DRIFTSIM, A User-Friendly Computer Program to Predict Drift Distances of Water Droplets

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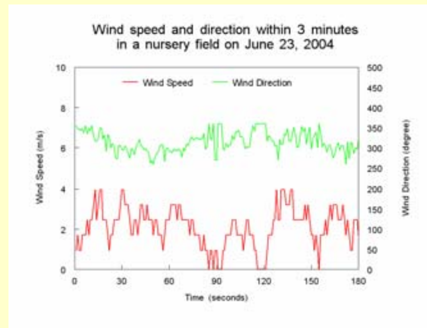
Introduction

Field experiments have the limitation that weather conditions, especially wind, cannot be controlled throughout the test period and can vary during a single pass with a sprayer. Terrain and vegetation also often vary among drift measurement sites and these can influence local wind conditions and drift deposits. Commercial available programs require a computer operator with special skills and a considerable amount of time to run the program.



Research Objective

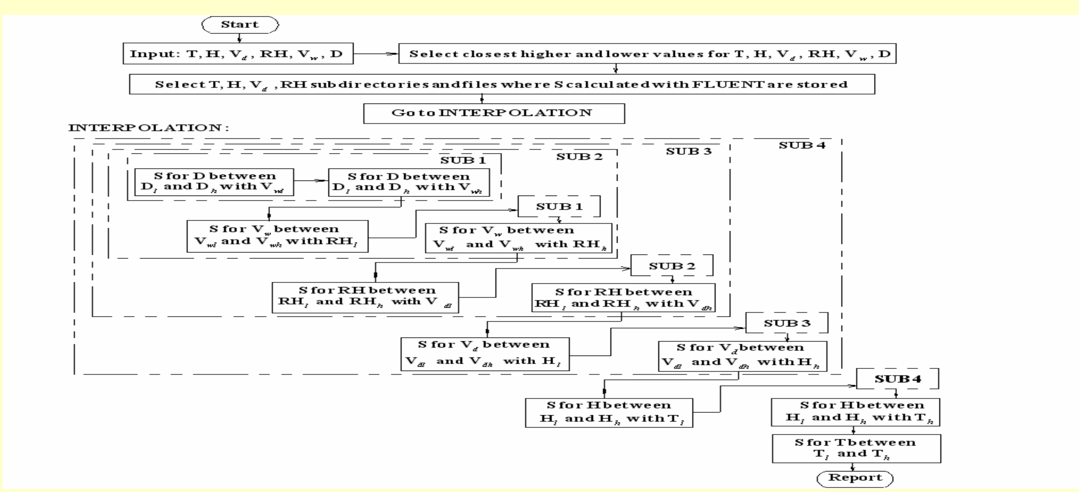
Develop an easy to use Visual BASIC language program, having a large internal data base of simulations with CFD system FLUENT, to calculate mean drift distances of water droplets up to 200 m (656 ft) from point of release under simplified field conditions.

Development of DRIFTSIM

A commercial available CFD program, FLUENT was used to calculate the mean drift distances of 100 water droplets for all combinations of values and all increments within the ranges of variables listed in Table below. Total 2,816,000 simulated mean drift distances were collected and stored in 3200 data files.

Variables and values used in simulations for database

Variable	Units	Range	Increment
Temperature	ºC (ºF)	10-30 (50-86)	5 (9)
Discharge height	m (ft)	0-2.0 (0-6.56)	0.25 (0.82)
Droplet velocity	m/s (ft/s)	0-20 (0-65.6)	5 (16.4)
		20-50 (65.6-164)	10 (32.8)
Relative humidity	%	10-100	10
Wind velocity	m/s (ft/s)	0-10 (0-32.8)	0.5 (1.64)
Droplet size	µm	10-100	10
		120-300	20
		350-1000	50
		1100-2000	100



Development of DRIFTSIM -- *continued*

DRIFTSIM contains four subroutines (SUB 1-4) that are repeatedly used to interpolate new drift distances for the combinations of each lower or higher value of one input variable with both lower and higher values of all other input variables.

