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Modeling for application factors of 1,3-Dichloropropene, modeling approach #2

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1 Modeling overview

The Department of Pesticide Regulation (DPR) has been proposing mitigation measures to reduce acute and chronic exposure from 1,3-Dichloropropene (1,3-D) to nonoccupational bystanders. Air dispersion modeling is used to determine the applications factors, setback settings, and township caps of 1,3-D. Various modeling approaches have been tested, and two of them are recommended for further evaluations. Table 1 summarizes the modeling approaches, configurations, and their associated documents.

Table 1. Modeling approaches for mitigating 1,3-D exposures non-occupational bystanders

Mitigation measures	Description
Approach #1:	
[1.1] Application factors	Seasonal factors: winter (Jan-Feb) and nonwinter (Mar-Nov); applications are prohibited during December
[1.2] Setbacks	Year-round setbacks for 11 months (Jan-Nov); applications are prohibited during December
[1.3] Township cap	170,750 ATP calculated based on [1.1] and [1.2]
Approach #2:	
[2.1] Application factors (**this report**)	Seasonal factors: winter (Nov-Feb) and nonwinter (Mar-Oct); applications are allowed during December
[2.2] Setbacks	Seasonal setbacks: winter (Nov-Feb) and nonwinter (Mar-Oct); applications are allowed during December
[2.3] Township cap	204,200 ATP calculated based on [2.1] and [2.2]

List of documents:

- [1.1] "Modeling for application factors of 1,3-Dichloropropene, modeling approach #1"
- [1.2] "Modeling for mitigation measures to reduce acute exposure from 1,3-Dichloropropene, modeling approach #1"

- [1.3] “Modeling for the township cap of 1,3-Dichloropropene applications, modeling approach #1”
- [2.1] “Modeling for application factors of 1,3-Dichloropropene, modeling approach #2”
- [2.2] “Modeling for mitigation measures to reduce acute exposure from 1,3-Dichloropropene, modeling approach #1”
- [2.3] “Modeling for the township cap of 1,3-Dichloropropene applications, modeling approach #2”

2 Introduction

1,3-Dichloropropene (1,3-D) is a fumigant used to control nematodes, insects, and disease organisms in the soil. It is commonly used as a pre-plant treatment that is injected into soil. It may also be applied through drip irrigation. Regardless of the application method, the possibility of offsite transport of this fumigant due to volatilization may subsequently cause human exposure through inhalation. To mitigate its potential cancer risk, the Department of Pesticide Regulation (DPR) limits the use of 1,3-D on a regional basis (township cap). The current township cap is 136,000 “adjusted” pounds during a calendar year in any township (six by six mile area). Adjusted pounds refers to the amount of 1,3-D active ingredient multiplied by an application factor (AF) to account for differences in air concentrations due to application method, region, and season of application.

AFs are multipliers that DPR originally intended to account for variation in cumulative emission between different application methods (e.g., deep vs. shallow shank injection). The basis for determination of an AF is the emission ratio (ER), an estimate of the emitted fraction of total applied mass at a given time post-application (ER = cumulative flux / mass applied). DPR derived the ER values currently used in AF calculations from a small selection of field-estimated ER values obtained from field flux studies. The first field flux studies were for an untarped, deep injection application method, and DPR assigned an ER of 0.35 and an AF of 1.0 to this method. The AFs for other field fumigation methods (FFMs) are relative to this application method and ER. Currently, additional AFs attempt to account for variation in 1,3-D air concentrations due to seasonal or regional meteorological variation. The most current version of the AFs since 2017 are summarized in Appendix I.

In this report, we explore the use of AERMOD (American Meteorological Society/ Environmental Protection Agency Regulatory Model) to estimate the AFs for seasonal and regional meteorological variation. Generally, AF is defined as a function of application method (k, FFM), time (t, months of season), and location (x, regions in California). AFs are formulated relative to the average concentration in the prescribed reference conditions (k_0, t_0, and x_0):

$$\mathrm{AF}(\boldsymbol{k}, \boldsymbol{t}, \boldsymbol{x}) = \mathrm{CONC}(\boldsymbol{k}, \boldsymbol{t}, \boldsymbol{x})/\mathrm{CONC}(\boldsymbol{k_0}, \boldsymbol{t_0}, \boldsymbol{x_0}) \tag{1}$$

The average concentration (CONC) for the given application method, time, and location will be determined by model simulations via AERMOD. Compared to the current approach, the two regions for AF are extended to the inland and coastal regions of California. The definition of seasons is also updated according to the predicted seasonality of the average concentrations. Details are provided in later sections of this paper.

