DRIPFUME: A VISUAL PROGRAM FOR SIMULATING FUMIGANT EMISSION AND MOVEMENT IN SOILS

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A Windows-based graphical user interface program (thereafter referred to as *DripFume*) was developed in visual basic (VB) to utilize a two-dimensional pesticide transport model (Wang et al., 2000) to simulate distribution and emission of volatile fumigant chemicals when applied through drip irrigation. *DripFume* provides an intuitive user interface by linking databases of soil and chemical properties to generate input files for the pesticide model, initiate model execution and monitor the simulation progress, and post-process the model output to graphical displays for easier interpretation (Fig. 1).

For the input, *DripFume* was configured to simulate any combination of up to three chemicals simultaneously to accommodate the possible need of fumigation with multiple chemicals. Physical and chemical properties of cis- and trans-isomers of 1,3-dichloropropene and chloropicrin for a typical medium-textured soil were available in the chemical database that can be selected as default values in the model input. If fumigants other than the three chemicals or for different soils are to be modeled, chemical properties of the new fumigants can be easily substituted during program initialization. A database containing transport properties of 12 soil series (from clay to sand, Carsel and Parrish, 1988) were created in *DripFume* as selectable sets of input values. Substitution is allowed if properties of an individual soil are known. Users of *DripFume* also have the option of selecting field geometries and application depths for their fumigation. The available field geometries are: flat field, 40, 42, or 80-inch wide beds; and the application depths are: 1, 3, 6, 8, 12, 18-inch from the soil surface. Users of the program also have the choice of selecting the duration of fumigant injection, total drip irrigation duration, and the duration of simulation to examine subsurface fumigation distribution patterns and surface emission losses. Other input options include selecting either one soil type or a two-layered soil profile, either with or without film cover, and with or without rain or sprinkler irrigation.

Output options in the post-processing of *DripFume* include data and graphs of cumulative volatilization loss, volatilization flux density, concentration profile by time for a selected location or by location for selected lapsed times after fumigant application. Cumulative volatilization is calculated as percent of cumulative volatilization loss over the total input integrated over the entire soil surface and displayed with a built-in automated program using Microsoft Excel (Fig. 2a). Volatilization flux density is calculated as the mass of fumigant lost to the atmosphere per unit surface area per unit time. To display fumigant

concentrations in the soil, five vertical cross-sections have been pre-selected according to distribution symmetry and log-distance from the fumigant source. Also, up to six elapsed times (after fumigation application) can be plotted on the same graph for each cross-section, and *DripFume* can internally find the nearest time output (to the targeted elapsed time selections) to plot the graph and automatically displayed in Excel (Fig. 2b). In short, the output options can provide an assessment for the spatial and temporal distributions of soil fumigants. This helps to determine the distribution uniformity or pest control efficacy in the soil. In addition to the pre-formatted graphical outputs, the data files are saved in Excel format, so the users can future process the raw data to create other graphical presentations that fit the users' specific needs.

A main function of the graphical interface program is to generate input files that would otherwise be manually created for the pesticide model. The steps of generating these input files are specially designed for fumigant application by subsurface drip irrigation. Comparisons indicated that exactly the same input parameters and data format were created using either *DripFume* or by manual preparation (Wang et al., 2004). Limitations on some of the soil parameters are inherent in the original code of the pesticide model, and the graphical interface program improved the pesticide model by providing warnings on parameter selections before model execution. The output selections were also tested by manually processing the raw data from model output. Exactly the same graphs were produced using the automated graphing capabilities of *DripFume*.

Although there are still limitations in selectable field configurations, the program should be useful in helping pesticide specialists, farm managers, or policy makers to optimize fumigant application to achieve the highest possible distribution uniformity and the lowest emission losses.

References:

Carsel, R.F, Parrish, R.S., 1988. Developing joint probability distributions of soil water retention characteristics. Water Resources Research 24, 755-769.

