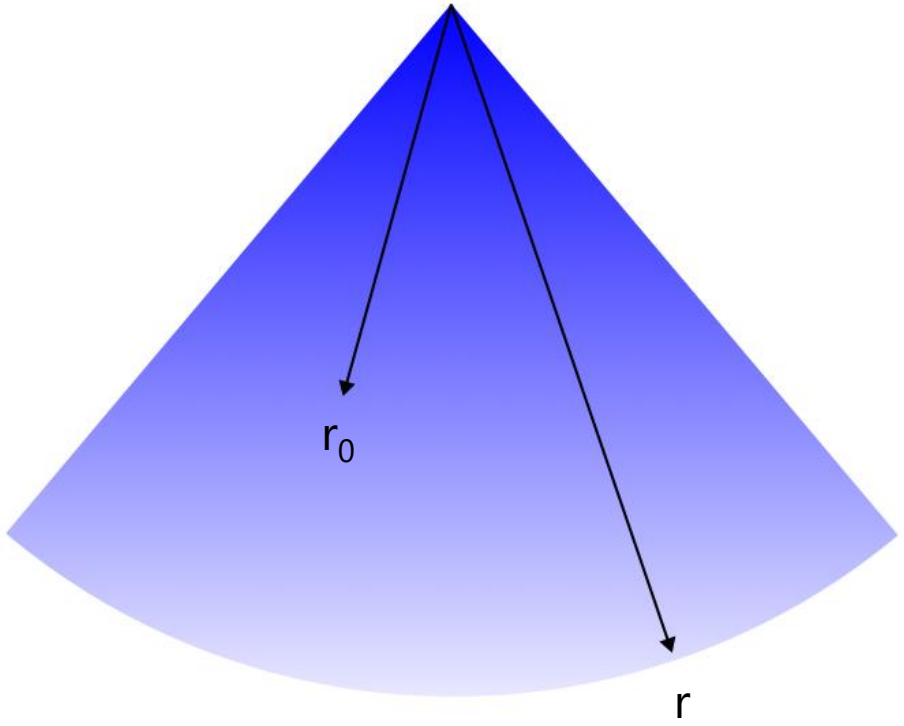


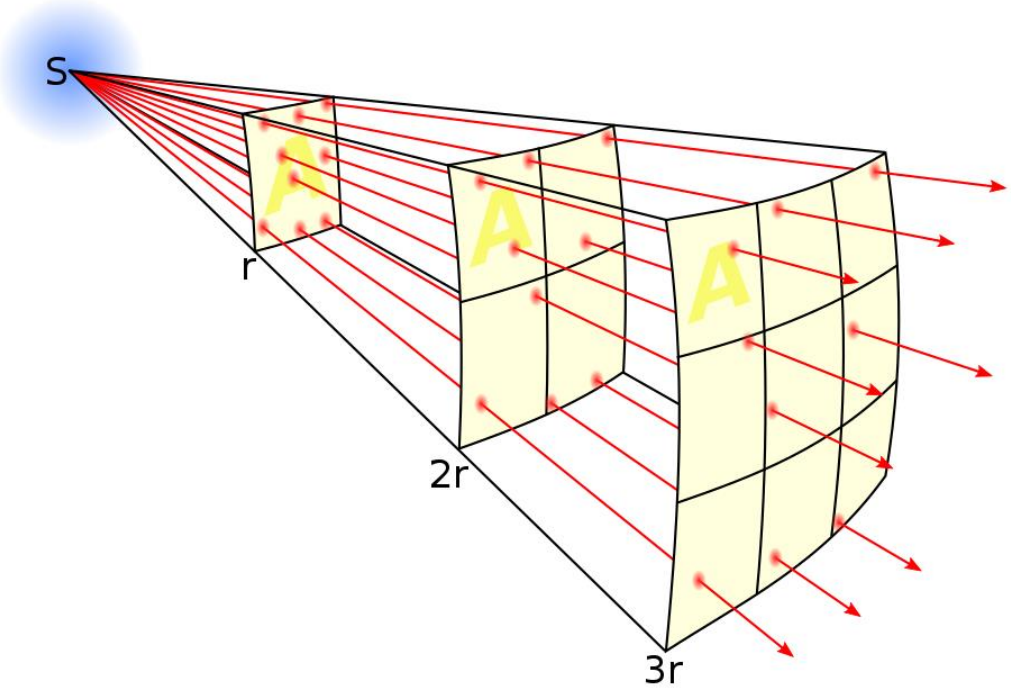
The Spray Nozzle People
spray-nozzle.co.uk



FLOW RATE IS INVERSELY PROPORTIONAL TO SQUARE OF DISTANCE

- Inverse square law – flux is inversely proportional to the square of distance
- $q_r = q_{r_0} \frac{r_0^2}{r^2}$
  - q_{r_0} is the measured flow rate at distance r_0
  - q_r is the calculated flow rate at distance r