3 Approaches and Materials

3.1 Field fumigation methods and flux time series

According to the updated 1,3-D regulation, 23 field fumigation methods (FFMs) are allowed in California (Appendix II), including 18 FFMs currently registered and 5 FFMs newly proposed (24-inch injection and 50% TIF methods). The FFMs are categorized into 8 groups according to injection depth, tarpaulin type, and emission ratio (Table 2). For each group of FFMs, the method with the highest emission ratio is selected as the representative FFM and modeled for conservative estimation of AF (Table 2).

Table 2. Groups of field fumigation methods (FFMs) and the representative method for the determination of AFs

Group of FFMs	FFMs in the group
1-Standard nontarped and non-TIF tarp shallow (12 inch) methods	**1201**, 1202, 1203, 1204, 1205
2-Standard nontarped and non-TIF tarp deep (18 inch) methods	**1206**, 1207, 1208, 1210, 1211
3-Chemigation (drip)/non-TIF tarp method	**1209**
4-24-inch injection methods	**1224**, 1225, 1226
5-TIF methods – broadcast and strip	**1242**, 1247, 1249
6-TIF methods – bed and drip	**1243**, 1245, 1248, 1259
7-50% TIF with 18-inch injection depth method	**1250**
8-50% TIF with 24-inch injection depth method	**1264**

Note: TIF = Totally Impermeable Film. Highlighted is the representative FFM for the group

Determination of AFs in both the current approach (DPR, 2018) and in this study are based on 1,3-D emissions after application, but in different ways. As mentioned before, the current approach calculated AFs mainly based on ERs determined by flux time series from field experiments, and also adjusted through professional judgment (Johnson, 2013, 2014; Wofford, 2014). The value of 0.35 for FFM 1206 "Nontarpaulin/Deep/Broadcast" was set as the reference ER.

This study uses hourly emission rates in flux time series generated via HYDRUS modeling (Brown, 2022). Hourly flux time series were prepared for each FFM with 21 soil datasets. Each flux time series provides hourly emissions (in $\mu g/m^2/s$) normalized by an application rate of 100 lb/ac for a duration of 500 hours, by which time volatilization is effectively complete (Figure 1). The modeled application is assumed to be finished at 8AM. For comparison, the modeled average ER for FFM 1206 is 0.29, lower than the reference ER (0.35) in the current approach.

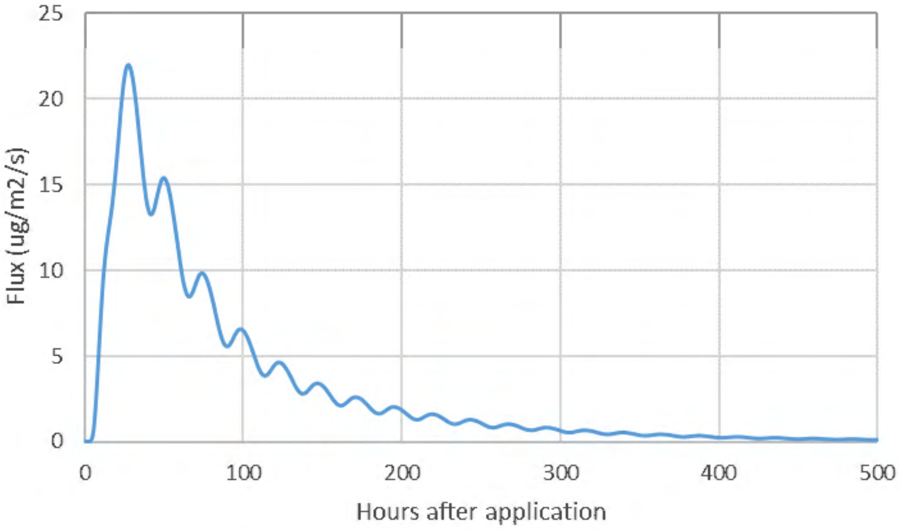

Figure 1. Example of the flux time series generated by HYDRUS, shown as one of the time series for FFM 1206

A 100 lb/ac application rate was chosen as the reference rate primarily with respect to DPR conventions for the reporting of simulation results. Although the assumed 100 lb/ac application rate falls below the maximum allowed rate of 332 lbs/ac, HYDRUS-estimated flux varies linearly with application rate and the chosen rate therefore has no bearing on the outcome of a relative comparison such as the one performed here, provided application rates are identical across simulations.

The flux time series were generated based on warm weather conditions. In order to investigate the effects of temperature on 1,3-D emissions, flux time series for cool-weather soil conditions were also generated with meteorological data representing multiple locations in California, using FFM 1206 as an example (Brown, 2019). Cool weather conditions result in lower air/water partitioning and slower degradation of 1,3-D. HYDRUS modeling results suggest that temperature effects on cumulative flux are likely to be minor compared to regional or seasonal variation in soil properties. Therefore, the effects are not considered in the estimation of AFs.