(1) Determine the closest higher and lower value subdirectories and files for each variable. (2) Search for the corresponding drift distance for each combination of the above lower or higher value of each variable with both lower and higher values of all other variables in the data files. (3) Repeatedly interpolate with the four subroutines (figure 1) for a new drift distance using the following equation.

$$S = S_l + (S_h - S_l)\frac{M - M_l}{M_h - M_l}$$

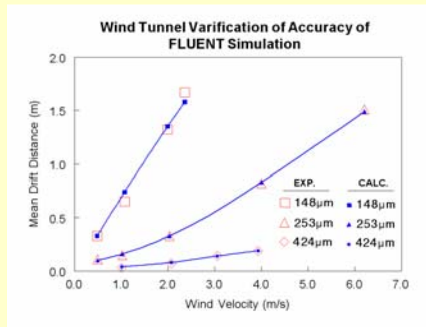
Accuracy of DRIFTSIM

Comparison of drift distances calculated with FLUENT and DRIFTSIM

T=20ºC, RH=55%, H=0.53 m, V_d=25 m/s

Droplet size	Wind velocity	Drift distance (m)		Diff.
µm	m/s	FLUENT	DRIFTSIM	m
15	5.0	3.00 *	3.40*	0.40
15	10.0	4.82 *	5.49*	0.67
110	5.0	5.00	5.24	0.24
110	10.0	10.20	10.65	0.45
325	5.0	0.07	0.08	0.01
325	10.0	0.14	0.17	0.03

* Droplet completely evaporated before deposition.



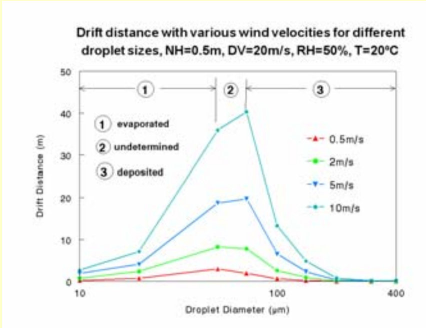
Limitations of DRIFTSIM

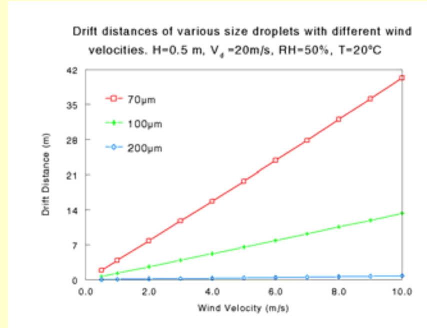
(1)Drift distances of droplets predicted by FLUENT and DRIFTSIM will not be exact for field applications because values of some variables usually are not precisely known and change during field applications. (2) DRIFTSIM calculates the mean drift distance of 100 droplets with 20% turbulence intensity. However, due to turbulence there is a range of drift distances for specific values of the other variables. (3) DRIFTSIM may not accurately predict drift distances of very small droplets when their drift distance is between two points where the droplet at one value completely evaporated before deposition or drifted beyond 200 m (656 ft), and the droplet at the other value deposited. (4) If the spray mixture contains a large portion of material that evaporates much more slowly than water, the drift distances of small droplets could be different from that predicted by the program. (5) In spray cloud, small droplets may not evaporate as fast as the program predicts for individual droplets. (6) The program should only be used to simulate drift distances of droplets from field sprayers without air assistance. (7) DRIFTSIM is also setup to only consider the initial vertical velocity component of the droplet. If the droplet has a large initial horizontal velocity component, its drift distance could be different from the distance predicted by DRIFTSIM.

