Modeling Spray Drift:

A Dispersion Model Case Study

Introduction

- Ongoing concern in WA State over pesticide use and potential impacts from spray drift
  - Potential acute or chronic health concerns for workers and residents who live in agricultural communities
  - Higher urinary levels of OP metabolite found in children residing near agricultural fields (Lowenherz et al. 1997, EHP, 105)
  - Volatilization off sprayed fields usually not included
    - Potential elevated risk estimates from vapor phase exposures (Lee et.al. 2002 EHP, 110, No. 12)
- When is drift a problem? (Is it a problem at all?)
- What does research tell us about conditions for drift?
- How can research inform current practices and policy?

Example of current rule on drift

- WAC 16-228-1220(4):
  - No pesticides shall be applied by aircraft or airblast sprayers to property abutting and adjacent to occupied schools in session, hospitals, nursing homes or other similar establishments under conditions that may result in contamination of these establishments or their premises.

Proposed Rule CR-102

- September 6, 2005
  - WSDA notice of proposed rulemaking (CR-102).
- Applicators would be required to give two days written notice before applying pesticides carrying a "Danger/Poison" label near schools, hospitals, nursing homes, and state-licensed adult or child day care centers when:
  - The application is made aerially or with an airblast sprayer, an outside fumigation, or by overhead chemigation methods.
  - The pesticide is applied on property that touches the property boundary (excluding a right-of-way). Notification applies to day care centers, not unlicensed or small-home child day cares.
  - The application site is within one-half mile of the touching property boundaries of one of the listed sites.
- December 30, 2005
  - WSDA withdrew the notice of proposed rulemaking re WAC 16-228-1220(4)

What is pesticide spray drift?

- Spray drift (EPA): Any *off-target* spray movement during or shortly after application.
- Orchard airblast spray drift: 1-30% of applied amount
- Many pesticides are acutely toxic to humans
  - 600+ cases/yr in CA of poisonings and unintentional exposures
  - 200+ cases/yr in WA
- Many pesticides cause adverse health effects at low-levels of chronic exposure
  - Neurological-cognitive deficits in children
  - Associated with cancer (Non-Hodgkins Lymphoma, Leukemia)
  - Reproductive & teratogenic effects

Pesticide Regulation

- Federal Insecticide Fungicide Rodenticide Act (FIFRA, 1947)
  - Mandated that pesticide use be regulated at the State level rather than by the Federal government
- EPA responsibilities:
  - Pesticide registration
  - Pesticide labeling ('Label is the law')
- Significant FIFRA amendment 1988
  - Required characterization of spray drift potential for all registered pesticides

The Spray Drift Task Force (SDTF)

- EPA + 39 pesticide manufacturers
  - Objective: Meet new *spray drift* requirement
  - Conducted field studies: aerial, forest, ground-boom, *orchard airblast* applications
  - **AgDRIFT** Model
- EPA Spray Drift Test Guidelines (1984, 1998)
  - All SDTF field studies followed guidelines
  - Encouraged:
    - Use of *perpendicular transects*
    - Sampling limited to fields adjacent to tree rows
  - *Potentially ineffective in capturing the full extent of drift*

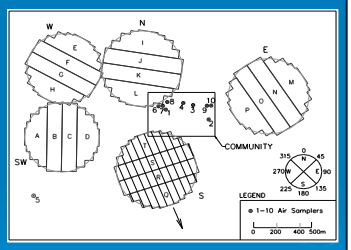
The AgDRIFT Model

- Separate components for
  - Aerial
  - Forestry
  - Ground-boom
  - Orchard airblast
- Orchard Airblast - empirical model
  - Based only on drift study data
  - No meteorology
- AgDRIFT's growing influence
  - Increasingly used for risk assessment and setting buffer sizes

WA Spray Drift Studies

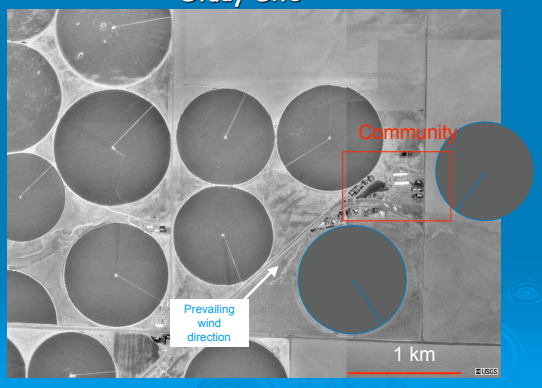
The Washington Aerial Spray Study (WASS)