3.2 Simulation domain and meteorological data

Meteorological data are selected to represent areas with relatively high uses of 1,3-D in California, based on the total, unadjusted use of 1,3-D during the last 5 years (2013-2017). Total applied amounts of 1,3-D are plotted by township (6×6 mi^2 area) in California (Figure 2). Reported use data are only utilized to identify high-use areas, and are not used in the calculation of AFs in this study.

High-use areas are observed in the counties of Fresno, Kern, Monterey, Merced, and Stanislaus, as well as in some agricultural areas in Imperial, Santa Barbara, Ventura, and Yuba counties. The current AFs were assigned to two regions of California (within and outside the San Joaquin Valley, SJV). Similarly, AFs in this study are determined for the inland or coastal regions in

California. Inland and coastal county designations follow the definition used for buffer zones of chloropicrin (DPR, 2017) (Table 3 and Figure 3).

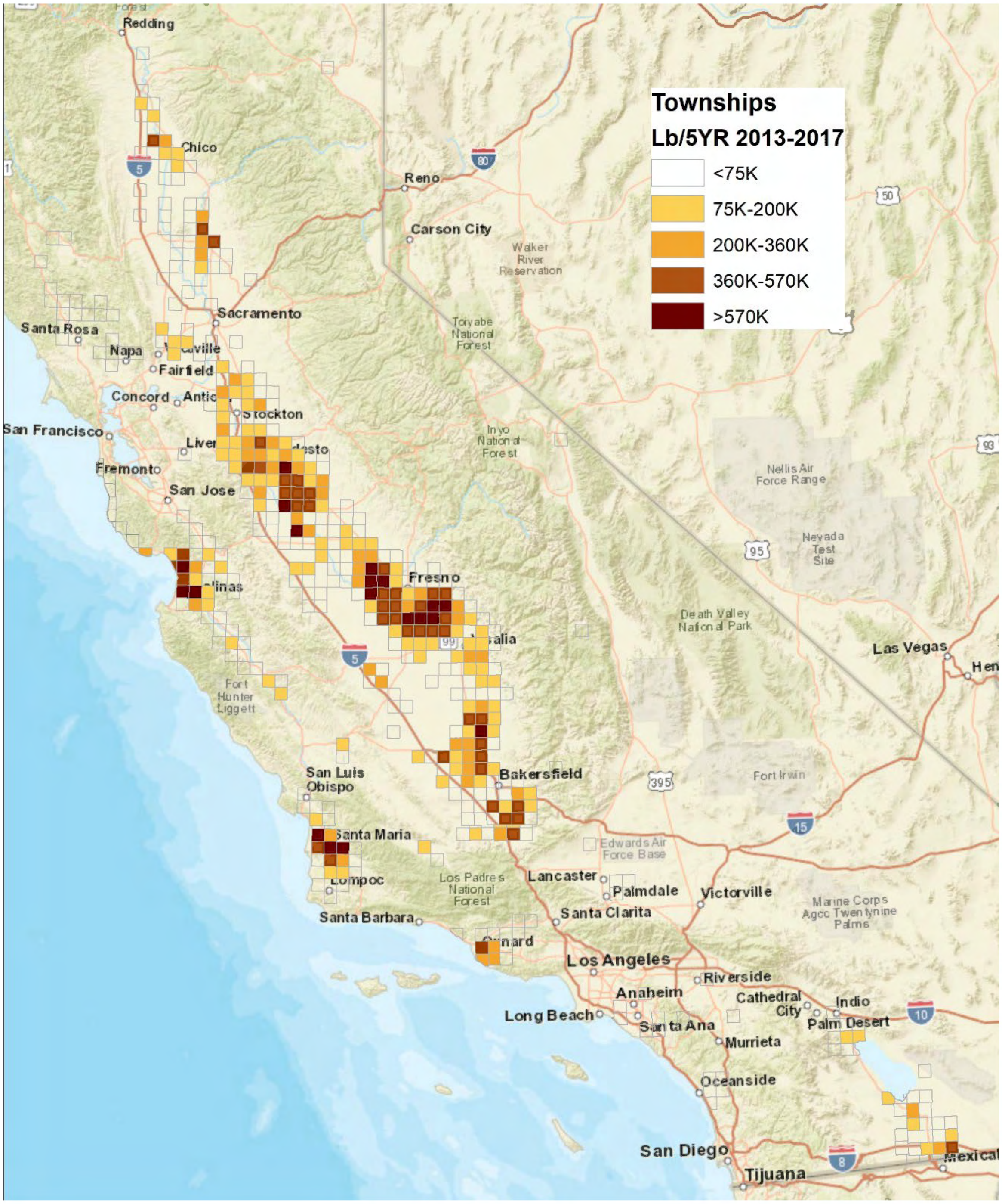

Figure 2. Five-year (2013-2017) total use of 1,3-D (in pounds) by township. Range classification of the use amounts is based on the “Natural Breaks (Jenks)” algorithm in ArcGIS

