Department of Pesticide Regulation
Environmental Monitoring Branch
1001 I Street
Sacramento, California 95812

Modeling 1,3-Dichloropropene Applications at Parlier, CA on October 9, 2018

Jing Tao

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Introduction

The Department of Pesticide Regulation (DPR) has been monitoring ambient air concentrations of 1,3-dichloropropene (1,3-D) at Parlier (Fresno County) since December 2016 (Brown, 2016). A concentration of 111 ppb (504 µg/m^3) was measured at this monitoring site during a 24-hr sampling period on October 9-10, 2018. This air concentration of 1,3-D is the highest concentration measured in ambient air monitoring studies conducted by DPR. Although the 24-hr concentration of 111 ppb does not necessarily indicate that DPR's acute human health screening level of 110 ppb for a 72-hr period was exceeded, the measured value could cause the annual average concentration at this site to exceed DPR's regulatory lifetime cancer risk goal (0.56 ppb) if similar annual concentrations were measured over several years. Therefore, an evaluation of this detection was conducted with use data information from preliminary 2018 pesticide use reports (PUR). Based on the use data, there were five possible 1,3-D applications on October 9, 2018 that likely could have been the sources that led to the high detection. Computer modeling using the AERMOD air dispersion model was employed to simulate these 1,3-D applications and examine if the measured concentration could be modeled under the weather conditions recorded by nearby meteorological stations.

1,3-D Applications

Table 1 listed the information of five reported applications. The sampling site and the fields were shown in Figure 1. The field areas ranged from 3.2 to 5.45 acres, which were larger than the treated areas.

Table 1. Preliminary application information of pesticide use report (PUR)

Site ID	5355	5237	5115	5354	5236
Source Group	1	1	2	2	3
Start Time (hr)	1030	1030	900	900	1200
1,3-D (lbs)	478.09	478.09	848.67	848.67	648.02
Treated Area (ac)	1.45	1.45	2.6	2.6	2
Field Fumigation Method (FFM)	1210	1210	1210	1210	1210
Application Rate (lbs/ac)	330	330	326	326	324