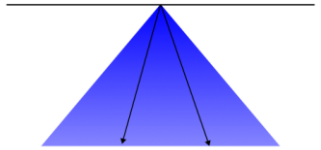




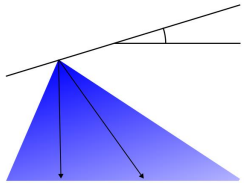
Borb, Wikimedia Commons

SPRAY DISTRIBUTION FROM ONE NOZZLE DUE TO ANGLED BOOM

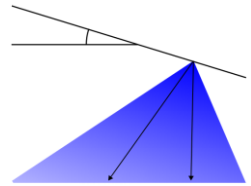
- Boom (nozzle) angle affects the spray distribution



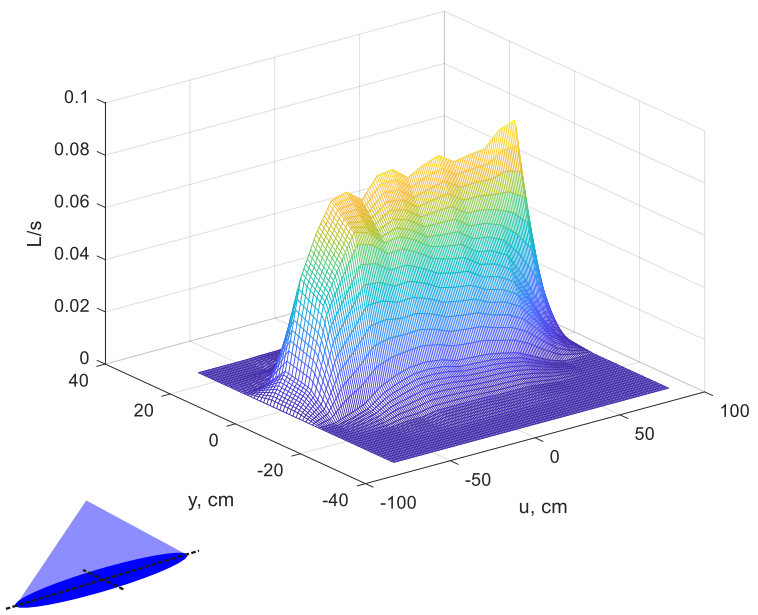
α = 0

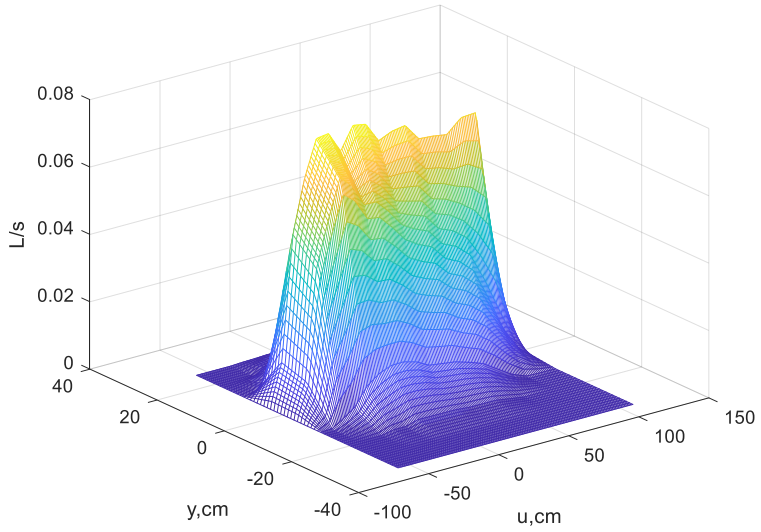


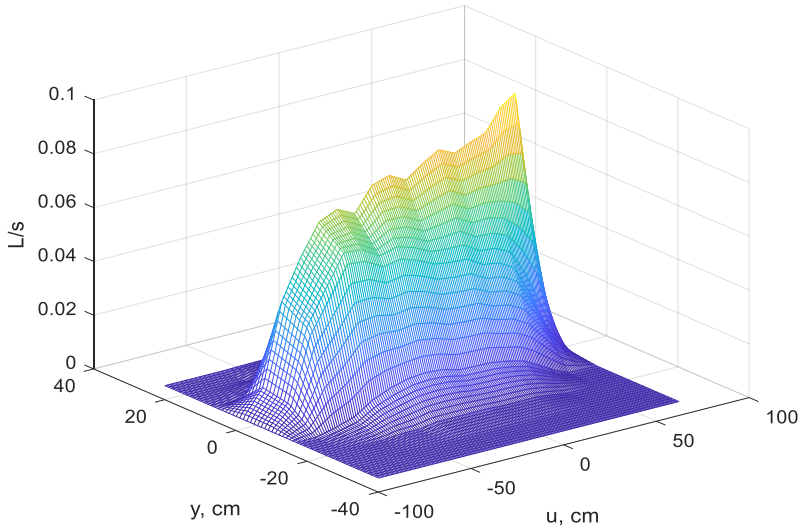
α = 0.1 rad (5.7 deg)



α = −0.1 rad (−5.7 deg)