Table 3. County designations for inland and coastal regions in California

Inland	Coastal
Alameda, Amador, Alpine, Butte, Calaveras, Colusa, Contra Costa, El Dorado, Fresno, Glenn, Imperial, Inyo, Kern, Kings, Lake, Lassen, Madera, Mariposa, Merced, Modoc, Mono, Napa, Nevada, Placer, Plumas, Riverside, Sacramento, San Benito, San Bernardino, San Joaquin, Santa Clara, Shasta, Sierra, Siskiyou, Solano, Stanislaus, Sutter, Tehama, Trinity, Tulare, Tuolumne, Yolo, Yuba	Del Norte, Humboldt, Los Angeles, Marin, Mendocino, Monterey, Orange, San Diego, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, Santa Cruz, Sonoma, Ventura

Figure 3. County designations for inland and coastal regions in California

Eight sets of meteorological data are used in the modeling and are grouped as inland and coastal regions (Table 4). For each selected location, 5-year meteorological data (2013-2017) are used for air dispersion modeling. The MetProc program is utilized to generate input data in the AERMOD required format (Luo, 2017). Name of the represented area is also used as the name of a modeling set in this study. For example, “modeling results at Merced” refer to the results with the meteorological data representing Merced area.

Table 4. Meteorological data and corresponding areas with 1,3-D uses in California

Surface station (by WBAN)	Upper air station	Represented area	Region
93205	OAK	Yuba City	Inland

23257	OAK	Merced	Inland
93193	OAK	Parlier	Inland
23233	OAK	Salinas	Coastal
23155	VBG	Shafter	Inland
23273	VBG	Santa Maria	Coastal
93110	VBG	Oxnard	Coastal
03144	NKX	Imperial	Inland

Notes: WBAN = Weather-Bureau-Army-Navy, a five-digit identifier for weather stations operated by National Weather Service. OAK = Oakland International Airport (WBAN = 23230), VBG = Vandenberg (93214), and NKX = Miramar Naval Air Station (93107).

3.3 Reference conditions

Reference conditions are critical to the determination of AFs. The proposed reference conditions are developed based on the current approach (Table 5). As mentioned before (Section 3.1), the reference application methods in the current approach and this study are associated with different ERs: 0.35 (the current approach) and 0.29 (this study). To be consistent with the current approach, the predicted concentrations for FFM 1206 in this study will be adjusted by the difference of the ERs,

$$\text{Reference concentration: CONC}(\boldsymbol{k_0}, \boldsymbol{t_0}, \boldsymbol{x_0}) \tag{2}$$

$$= \text{CONC (FFM 1206, non-winter months, inland)} \times (0.35/0.29)$$

where the reference conditions (k_0, t_0, and x_0) are defined in Table 5.

Table 5. Reference conditions for calculating application factors of 1,3-D

	Current approach (DPR, 2018)	This study
Application method ($\boldsymbol{k_0}$)	FFM 1206, representing the FFM group of "Deep, non-60% credit" (Appendix I)	FFM 1206, representing the FFM group of "Standard nontarped and non-TIF tarp deep (18 inch) methods" (Table 2)
Months ($\boldsymbol{t_0}$)	Non-winter season of Feb-Nov	Non-winter season of Mar-Oct
Location ($\boldsymbol{x_0}$)	Not explicitly defined. AF = 1.0 is set for "Deep, non-60% credit" *both* within and outside SJV	Two regions (inland and coastal) are considered (Table 4). According to the current AFs (Appendix I), regions within SJV are associated with higher AFs for nontarped and non-TIF methods during winter months. Therefore, the inland region is set as the reference location in this study

3.4 Modeling settings (domain, source, and receptor)

The latest version of AERMOD (ver. 21112) is used in this study with the modeling settings recommended by the model evaluation for 1,3-D (Luo, 2019a). All model simulations are managed by AERFUM, an integrated air dispersion modeling system for soil fumigants developed by DPR (Luo, 2019b). AERMOD is configured to predict concentrations of 1,3-D from a hypothetical source over a flat terrain. Note that model simulations in this study are only differentiated by the meteorological inputs, while landscape characteristics varying over the locations are not considered. The source area (i.e., treated field) is assumed to be a square of 20 acres. The area is determined based on the "treated acreage" for individual 1,3-D applications in California during the simulation period of 2013-2017, with a median value of 16 acres and mean of 24. A grid of receptors is developed with the treated field in the center (Figure 4). Two parameters are used to characterize the grid: L (half of the side length) and ΔL (interval).