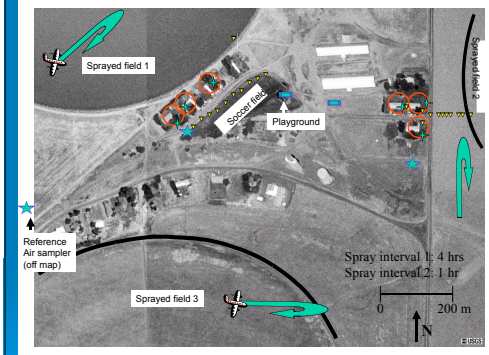
- Aerial application of OP pesticide (methamidophos) to potato crop in Eastern WA (Weppner et al., 2005)
- Deposition and vapor samples collected
- Analysis of air samples found high concentrations following the spray
- Attributed to **volatilization** off the sprayed fields at high temperatures (Ramaprasad et al 2004)
- Conducted modeling of the spray drift and post spray volatilization using a Gaussian plume model (Tsai et.al. 2005)



The WASDS study included families living in a farm community surrounded by potato, corn and wheat fields. The community had a centrally located playground and soccer field. The households that participated in the study were within 15 to 200m of the nearest treated field.

Study Site

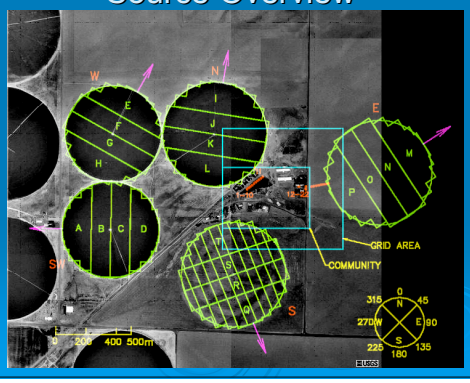


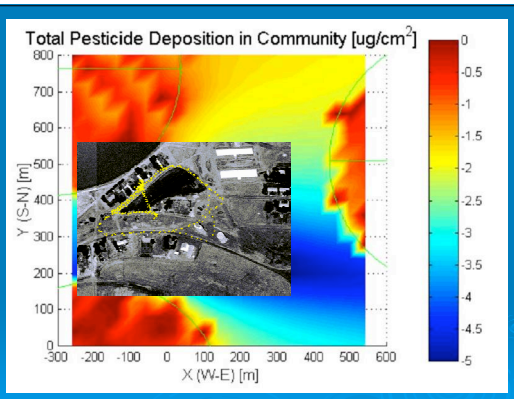


○ = participating home
▾ = deposition plate
▬ = 200 lpm air sampler
▾ = 30 lpm dual air sampler
✛ = 25 lpm air sampler
= airplane flight path

Sampler locations and airplane flight path

Source Overview

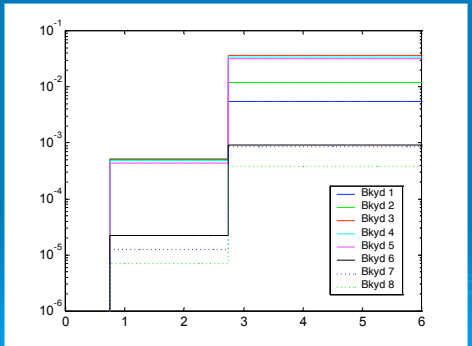




- Log_{10} Scale deposition values over area

Deposition over time

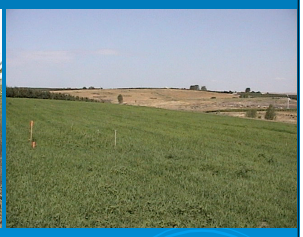
Cumulative Deposition in 8 Backyards



Washington Orchard Airblast Study

- Study site is an apple orchard in central Washington State.
- Four controlled orchard airblast applications of Phosmet over two days (9/2-3/2004, post-harvest).
- Deposition sampling (~80 plates for each spray event).
- Air sampling (twelve 25 lpm medium flow samplers).
- Scanning Lidar (laser radar) sampling at 355nm, 10Hz (4 seconds per profile).
- Two on-site meteorological stations.