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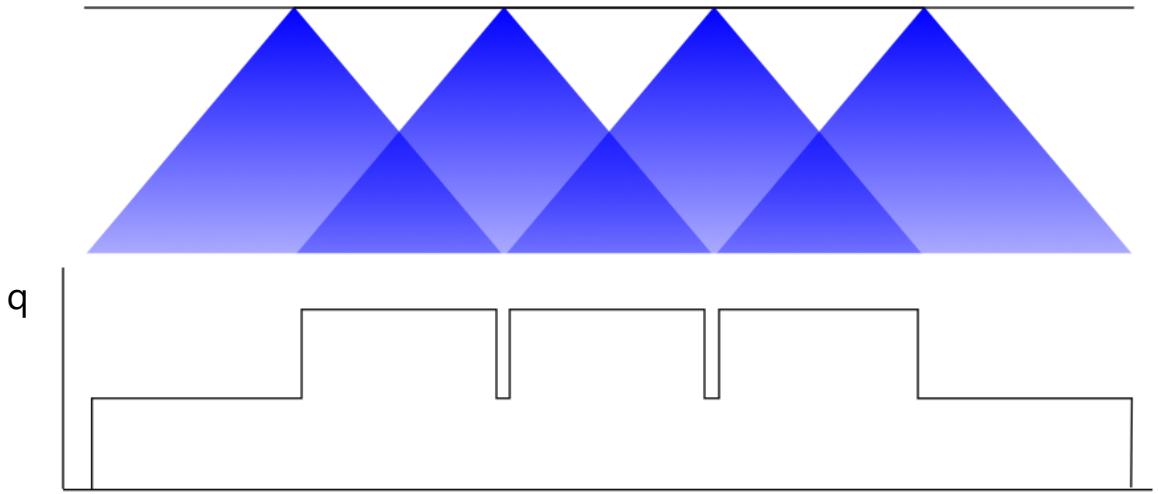
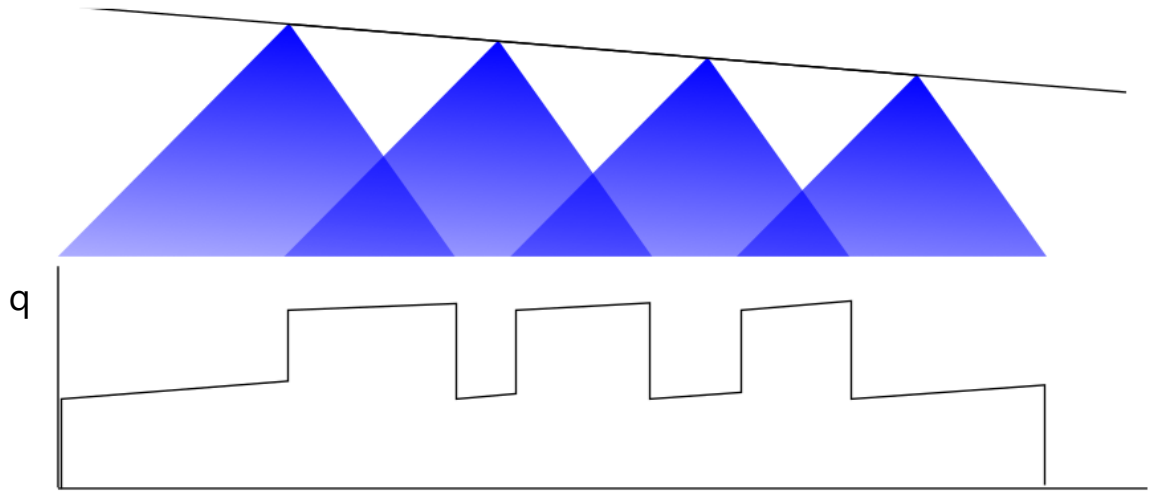
SUPERPOSITION OF SPRAY DISPERSION FROM MULTIPLE NOZZLES

- Applied superposition to multiple nozzles to calculate flow rate over coverage area