Wang, D., Knuteson, J.A., Yates, S.R., 2000. Two-dimensional model simulation of 1,3-dichloropropene volatilization and transport in a field soil. Journal of Environmental Quality 29, 639-644.

Wang, D., He, J. M., Knuteson, J. A. 2004. Concentration-time exposure index for modeling soil fumigation under various management scenarios. Journal of Environmental Quality 33, 685-694.

Fig. 1. Flow chart of the DripFume interface program.

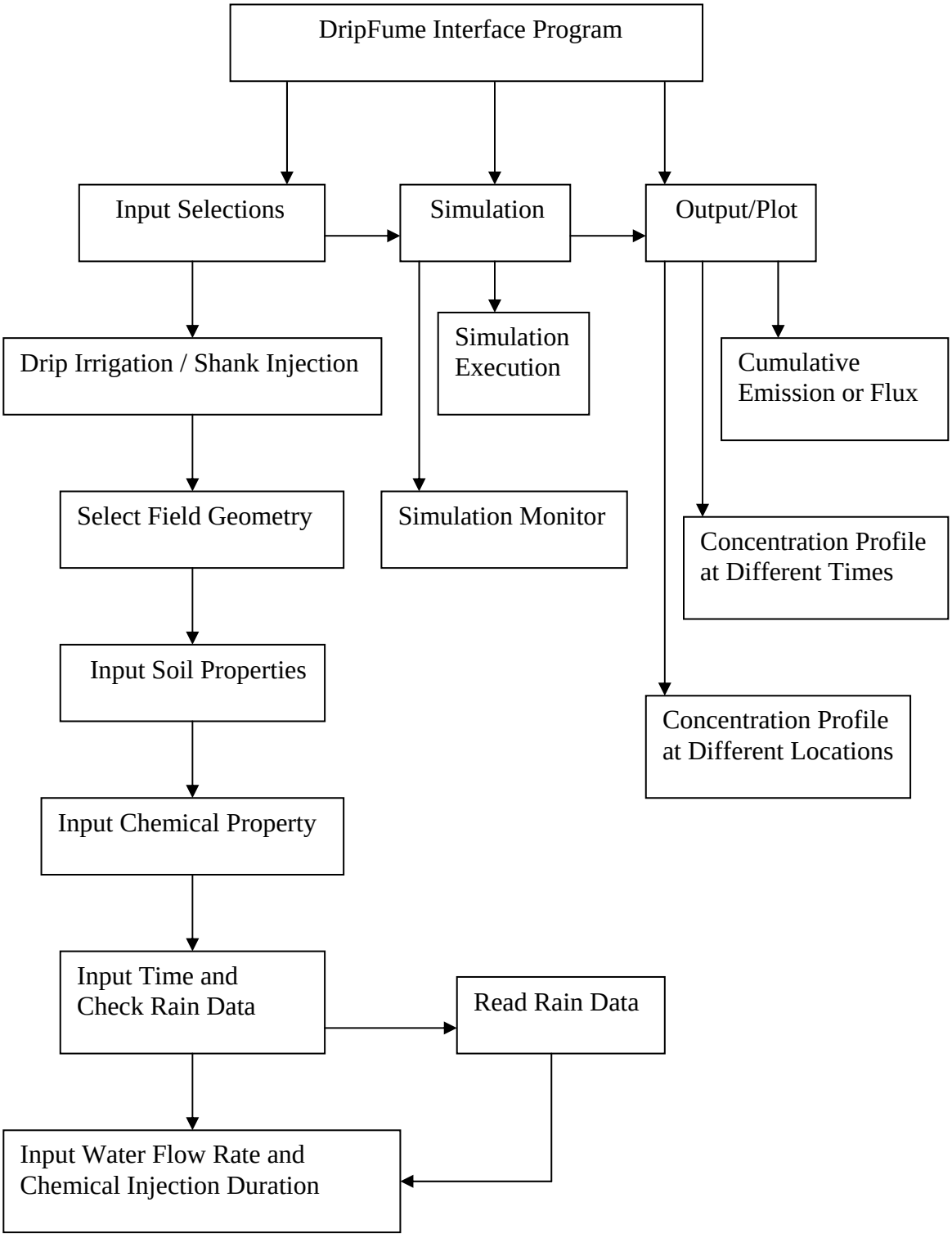
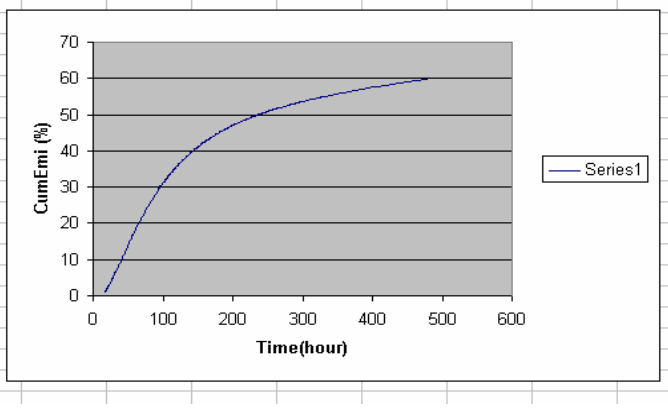