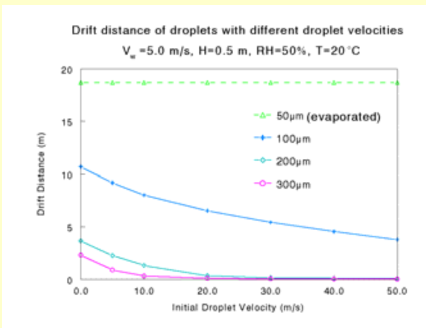
Summary and Conclusions

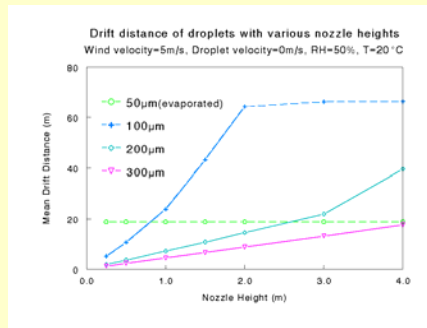
The drift simulation program, DRIFTSIM in Windows version was developed to predict the drift distances of individual droplets for a wide range of conditions including droplet size, discharge velocity and height, wind velocity, relative humidity and temperature. The program prompts the operator for values of all variables without much computer experience. Many inexpensive, portable computers would be sufficient to run DRIFTSIM. The program indicates relative effects of the input variables on drift distances and should, especially for large droplets, provide reasonable accuracy for many field applications.

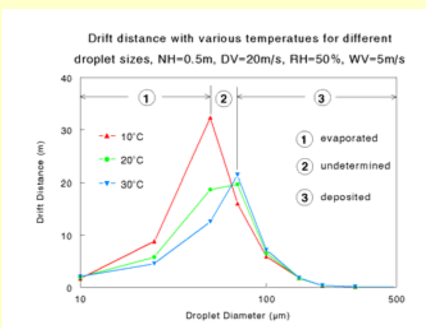
Results from DRIFTSIM Calculation

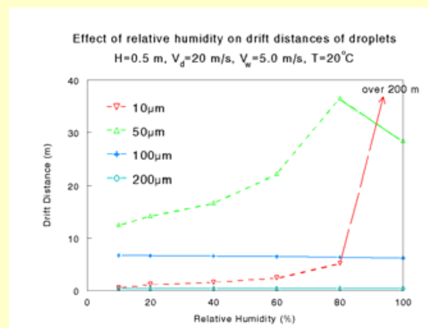












Effect of relative humidity and temperature on mean drift distance

H=0.5m, V_d=20m/s, V_w=2.5m/s

Droplet size (μm)	Temperature (°C)	Mean drift distance (m) RH (%) 20	80
50	10	24.5 *	40.3
50	30	10.1 *	23.5*
100	10	6.5	6.4
100	30	7.2	6.8
200	10	0.4	0.4
200	30	0.4	0.4

* Droplet completely evaporated before deposition.

Effect of discharge height on mean drift distance

V_d=20m/s, T=20°C, RH=50%

Droplet size (μm)	Wind velocity (m/s)	Mean drift distance (m) Discharge height (m) 0.25	0.50	1.0
100	2.5	0.66	3.27	9.30
100	5.0	1.34	6.55	18.50
200	2.5	0.02	0.17	1.76
200	5.0	0.05	0.36	3.54
300	2.5	0.01	0.05	0.41
300	5.0	0.02	0.10	0.84

Effect of wind velocity on mean drift distance

H=0.5m, V_d=20m/s, RH=60%, T=20°C

Droplet size (μm)	Drift distance (m) Wind velocity (m/s) 2.5	5.0
50	12.0*	22.1*
100	3.2	6.5
200	0.17	0.36
300	0.05	0.10
500	0.02	0.04

* Droplet completely evaporated before deposition.

Effect of initial droplet velocity on mean drift distance

H=0.5m, T=20°C, RH=50%

Droplet size (μm)	Wind velocity (m/s)	Mean drift distance (m) Droplet velocity (m/s) 0	20	40
100	2.5	5.34	3.27	2.29
100	5.0	10.70	6.55	4.56
200	2.5	1.79	0.17	0.05
200	5.0	3.67	0.36	0.09
300	2.5	1.08	0.05	0.02
300	5.0	2.32	0.10	0.03