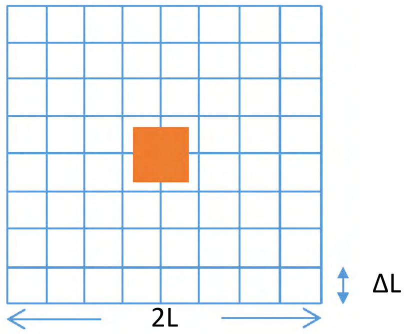

Figure 4. The receptor grid used in this study. The treated field is located in the center of the grid

To evaluate the potential uncertainties associated with the above modeling settings, additional sensitivity analysis is conducted (Table 6). For demonstration purposes, sensitivity analysis is conducted for Parlier only, based on the high uses of 1,3-D in the surrounding areas (Figure 2).

Table 6. Summary of modeling settings

	Baseline simulation	Sensitivity analysis
Source	20 acres (between median and mean)	56 acres (the 90th percentile)
Domain	2L = 1600 m (a section)	2L = 9600 m (a township)
Receptors	ΔL = 200 m	ΔL = 50 m

3.5 Modeling procedures

For each selected location (one of the 8 locations presented as a meteorological dataset, Table 4) *and* each flux time series, the following set of model simulations are conducted:

- Started on 1/1/2013, an 1,3-D application event of 100 lb/ac is assumed to complete at 8 AM, and the corresponding emission rates are assigned to the subsequent hours;
- Run AERMOD for the flux duration of 500 hours, with the modeling settings specified in Table 6;

- Retrieve hourly concentrations at each receptor (Figure 4);
- Calculate the domain-wide average concentration over all receptors during the flux duration;
- Assign the resulting average concentration to the date of application;
- Move to the next day in the simulation period (2013 to 2017), and repeat above processes (Note: according to the flux duration, applications on the last 21 days of 2017 will not be modeled, i.e., 12/11/2017-12/31/2017);
- 1805 concentration values (1805 = days of the 5-year simulation period minus the flux duration in days) will be generated, indexed by date;
- Calculate the long-term monthly average values. For example, 155 values (= 5 years × 31days/January/year) associated with applications in January are averaged and assigned to January.
- Finally, 12 monthly average concentrations are generated for the given flux time series and meteorological dataset.

For one location and one flux, there are 1805 model runs (number of days in the simulation period of 2013-2017) involved in the above processes. For all selected locations (×8), FFMs (×8), and soils (×21), the estimated total number of model runs is about 2.4 million. The sensitivity analysis (Table 6) requires additional 0.9 million runs.

4 Results and discussion

4.1 Predicted concentrations

For each FFM, the above modeling procedures are repeated for the 21 soils. The median values of monthly averages over the soils are reported as modeling results for the corresponding FFM. The results represent concentrations as a function of application method (k), month (t), and location (x). The resulting three-dimensional matrix [CONC(k, t, x)] is summarized by locations. The results are further averaged by region (inland and coastal) as shown in Table 7. The numerical values are the model-predicted average concentration (μg/m^3) associated with a single application by an application method in a month (January to December).

Table 7. Predicted average concentrations (μg/m^3) related to a single application in each month for the (a) inland and (b) coastal regions of California

(a) Modeling results averaged for the inland region

FFM Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1201	6.34	5.38	3.85	2.93	2.34	2.11	2.23	2.49	3.40	4.70	5.56	6.20
1206	3.72	3.10	2.22	1.69	1.37	1.24	1.34	1.50	2.05	2.79	3.32	3.68
1209	4.66	3.85	2.77	2.12	1.75	1.60	1.68	1.85	2.42	3.32	4.03	4.57
1224	2.14	1.78	1.27	0.97	0.79	0.72	0.79	0.89	1.22	1.64	1.95	2.14
1242	0.98	0.77	0.54	0.42	0.35	0.32	0.34	0.38	0.50	0.70	0.88	1.00
1243	1.65	1.37	0.97	0.74	0.60	0.55	0.60	0.66	0.88	1.19	1.43	1.63
1250	2.23	1.85	1.32	1.01	0.82	0.75	0.81	0.91	1.23	1.66	1.98	2.21
1264	1.38	1.14	0.80	0.61	0.50	0.46	0.51	0.58	0.78	1.04	1.25	1.38
Avg	2.89	2.41	1.72	1.31	1.07	0.97	1.04	1.16	1.56	2.13	2.55	2.85