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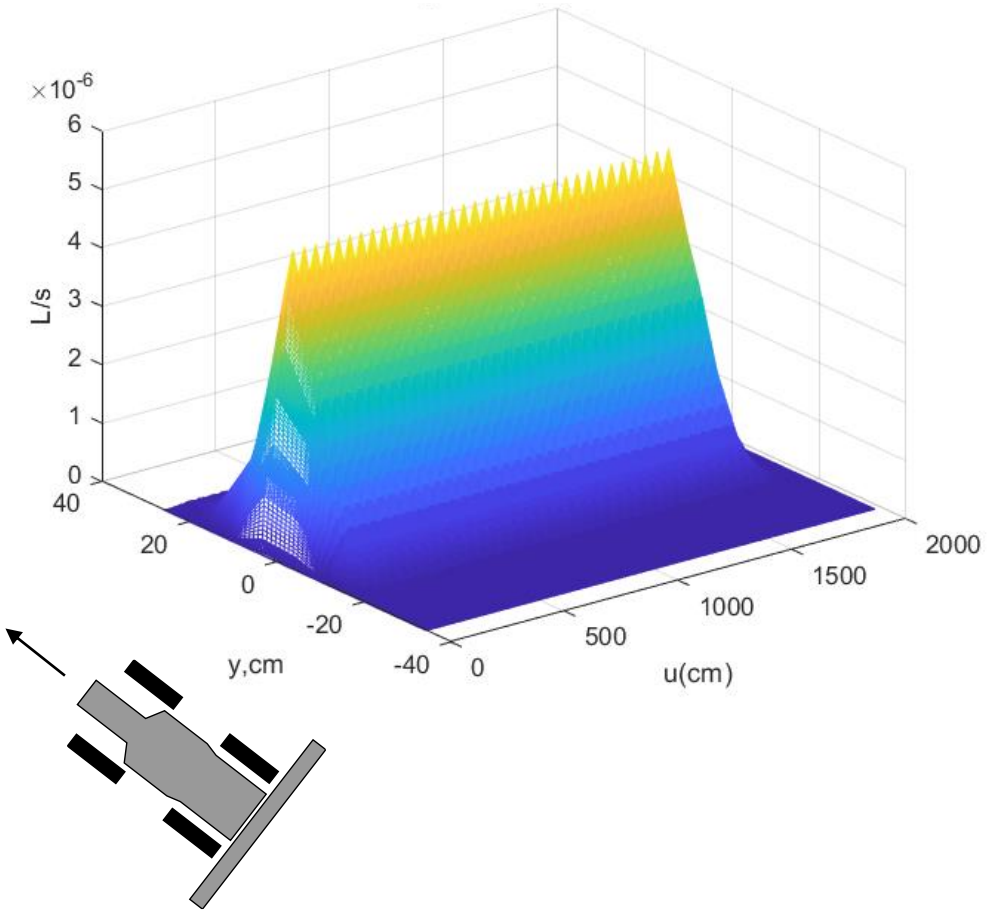
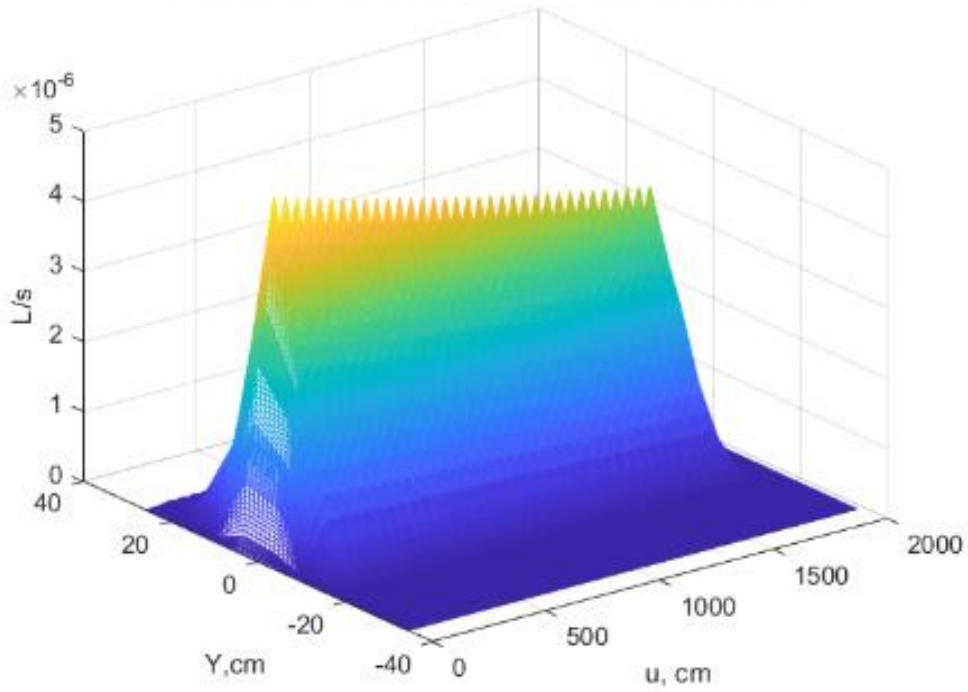
SPRAY DISTRIBUTION FROM MULTIPLE NOZZLES DUE TO ANGLED BOOM

