Aerial Pesticide Spray Drift Models for Use in Regulatory Applications

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1. Introduction

Pesticide spraying is intended to kill a particular pest in the immediate spray area. However, there is concern that an important fraction of the toxic spray escapes the target area and drifts considerable distances to impact non-target areas (Reid and Crabbe, 1980).

Numerous interacting physical processes pertain to the fate of aerial sprays. Their relative importance depends upon the specific spray in question and the conditions of spraying (for example, spray height, meteorological conditions). Unfortunately, a good general treatment of spray drift allowing for all possible processes and interactions is far beyond the bounds of current knowledge (Reid, 1979).

2. Spray Drift Models

Various models have been developed to approximate spray drift. These models take one of three basic approaches:

(1) Gaussian dispersion models, such as the Cramer model used by U.S.D.A. Forest Service (Dumbauld et al, 1980).

(2) Gradient-Diffusion models, such as the N.R.C. model of Dr. R. Crabbe (Reid and Crabbe, 1980).

(3) Lagrangian-Monte Carlo models, such as the AES model of Dr. John Reid (Reid and Crabbe, 1980) and the similar model of Professor J. Picot (Picto, 1981) of the University of New Brunswick.

2-1. Gaussian Models

Gaussian models assume that spray drift is the same as plume dispersion. They use the Gaussian dispersion equations and Pasquill-Gifford dispersion parameters. They do not include turbulence directly in the model and generally do not contain enough physical equations. They are basically statistical models using equations that were originally developed for grassed, level surfaces. The model used by the U.S. Forest Service is this type of model (Dumbauld et al, 1980).

2-2. Gradient Diffusion Models

Gradient diffusion (or transfer) models are based on a simplifying assumption that introduces empirically derived constants to attempt to describe turbulence. Diffusion of the spray occurs due to a gradient in spray concentration using K theory. It has been found that gradient theory is inaccurate for short times and distances after spray release.

Professor Jules Picot at the University of New Brunswick developed a gradient diffusion model (Picot and Kristmanson, 1980), but then developed a more sophisticated lagrangian model (Picot, 1981).

2-3. Lagrangian Models

Lagrangian models attempt to calculate spray droplet trajectories from the spray release point to their impaction on the trees or the ground. For each droplet, a path or "jump" is calculated for each time step based on the assumption that the droplet responds to physical principles in the air flow, such as turbulent motion, gravitational settling and the horizontal wind.

A Lagrangian model developed by Professor Jules Picot (Picot, 1981) at the University of New Brunswick differentiates among droplets impinging on foliage, remaining in suspension or falling to the ground. His model is being sponsored by the Atmospheric Environment Service (Downsview) and is currently being validated against field trial results from New Brunswick. The model requires about 256K memory.

3. Conclusion

For use in regulatory applications, i.e., to estimate buffer zones around non-target areas, a spray drift model, or combination of models, must be chosen that will neither be unduly complicated nor overly simplistic. Also, none of these spray drift models can be treated like "black boxes". The approximations and assumptions that are made due to our lack of knowledge about turbulent processes imply that the results must be hedged by confidence limits and the input parameters must be carefully chosen. These models should not be run by people not knowledgeable about the working of the model if they have not been given guidelines on what values to input.

The recommendation is to hire a contractor who either is, or can become, familiar with the available models and who can determine how one, or a combination of them, can best be used for regulatory applications. The contractor could then develop guidelines on running the model for different situations.

4. References

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