(b) Modeling results averaged for the coastal region

FFM Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1201	5.36	4.92	4.36	3.89	3.22	3.23	3.37	3.58	4.34	4.50	4.71	4.99
1206	3.14	2.86	2.54	2.24	1.85	1.89	1.96	2.12	2.56	2.62	2.78	2.94
1209	3.85	3.43	2.99	2.62	2.20	2.21	2.30	2.44	2.90	3.07	3.33	3.63
1224	1.82	1.66	1.48	1.30	1.07	1.12	1.15	1.26	1.51	1.53	1.63	1.71
1242	0.81	0.70	0.59	0.51	0.43	0.45	0.46	0.50	0.59	0.63	0.72	0.78
1243	1.36	1.25	1.09	0.95	0.80	0.82	0.85	0.92	1.09	1.11	1.19	1.27
1250	1.87	1.71	1.51	1.34	1.11	1.15	1.19	1.28	1.53	1.55	1.65	1.75
1264	1.16	1.06	0.94	0.82	0.69	0.72	0.74	0.81	0.96	0.97	1.03	1.09
Avg	2.42	2.20	1.94	1.71	1.42	1.45	1.50	1.61	1.94	2.00	2.13	2.27

4.2 Application factors

According to the modeling results, the highest concentrations are predicted for applications in Dec and Jan, followed by Nov and Feb (Table 7). Based on the relative values of predicted monthly concentrations, two seasons are defined for calculating AFs: winter (Nov-Feb) and non-winter (Mar-Oct). The average concentration during Mar to Oct is calculated for the non-winter season. The average concentration during Dec and Jan is calculated as the conservative representation of the winter season (Nov-Feb). For each FFM, for example, the average concentration for "winter" and "inland" conditions is calculated as the average of 10 relevant values in Table 7, involving 5 locations (Imperial, Merced, Parlier, Shafter, and Yuba City) and 2 months (Dec and Jan). Results of the seasonal average concentrations are summarized in Table 8. The uncertainty in the averaging is investigated as the coefficient of variation (CV, i.e., standard deviation normalized by mean value). The CV values range from 0.08 to 0.16 for the inland region, and from 0.15 to 0.19 for the coastal region, varying by FFM and season.

Table 8. Average concentrations (μg/m^3) by season, by region, and by FFM

FFM Code	Inland		Coastal	
	Dec-Jan	Mar-Oct	Dec-Jan	Mar-Oct
1201	6.27	3.01	5.18	3.81
1206	3.70	**1.78**	3.04	2.22
1209	4.62	2.19	3.74	2.59
1224	2.14	1.04	1.77	1.30
1242	0.99	0.44	0.80	0.52
1243	1.64	0.77	1.32	0.95
1250	2.22	1.06	1.81	1.33
1264	1.38	0.66	1.13	0.83

According to Eq. (2) and associated definitions for the reference conditions (Table 5), the reference concentration is calculated as 1.78×0.35/0.29 = 2.15 μg/m^3, where 1.78 μg/m^3 (highlighted in Table 8) is the average concentration during Mar-Oct for FFM 1206 in the inland region. All concentrations in Table 8 are divided by this reference concentration value to generate AFs (Table 9).

Table 9. Table of Application Factors for 1,3-dichloropropene

Field Fumigation Methods (FFMs) and FFM codes	Inland		Coastal	
	Nov-Feb	Mar-Oct	Nov-Feb	Mar-Oct
Standard nontarped and non-TIF tarp shallow (12 inch) methods (1201, 1202, 1203, 1204, 1205)	2.93	1.40	2.42	1.78
Standard nontarped and non-TIF tarp deep (18 inch) methods (1206, 1207, 1208, 1210, 1211)	1.73	0.83	1.42	1.04
Chemigation (drip)/non-TIF tarp method (1209)	2.15	1.02	1.74	1.21
24-inch injection methods (1224, 1225, 1226)	1.00	0.48	0.82	0.61
TIF methods (broadcast: 1242, 1247, 1249)	0.46	0.21	0.37	0.24
TIF methods (bed: 1243, 1245, 1248, 1259)	0.76	0.36	0.62	0.45
50% TIF with 18-inch injection depth method (1250)	1.03	0.50	0.84	0.62
50% TIF with 24-inch injection depth method (1264)	0.64	0.31	0.53	0.39

4.3 Sensitivity analysis

Sensitivity analysis is conducted to evaluate the effects of modeling settings (domain, source, and receptor, Table 6) on the resulting AFs. Strong correlations are observed among the concentrations (columns in Table 8) or AFs (Table 9) (see the results of correlation analysis in Appendix III). Therefore, the sensitivity analysis can be simplified by only testing the correlation of predicted concentrations between winter and non-winter at one location (here, Parlier as an example) for each set of alternative modeling settings (Table 6).