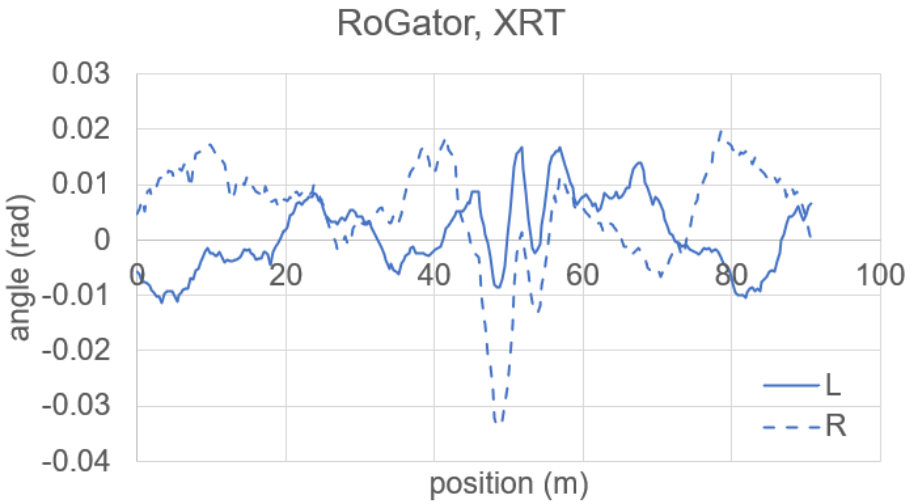
α = 0

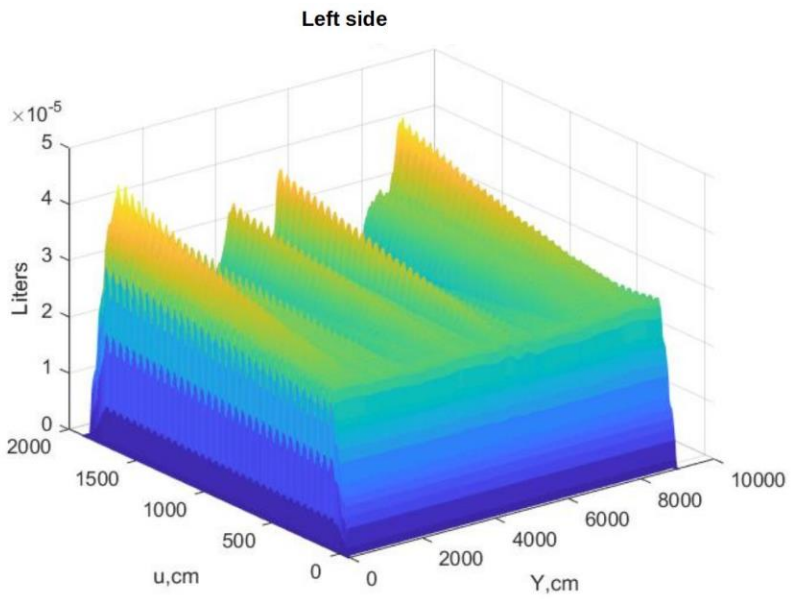


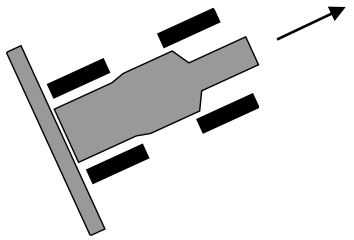
α = 0.01 rad (0.57 deg)

