UPDATES IN FEMS MODEL TO MORE ACCURATELY REPRESENT EXPOSURES FROM FUMIGANTS

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The Fumigant Emissions Model (FEMS) has been under development over the past four years to provide a refined method to compute buffer zones for agricultural fumigants. Initial modeling in FEMS was performed using the ISCST3 dispersion model. The limitations of ISCST3, however, during periods of low wind speeds / calm conditions is widely recognized. Advancements in meteorological data collection equipment used in recent field studies for agricultural fumigants, and the release of CALPUFF 6.0 (sub-hourly modeling capability) over the past year have provided a substantially improved basis to evaluate exposures and buffer zones from the use of agricultural fumigants.

Specific refinements made to the FEMS model over the past year have included the following:

1. Option to use the state-of-the-art CALPUFF 6.0 model at 5 minute resolution, which more realistically represents measured concentration fields around treated fields, and, thereby, provides more realistic assessment of buffer zones.

2. Improved, Monte Carlo-based processing of low wind speed / calm conditions when modeling long-term meteorological data sets. Through 8 field studies conducted over the past year, and supplemental meteorological data collected during the summer of 2006 in Arvin, California, low threshold wind data are now available to represent low wind speed conditions ("calm" conditions for standard wind sensors) in typical agricultural settings. The Metam Alliance is collaborating with technical staff from the California Department of Pesticide Registration to further refine the treatments of "calm" conditions in FEMS.

3. Added features to display distributions of exposures and buffer zones as a function of a range of exposure perspectives ranging from a one or two day basis to an annual basis.

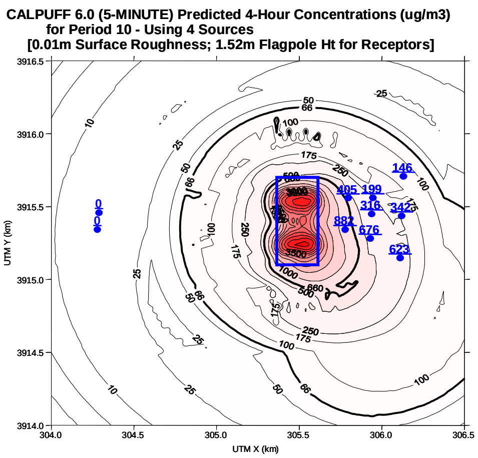
4. Improved matching of the start of the application to model averaging sequence. Resolution of seasonal carry-over issue noted by the California Department of Pesticide Registration

Examples of model refinements are summarized below:

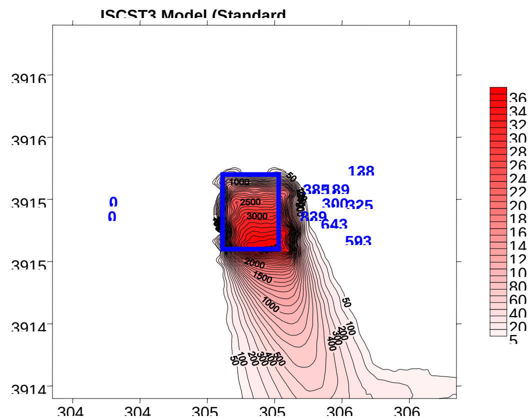
CALPUFF vs. ISCST3 Model Treatments

Figure 1: Comparison of Concentration Fields for a Four-Hour Period Based on CALPUFF 6 vs. ISCST3 (measured concentrations shown in blue)

CALPUFF 6



ISCST3



As shown in this representative example, CALPUFF is much better suited to replicate concentration fields during periods with low wind speeds, which are common during nighttime periods that are the most critical to buffer zone assessment. The ISCST3 model limitations can result in the spreading of the plume to be mischaracterized, with subsequent compensation in emission fitting by artificially increasing the magnitude of the emission term. CALPUFF 6 has been found to substantially reduce this bias, and thereby, improve the realism of buffer zones.

Example of Maximum Day Basis for Buffer Zone Assessment

FEMS has provided the option of basing buffer zone and exposure distributions on a range of periods from four-day active off-gassing period, to monthly, seasonal, or annual. Based on requests from EPA and the California Department of Pesticide Registration, a maximum 1-day basis for distributions (very conservative treatment) has been added to provide further perspective to risk assessors. An example of output based on this level of resolution is shown in Figure 2 in terms of buffer zone distributions based on a generic example.

Figure 2: Example FEMS Output Showing Buffer Zones Modeled Using Maximum Day as Basis for Percentiles (alternative base periods are available from 1 day to 1 year)

PERCENTILES BASED ON A 1 DAY PERIOD

BUFFER ZONES (METERS) FOR 12.50 % OF MAXIMUM APPLICATION RATE

	THRESHOLD (UG/M3)	
Percentile	66	660
25.00	0	0
50.00	0	0
75.00	70	0
85.00	140	0
90.00	190	0
95.00	330	0
97.50	560	0
98.00	620	0
98.50	680	0
99.00	780	0
99.25	990	0
99.50	1270	40
99.60	1390	70
99.80	1740	130
99.90	2350	160
99.92	2680	170
99.94	3040	180
99.96	3440	180
99.98	3890	190
99.99	4140	200

“Calm” Conditions

Wind Speed Treatment - Initial research has shown that during conditions that would be listed as calm (i.e. < 1 knot) for standard wind sensors at airport monitoring stations, the average wind speeds in agricultural settings is 0.31 m/sec, with a standard deviation in natural logarithm units of 0.448 m/sec. Within FEMS, the wind speed term during “calm” conditions is set to a best fit of 0.31 m/sec, with the probability distribution function based on sampling in natural logarithm units based on a sigma of 0.45. The sampling range for wind speed during calm conditions, therefore, is from 0.13 to 0.73 m/sec in original units.

Wind Direction Treatment – Figure 4 show the relationship that has been established as an interim approach to represent the increase in plume meander (presented as sigma theta (standard deviation of wind horizontal wind direction) as a function of the number of sequential 5 minute “calm” data blocks (fundamental modeling unit in FEMS /CALPUFF) occur:

Sigma Theta = 5.975 + 29.499 * Ln (# sequential calm 5 minute data blocks)

Figure 4: Example Logarithmic Curve Fitted to Estimate the Standard Deviation of Wind Direction as a Function of the Number of Sequential "Calm" 5 Minute Periods (Basis for initial Monte Carlo sampling of wind direction during calm periods)

Model Summary and Parameter Estimates

Dependent Variable: sigma

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Logarithmic	.972	276.324	1	8	.000	5.975	29.499

The independent variable is number_blocks.

Sigma = the standard deviation of horizontal wind direction, which is shown to increase as a logarithmic function of the number of 5-minute data blocks with "calm" data: