TECHNICAL ADVANCES IN MODELING AERIALLY APPLIED SPRAYS

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ABSTRACT. *Since the 1989 publication of the original modeling approaches assembled into AGDISP, significant advances have been made in the development and validation of spray drift models. The latest version of AGDISP (version 8.08) now embodies the latest refinements to the computational engine first developed for NASA, improved by the USDA Forest Service, and implemented by the Spray Drift Task Force and the U.S. Environmental Protection Agency into a regulatory version. This article updates the previous summary of AGDISP, builds on a recent publication summarizing the regulatory version of the model, and includes the most recent modeling additions of atmospheric stability effects, vortical decay, simple terrain features, plant canopy, riparian barriers, and the aerial release of dry materials.*

Keywords. *Aerial application, Deposition, Drift, Lagrangian, Spray model.*

Over the last 25 years, a significant modeling and data collection effort has been undertaken by the USDA Forest Service and its cooperators to develop accurate, validated models that predict the behavior of pesticides applied by aerial application above forests (Teske et al., 1998b). The two models most focused on are the Lagrangian trajectory model AGDISP (Bilanin et al., 1989) and a Gaussian slanted–plume model, combined with AGDISP into FSCBG (Teske et al., 1993b).

In the mid to late 1990s, these efforts were supplemented by the Spray Drift Task Force, in response to re–registration of its agricultural pesticide products with the U.S. Environmental Protection Agency. In their collaborative effort with the USDA Forest Service and the USDA Agricultural Research Service, the Spray Drift Task Force developed a regulatory version of the Lagrangian trajectory model, identifying it as AgDRIFT (Teske et al., 2002a). An extensive field study (Hewitt et al., 2002) and model validation effort (Bird et al., 2002) confirmed the predictive capability of the Lagrangian computational engine that drives the near–wake solution scheme in all three models.

AGDISP 8.08 is based on a Lagrangian approach to the solution of the spray material equations of motion, and includes simplified models for the effects of the aircraft wake and aircraft–generated and ambient turbulence. Reed (1953) first developed the equations of motion for spray material released from nozzles on an aircraft. His insight was the realization that the wingtip vortices play a significant role in the subsequent behavior of the spray material released close to the aircraft. Vortex swirling behavior can be quantified by a simple model that, when combined with the local wind speed and with gravity, effectively predicts the motion of spray material released into it. The original AGDISP model included the innovative step of developing ensemble–averaged turbulence equations to predict the growth of the spray cloud during the calculations, eliminating the need for a random component in the solution procedure.

In this same time period, other researchers independently developed their own spray drift models, or contributed essential pieces to the modeling process. These authors include Williamson and Threadgill (1974), Bache and Sayer (1975), Trayford and Welch (1977), Frost and Huang (1981), Atias and Weihs (1984), Bragg (1986), Gaidos et al. (1990), Himel et al. (1990), Saputro and Smith (1990), and Wallace et al. (1995). Lagrangian modeling is now used to simulate fire retardant dispersal (Teske et al., 1999), chemical/biological cloud impact on helicopters (Quackenbush et al., 1997), and jettisoning of jet fuel at altitude (Quackenbush et al., 1994).

In spray drift modeling, the initial focus and original applications of the AGDISP model were primarily toward defining in–swath deposition patterns or as a near–wake model for forestry or other high–release applications where calculations for downwind deposition were made following a handoff from the Lagrangian calculations to a Gaussian plume algorithm (Teske et al., 1993b). The use of AgDRIFT as a tool for assessing off–field drift and mitigation of drift from low–flight applications for regulatory decision–making extended the Lagrangian model accuracy to approximately 800 m downwind (Teske and Thistle, 2003) and opened the door for improved solution handoff to mesoscale atmospheric transport models (Allwine et al., 2002). This article highlights the technical advances now included in AGDISP 8.08 and details the options that make AGDISP more applicable to a growing number of problems in the forestry community. Analytical model details are summarized in Appendix A.

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