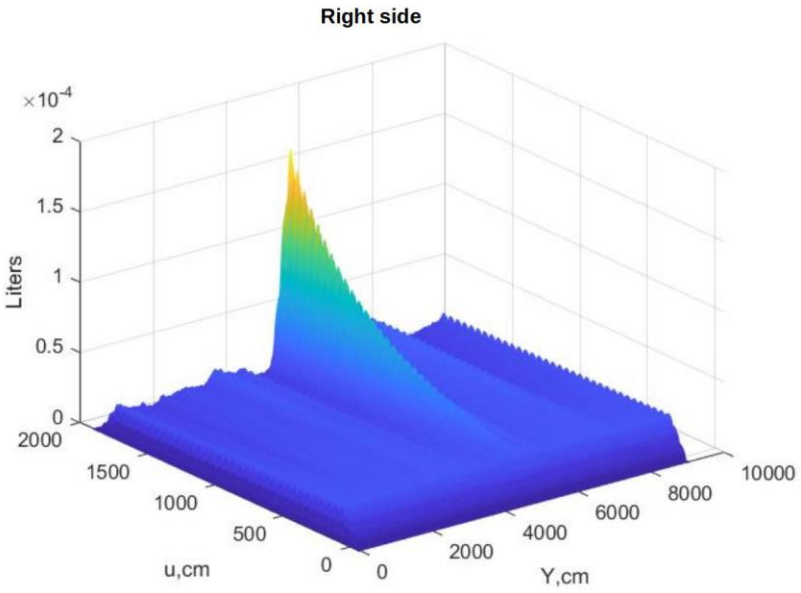


SPRAY DISTRIBUTION DUE TO MEASURED BOOM HEIGHTS



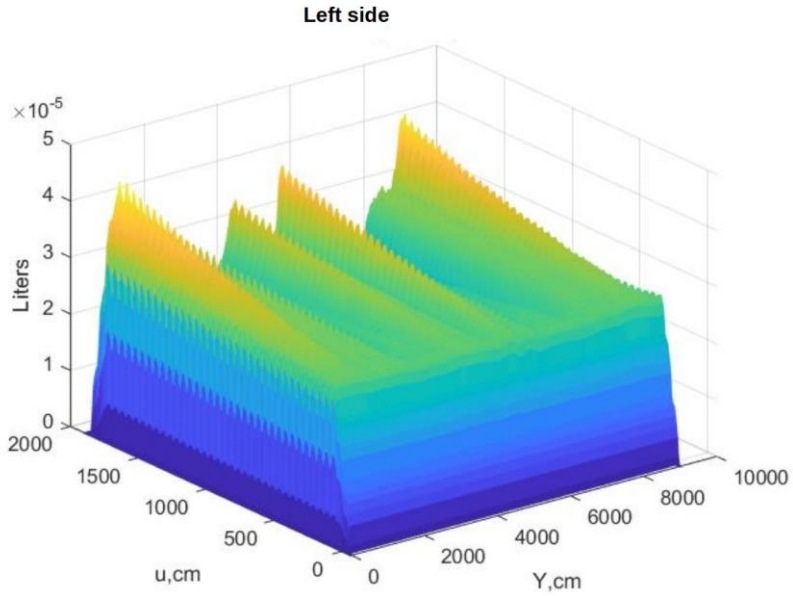






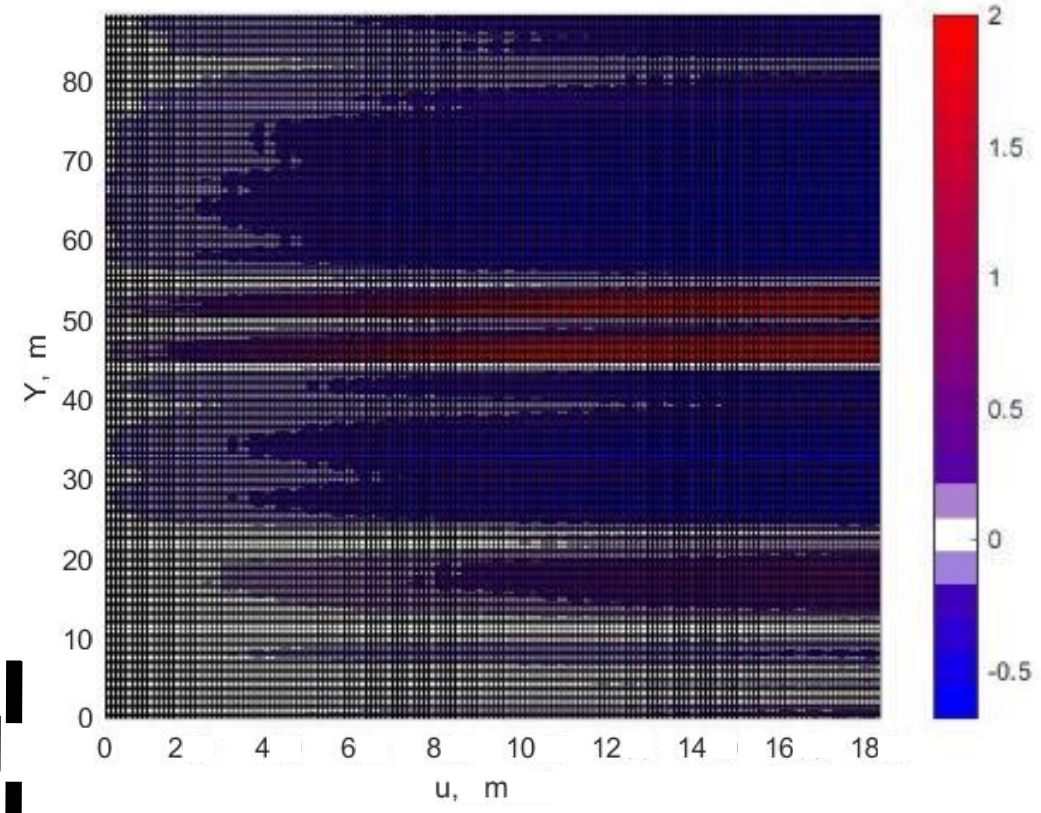
CALCULATED APPLICATION ERROR RELATIVE TO LEVEL BOOM

- $Application\ Error\ = \frac{V_{measured\ boom\ heights} - V_{level\ boom}}{V_{level\ boom}}$
  - $V_{measured\ boom\ heights}$ is volume from measured boom heights
  - $V_{level\ boom}$ is volume from level boom
    - Same course