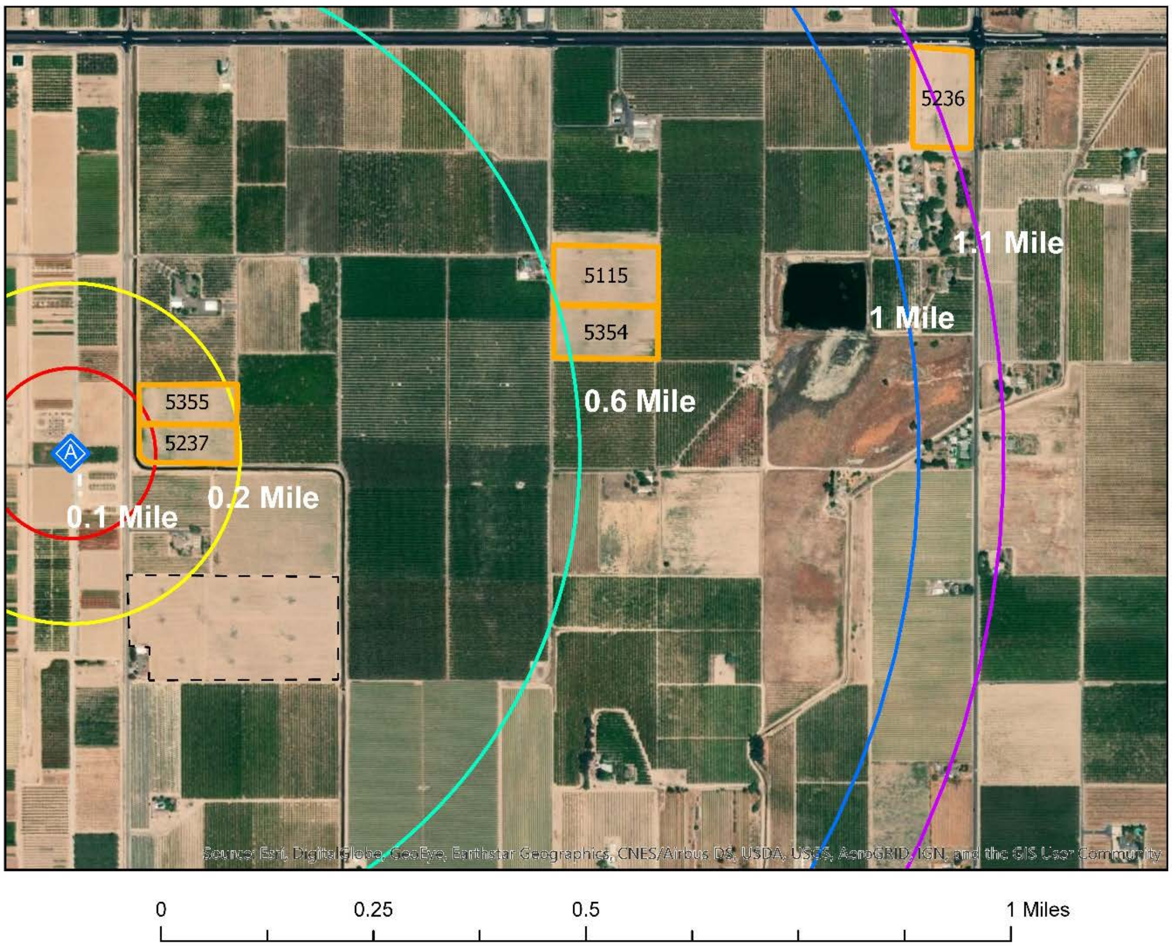

Figure 1. Location of 1,3-D monitoring site at Parlier and agriculture fields where the applications were conducted on 10/09/2018.

AERMOD Configuration and Post-Processing

Although PUR contains field information, the exact treated area of each field is unknown. Therefore, an area close to the monitoring site and within the reported field was configured as each source location (Figure 2). A receptor was set at the Parlier monitoring site with height of 4 m to match the monitoring site (Figure 2). A uniform grid receptor network at the same height with spacing of 50 m was also used to output contour plots. DPR developed flux profiles for all 1,3-D field fumigation methods (FFMs) applied in 16 soil types using HYDRUS modeling (Brown, 2018). All the applications around the sampling site on 10/9/2018 were reported use of FFM 1210 but the soil information was unknown. This modeling used the flux of soil #5 because this flux produces the highest emission among the 16 examined soil types. The flux was developed for a nominal rate of 100 lbs/ac and had units of ug/m^{2}s. It was accordingly converted to the flux profiles for the different application rates starting at the reported application hours.

The air sampling started at 16:37 and lasted for 24 hours so the modeling period was first set as hour 17 of 10/09/2018 to hour 16 of 10/10/2018 to estimate the 24-hr average concentration of this period. In addition, the model outputted hourly concentrations from 10/09/2018 to 10/15/2018. The results were used to estimate the rolling 24-hr and 72-hr average concentrations after applications.