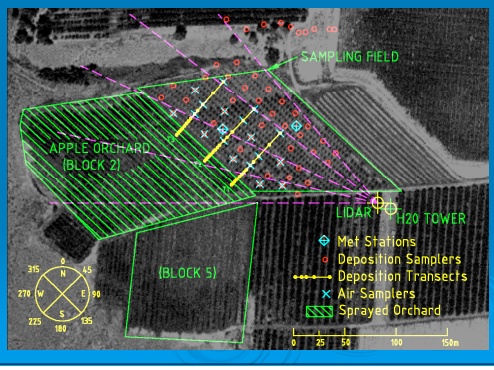
Prosser Images



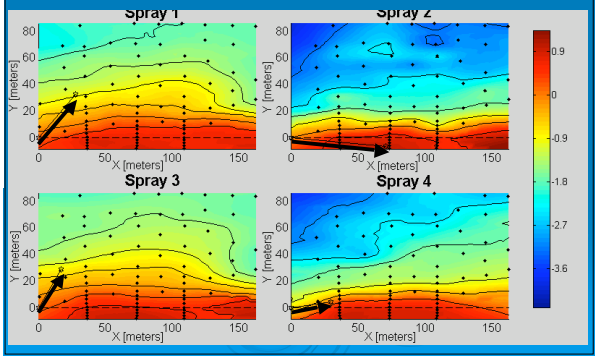
Prosser Images

Traditional Sampling Equipment

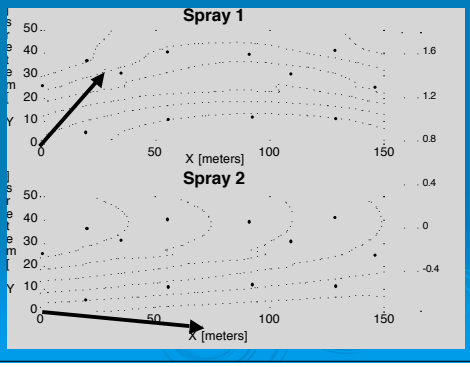
Prosser field overview



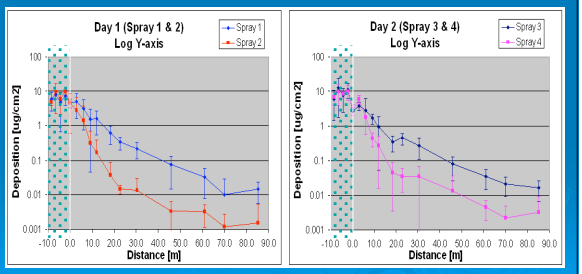
Deposition sample results



Air Sample Results



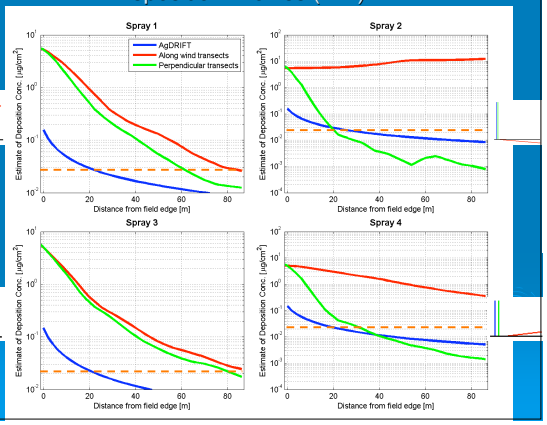
Deposition Transect Results



Shaded box shows deposition inside the tree canopy

Deposition Profiles (1-D)

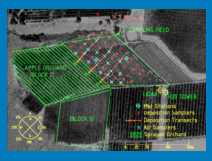
1-D

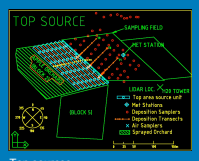


Orchard Spray Drift Model (OSDM)

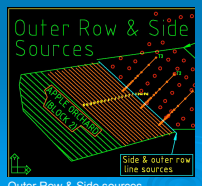
- Based on EPA's Fugitive Dust Model
  - Gaussian heavy particle model
- Include Meteorology (unlike AgDRIFT)
- Create complex source definition
  - Based on previous airblast field studies
    - Herrington et al. (1981)
    - Miller et al. (2003)
- Calibrate with particle size distribution