Although numerical values and ranges of model-predicted concentrations vary with alternative modeling settings in sensitivity analysis, correlations between concentrations (aggregated by predefined seasons) are very similar to those observed in the baseline simulation (Figure 5). This finding confirmed that the modeling approach is reliably designed and its results in terms of AFs are not sensitive to modeling settings of simulation domain, source size, and receptor grid.

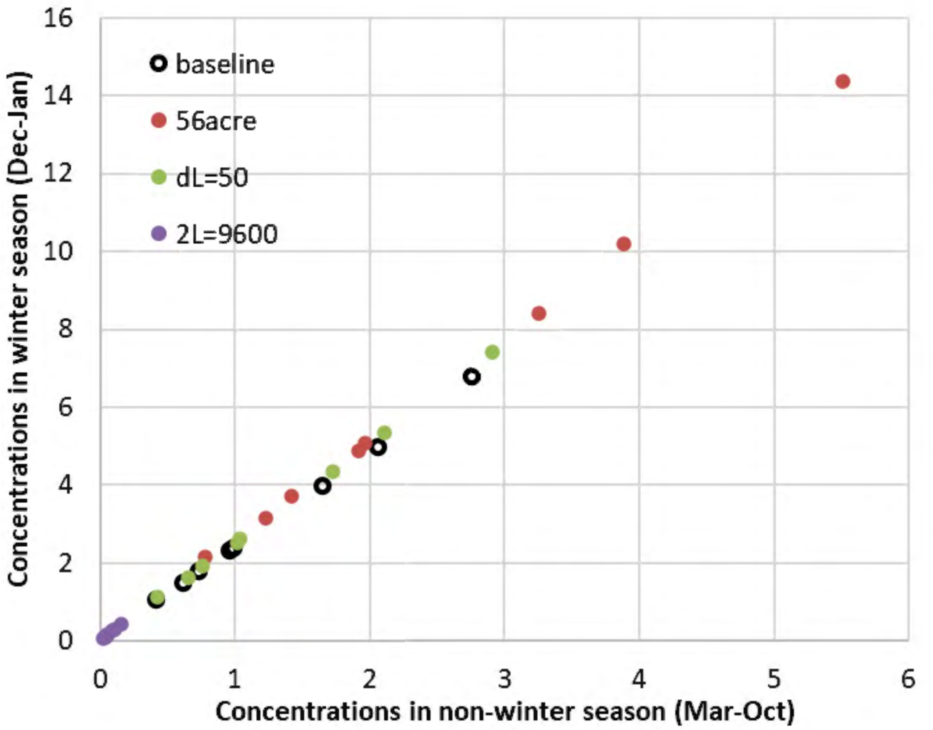

Figure 5. Model-predicted concentrations (μg/m^3) at Parlier, aggregated by seasons for baseline simulation (source area of 20 acres, receptor interval = 200 m, and domain size of 1600×1600 m^2) and sensitivity analysis (source area of 56 acres, receptor interval = 50 m, and domain size of 9600×9600 m^2)

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Appendix I. Current application factors (since 2017)

The current AFs were retrieved from the Recommended Permit Conditions (Rev. 12-17) as Appendix J of Pesticide Use Enforcement Program Standards Compendium Volume 3, Restricted Materials and Permitting.

Tarp type	Months [1]	FFM category	Application factor [2]	
			Within SJV	Outside SJV
Non-60% credit	Jan	Shallow	Prohibit	2.3
		Deep	1.9	1.2
		Drip	1.16	1.16
	Feb-Nov	Shallow	1.9	1.9
		Deep	1.0	1.0
		Drip	1.16	1.16
60% credit	Jan	Shallow or Deep	0.6	0.6
		Strip	1.2	1.2
		Drip	1.16	1.16
	Feb-Nov	Shallow or Deep	0.3	0.3
		Strip	0.6	0.6
		Drip	1.16	1.16

Notes: [1] All applications are prohibited during December. [2] SJV = San Joaquin Valley. Within SJV = Counties of Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare. Outside SJV = All other counties in California.