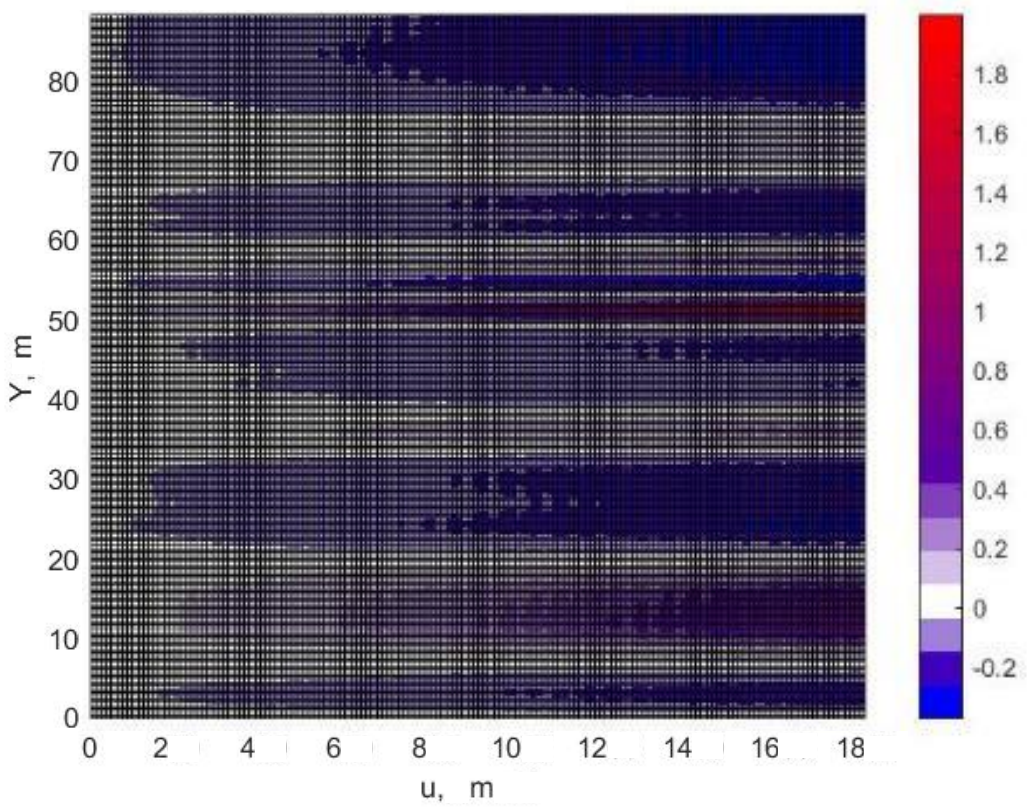


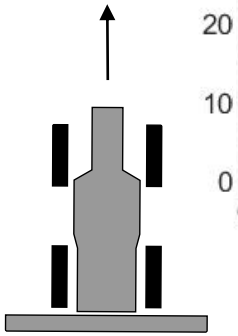
COVERAGE MAPS: APPLICATION ERROR RELATIVE TO LEVEL BOOM

R4045, BT



R4045, XRT





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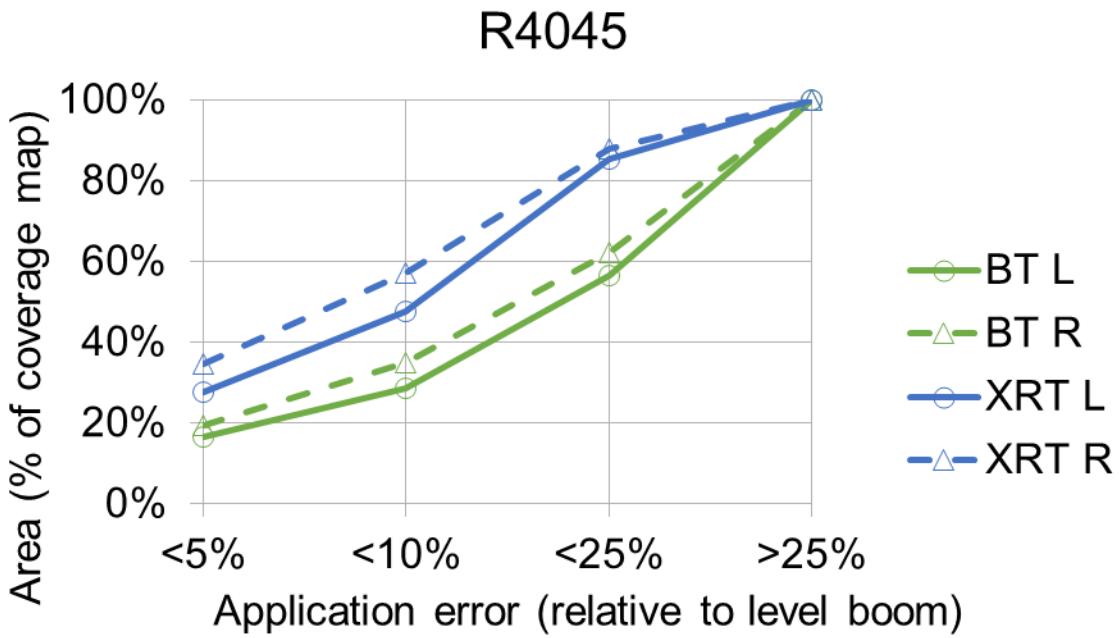
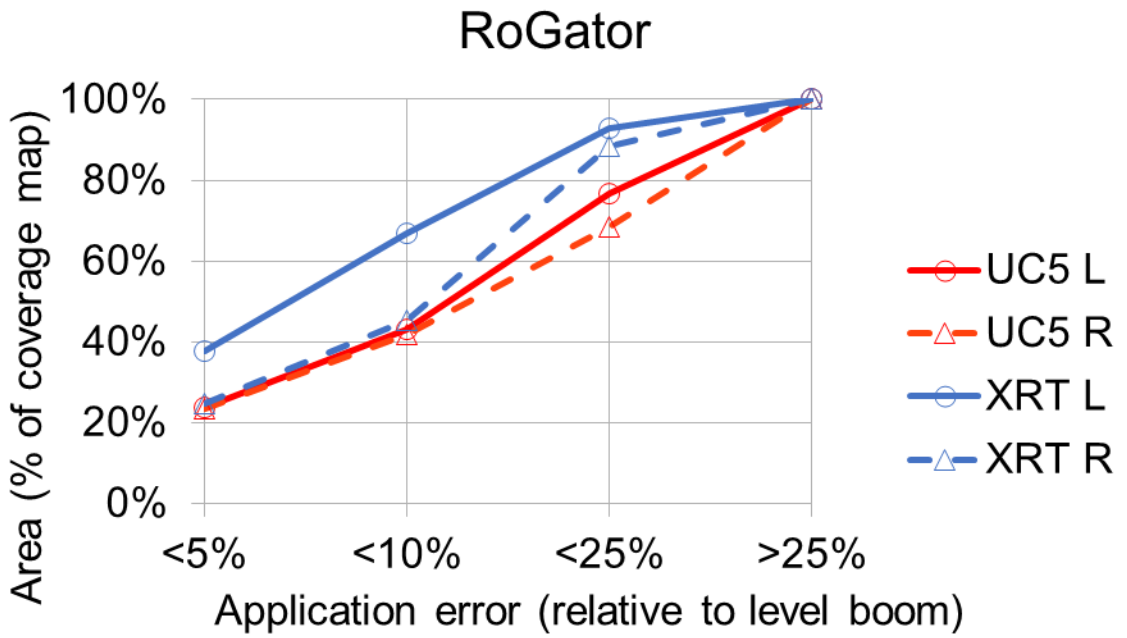
RESULTS: COMPARISON OF APPLICATION ERROR FOR 3 SYSTEMS