OSDM's 4 Sources

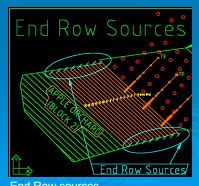




Top sources



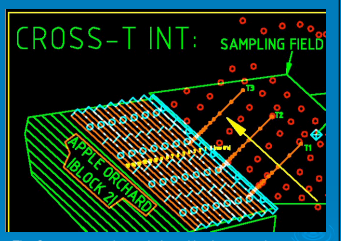
Outer Row & Side sources



End Row sources

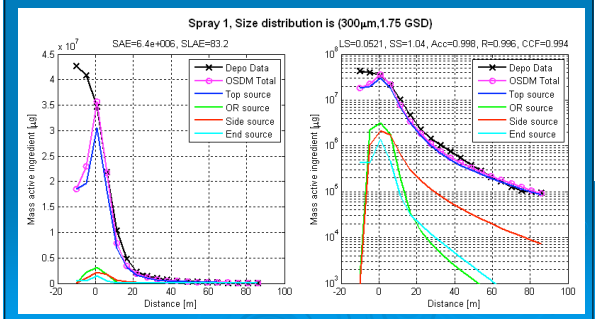
OSDM Model Calibration

- Calibrate OSDM by
  - adjusting size distribution and comparing the output with deposition data
- Use Cross-transect integral

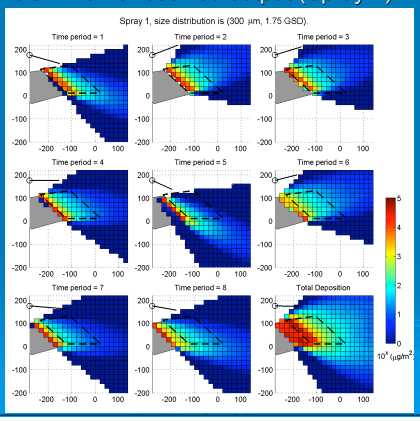


The Cross-transect integral: deposition is summed across The width of the sampling field.

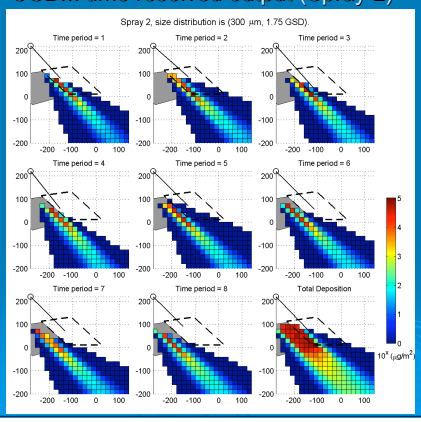
Calibrated Model (Spray 1)
(Cross-transect Integrals)



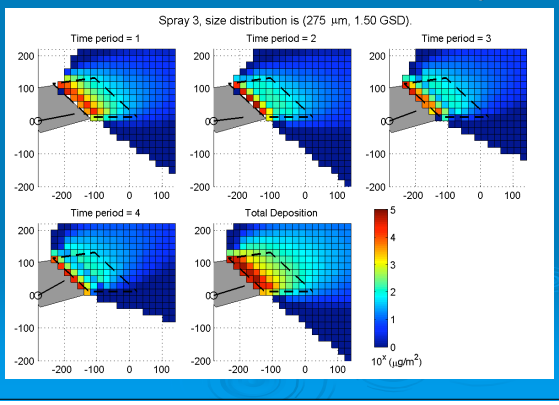
OSDM time resolved output (Spray 1)



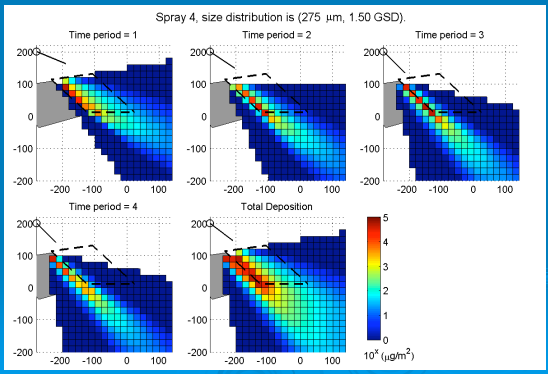
OSDM time resolved output (Spray 2)



OSDM time resolved output (Spray 3)



OSDM time resolved output (Spray 4)



Modeling Conclusions

- Can model spray drift from aerial or orchard airblast applications
- Time resolved model output:
  - demonstrated the importance of wind direction on drift (not considered in AgDRIFT)
  - predicted deposition beyond ends of the tree rows

Discussion & Conclusions

- Need to account for meteorology in a probabilistic way for forecasting
- Need to include details about spray methods and crop (define source)
- Need to define the endpoint – is deposition the only metric?
- How to account for multiple source terms?