OPTIMAL METHODS TO COMPUTE AIRBORNE FLUX FOR BUFFER ZONE ASSESSMENT

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As part of registration for many pesticides, it is necessary to document airborne flux (emissions) during and after pesticide applications. Ultimately, these data are used to model airborne concentrations around the field as an input to buffer zone assessment. Based on our experience in conducting field trials, the IHF method is often preferred in terms of compact field size and efficiency of data collection.

The standard IHF method is a simplification that uses a multi-level profile of airborne concentration and wind speed at a mid-field (central) location to approximate the average flux across the treated field. It assumes that by integrating the fitted functions of wind speed times airborne concentration at the central location as a function of height, and then dividing by the upwind fetch, that the average flux can be estimated. This of course is far easier than placing multiple masts across the full crosswind extent of the plume in order to conduct a complete assessment of the full cross-wind plane of the plume. While it is not feasible to measure concentration or wind in this fashion, this more direct approach can be simulated through dispersion modeling. The key question is: how well does the standard IHF treatment compare to the modeling analysis of the full cross-wind plane treatment of the plume as a function of field size and stability? The AERMOD[1] dispersion model was run to compute concentrations across the full crosswind plume at the mid-point of each field size to simulate neutral, stable, and unstable conditions. The plane was extended horizontally

[1] AERMOD computes concentration using a constant wind speed set to a near-surface height to model ground-level area sources. Since the IHF method accounts for the variability of wind speed as a function of height, the AERMOD concentrations used to simulate the profiles were multiplied times the ratio of the reference height wind speed (1 m/sec in this case) divided by the wind speed at each level of the profile, which acts to conserve mass.

and vertically to ensure that the entire plume was contained within the mid-field cross-wind plane. A normalized flux of 1 µg/m^2/sec was used to model the full extent of the mid-field crosswind plane and also with discrete receptors to simulate five-level IHF profiles at the mid-field location. Flux was estimated from the full-plane AERMOD treatment using comparable calculations as the IHF method except the crosswind extent of the area source was placed into the divisor in addition to the upwind fetch. Trapezoidal integration was used for the IHF and full plane integration. The AERMOD results were used to define the top of the profile height for each area establishing the top of the profile at 0.01 µg/m^3 during neutral conditions. Equal spacing in natural logarithm space was used to define the remaining bottom four levels.

Figure 1 presents the results of the comparative testing of the flux comparisons between the IHF method and the AERMOD simulation based on the full extent of the plume along the crosswind, mid-field plane. The perfect flux fit would match the AERMOD emission rate of 1.00 µg/m^3. Table 2 compares flux based on the IHF method with standard profile heights of 0.3, 0.6, 0.9, 1.8, and 3.0 m used in many field trials. The results show for neutral and stable conditions the IHF methodology has minimal bias for field sizes of 20 x 20 m to 40 x 40 m sources based on the AERMOD simulated concentration fields. For unstable conditions, these field sizes were 15-20 percent biased low. Unstable conditions, however, generally have favorable dispersion and in many cases do not result in worst case concentrations. Larger field sizes in the 100 x 100 m to 200 x 200 m range showed overstatement for stable and unstable conditions. Using lower profile heights for the largest source areas tested was found to reduce the positive bias of the IHF method for neutral and stable conditions.[2] Mass balance artifacts in AERMOD were observed for the smallest field sizes of 5 x 5 m and 10 x 10 m as shown in Table 1.[3] Based on these results, a minimum field size of 20 x 20 m with a mast height in the range of 1 to 1.6 m would allow for sufficient equilibration with the applied surface, which would be most applicable to an application method with clearly delineated edges to the treated zone

[2] Most applied fields show neutral conditions during nocturnal periods due to the higher heat capacity of the fields due to irrigation or tarping practices (Sullivan, D; and R. Sullivan, On-Field Dilution of Airborne Flux: Importance For Modeling Exposures, MBAO, Orlando, CA 2014).

[3] Future review may identify methods to resolve this deficiency, however, in most cases edge effects associated with the application would generally preclude fields <= 10 x 10m.

(e.g. drip irrigation). A one-half acre (40 x 40 m) area is preferred based on this analysis. Further refinement is recommended to expand on this initial review.

Table 1: Comparative Flux Results (IHF vs. Full Plane AERMOD run at 1 g/m^2/Sec

Field Size (m)	Atmospheric Stability	Source Matched Profile Heights (m)	IHF Treatment ($\mu g/m^2/sec$)	AERMOD Full Plane Treatment ($\mu g/m^2/sec$)	Percent Mass from Full-Plane AERMOD Treatment
5 X 5	Unstable	0.15, 0.19, 0.24, 0.31, 0.40	0.58	0.60	59.64
10 X 10	Unstable	0.15, 0.23, 0.36, 0.54, 0.82	0.70	0.81	80.74
20 X 20	Unstable	0.15, 0.28, 0.50, 0.90, 1.62	0.80	0.92	91.62
40 X 40	Unstable	0.30, 0.55, 0.99, 1.80, 3.26	0.85	1.00	99.62
100 X 100	Unstable	0.30, 0.68, 1.53, 3.43, 7.71	0.81	1.04	104.17
200 X 200	Unstable	0.30, 0.80, 2.08, 5.43, 14.17	0.71	1.04	103.61
5 X 5	Neutral	0.15, 0.19, 0.24, 0.31, 0.40	0.30	0.54	54.42
10 X 10	Neutral	0.15, 0.23, 0.36, 0.54, 0.82	0.65	0.76	76.37
20 X 20	Neutral	0.15, 0.28, 0.50, 0.90, 1.62	1.00	0.89	88.73
40 X 40	Neutral	0.30, 0.55, 0.99, 1.80, 3.26	1.00	0.96	95.75
100 X 100	Neutral	0.30, 0.68, 1.53, 3.43, 7.71	1.29	1.00	100.41
200 X 200	Neutral	0.30, 0.80, 2.08, 5.43, 14.17	1.37	1.01	100.75
5 X 5	Stable	0.15, 0.19, 0.24, 0.31, 0.40	0.22	0.53	53.46
10 X 10	Stable	0.15, 0.23, 0.36, 0.54, 0.82	0.59	0.76	75.71
20 X 20	Stable	0.15, 0.28, 0.50, 0.90, 1.62	0.99	0.88	88.32
40 X 40	Stable	0.30, 0.55, 0.99, 1.80, 3.26	0.98	0.96	95.56
100 X 100	Stable	0.30, 0.68, 1.53, 3.43, 7.71	1.44	1.01	100.52
200 X 200	Stable	0.30, 0.80, 2.08, 5.43, 14.17	1.76	1.02	102.17

Table 2: Comparison of Standard Profile with Profiles Matched to Plume Heights

Field Size (m)	Computed Flux with Matched Profile	Computed Flux with Standard Profile (0.3, 0.6, 0.9, 1.8, and 3.0 m)
5 X 5	0.30	0.04
10 X 10	0.65	0.39
20 X 20	1.00	0.80
40 X 40	1.00	0.98
100 X 100	1.29	0.91
200 X 200	1.37	0.78

Figure 1: Computed Flux Based on IHF Method with Matched Profile (Top) and Full Plane AERMOD results (Bottom)