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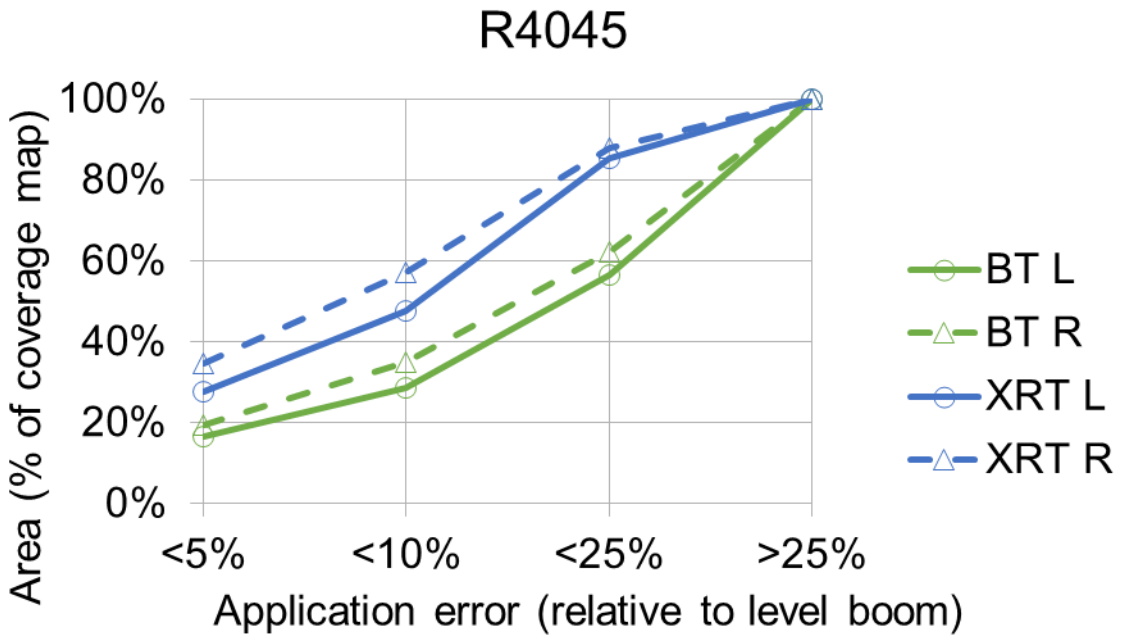
CONCLUSIONS AND NEXT STEPS

- Computational model effectively calculates coverage maps from boom heights and sprayer position
- Model can calculate application error relative to level boom
- Very preliminary result implies AutoBoom XRT improves spray dispersion coverage
  - Only one run from each system
  - Only one speed
- Next steps
  - Analyze more runs
  - Make a more thorough comparison between automatic boom leveling systems



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QUESTIONS/DISCUSSION

- Acknowledgement (single nozzle spray pattern)
  - Dr. Jeff Doom, SDSU

- Connect
  - Travis Burgers, Raven Industries
  - travis.burgers@ravenind.com

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