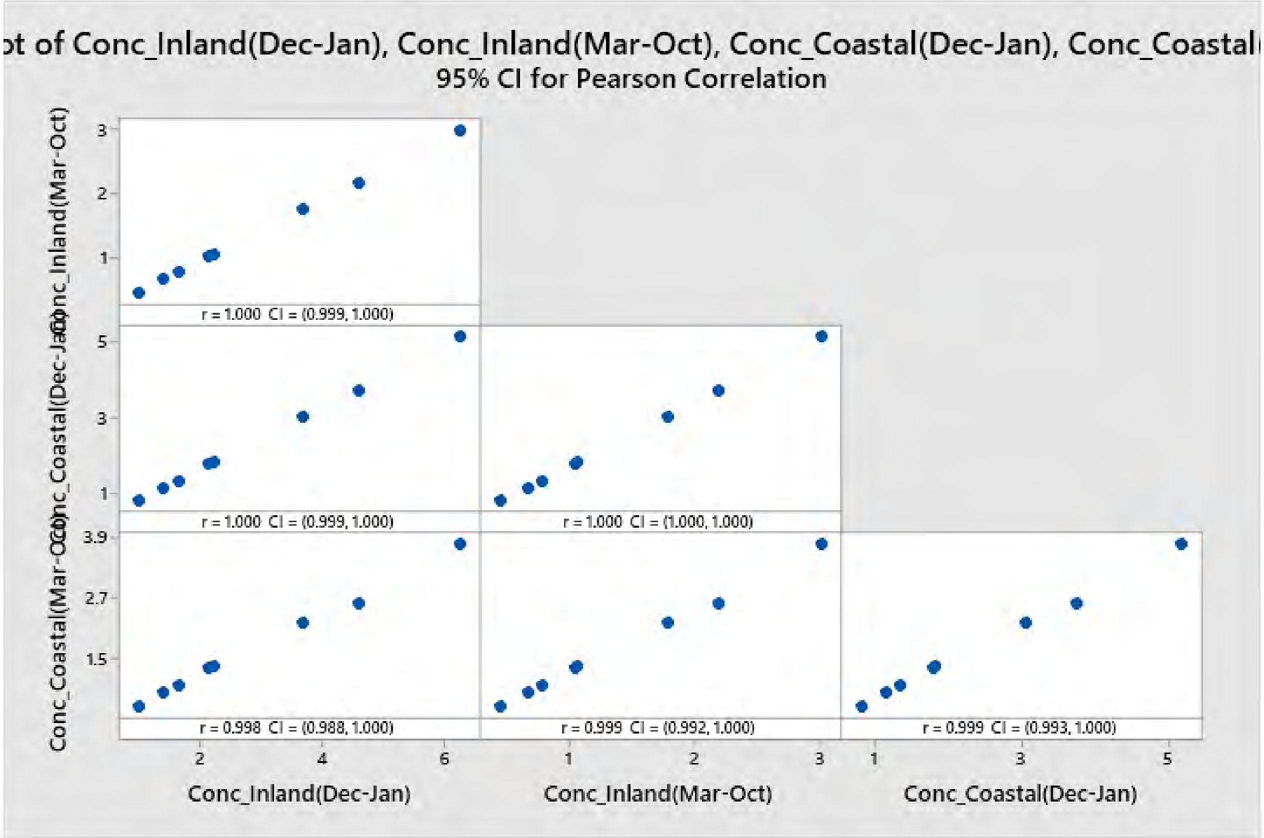
Appendix II. 1,3-Dichloropropene field fumigation methods

Method Group	Method Name	Field Fumigation Method (FFM) Code
1	Nontarp/shallow/broadcast or bed	1201
1	Tarp/shallow/broadcast	1202
1	Tarp/shallow/bed	1203
1	Nontarp/shallow/broadcast or bed/3 water treatments	1204
1	Tarp/shallow/bed/3 water treatments	1205
2	Nontarp/18 inches deep/broadcast or bed	1206
2	Tarp/18 inches deep/broadcast	1207
2	Tarp/18 inches deep/bed	1208
3	Chemigation (drip system)/tarp	1209
2	Nontarp/18 inches deep/strip	1210
2	Nontarp/18 inches deep/GPS targeted	1211
4	Nontarp/24 inches deep/broadcast	1224
4	Tarp/24 inches deep/broadcast	1225
4	Nontarp/24 inches deep/strip	1226
5	Totally Impermeable Film (TIF) tarp/shallow/broadcast	1242
6	TIF tarp/shallow/bed	1243
6	TIF tarp/shallow/bed/3 water treatments	1245
5	TIF tarp/deep/broadcast	1247
6	TIF tarp/deep/bed	1248
5	TIF tarp/deep/strip	1249
7	50% TIF tarp/18 inches deep/broadcast	1250
6	Chemigation (drip)/ TIF tarp	1259
8	50% TIF tarp/24 inches deep/broadcast	1264

Appendix III. Correlation analysis on the model-predicted concentrations or AFs

Strong correlations are observed among the concentrations (columns in Table 8) or AFs (Table 9). Results of correlation analysis (directly copied from Minitab v19) are shown as follows.

Correlations between the modeled concentrations



Correlations between the modeled AFs