Fig. 2. Post-processing for automated Excel display of (a) cumulative volatilization loss over time, (b) gaseous phase concentrations over soil depth.

(a)

	A	B
1	Time(hour)	CumEmi
2	16.4448	1.036402
3	17.4624	1.27
4	18.4824	1.53234
5	19.5096	1.82226
6	20.5464	2.137267
7	21.6336	2.489325
8	22.668	2.840552
9	23.772	3.231653
10	24.768	3.594676
11	25.8408	3.996577
12	26.9808	4.434033
13	27.984	4.824636
14	29.0424	5.243317
15	30.1512	5.68775
16	31.296	6.151622
17	32.28	6.553024
18	33.324	6.98184
19	34.4256	7.437239
20	35.5992	7.925202
21	36.7992	8.425293
22	38.0328	8.942164
23	39.3504	9.494758
24	40.38	9.927894
25	41.4384	10.37316
26	42.54	10.8362
27	43.692	11.32084
28	44.892	11.82475



(b)

	A	B	C	D	E	F	G	H	I	J	K	L
Tageted T		4	16	24	120	240	480	hour				
Found T		4.8744	14.7072	19.6344	117.9024	238.1448	473.9904	(T1,T2,T3,T4,T5,T6)				
Y (cm)		Concentration,		X =	33.8	cm						
		4.9	14.7	19.6	117.9	238.1	474.0					
	0	0.00131	0.013776	0.026684	0.017416	0.004575	0.001579					
	1	0.013513	0.147286	0.346371	0.300714	0.074866	0.024702					
	2	0.02599	0.28756	0.682545	0.585273	0.145393	0.047886					
	3	0.038948	0.440737	1.0479	0.870313	0.216076	0.071148					
	4	0.052623	0.614438	1.451005	1.155179	0.28681	0.09445					
	5	0.067082	0.816379	1.897028	1.439161	0.357498	0.11779					
	6	0.082393	1.05285	2.38829								
	7	0.098442	1.328018	2.92511								
	8	0.114559	1.64369	3.50571								
	9	0.130116	1.998909	4.12520								
	10	0.14434	2.389604	4.77544								
	11	0.156402	2.808081	5.44562								
	12	0.165536	3.241919	6.1217								
	13	0.171125	3.674787	6.7860								
	14	0.172754	4.086555	7.41911								
	15	0.170218	4.455629	8.00018								
	16	0.163621	4.759731	8.50722								
	17	0.153418	4.977051	8.91913								
	18	0.140409	5.090394	9.21632								
	19	0.125625	5.087824	9.38198								
	20	0.110146	4.964574	9.40411								
	21	0.094942	4.723617	9.27563								
	22	0.080724	4.376602	8.99603								
	23	0.067906	3.944007	8.57283								
	24	0.056644	3.452417	8.020426	5.422654	1.5197	0.538826