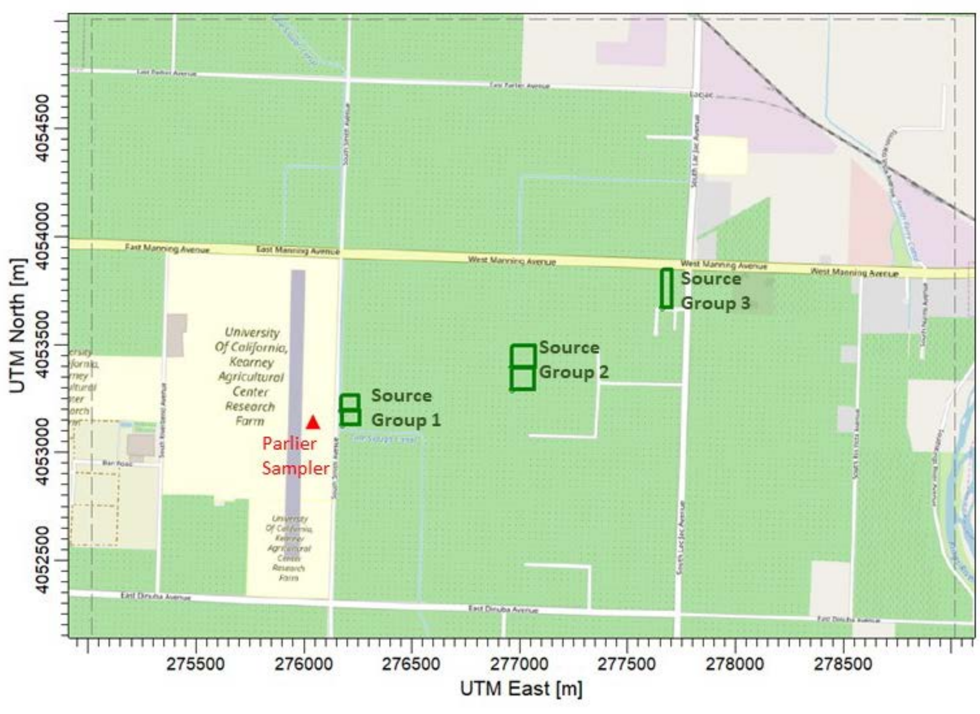

Figure 2. Diagram of modeling sources and the receptor at the Parlier site

Meteorological Data

Meteorological files used in the AERMOD modeling are processed by MetProc. MetProc is an interface of AERMET, the meteorological data processer of AERMOD developed by the United States Environmental Protection Agency (USEPA). DPR developed MetProc to process weather data for AERMOD modeling of pesticide uses (Luo, 2017). For this modeling, the upper air soundings used data of the station WBAN 23230 at Oakland International Airport. The surface weather data was from the station at Fresno Airport (WBAN 93193), which is about 17 miles away from the monitoring site. A station of the California Irrigation Management Information System (CIMIS) at Parlier (#39) is located 0.5 mile southeast of the monitoring site and was considered for use as an onsite station. However, since CIMIS stations measure weather conditions at 2 m above the ground, their wind measurements are only considered to be valid and compiled into the AERMOD meteorological files by AERMET in the hours when the surface roughness is lower than 1/7 of the anemometer height 2 m (USEPA, 2018). For the 24-hr period from hour 17 of 10/09/2018 to hour 16 of 10/10/2018, 22 hours of CIMIS hourly records were valid. Figure 3 compared the wind roses of the AERMOD ready meteorological file compiled from the WBAN 93193 data only and the data including CIMIS 39 as an onsite station during the sampling period. CIMIS 39 recorded more low wind speeds at 0.5 - 1 m/s and less variation of wind directions than WBAN 93193. No calms hours were recorded at both stations.

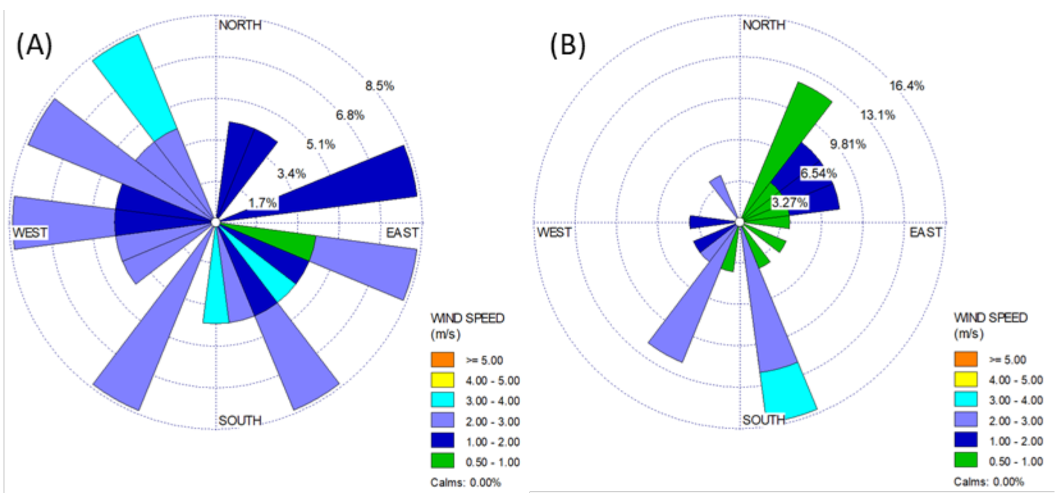

Figure 3. Wind roses of AERMOD ready meteorological files compiled with surface station (A) WBAN 93193 and (B) CIMIS #39 + WBAN 93193 during the 24-hr period between hour 17 of 10/09/2018 to hour 16 of 10/10/2018.

Results and Discussion

<u>*Average Concentration during Sampling Period*</u>

The two sets of meteorological files, (A) WBAN 93193 and (B) CIMIS #39 + WBAN 93193, estimated 24-hr average concentrations as 35.5 and 30.1 ppb at the sampling site during the sampling period (Table 2). The estimated concentrations were about 32% and 27% of the sampling result 111 ppb. Although two sets of data closely estimated the concentrations, contour plots showed that the spatial distribution of concentrations in the modeling domain area were different (Figure 4). Table 2 listed the contribution of three source groups to the concentrations estimated at the sampling site. CIMIS #39 had more low wind speed and estimated a higher concentration contributed by the nearby sources (Source Group 1). Higher wind speed recorded by WBAN 93193 might convey higher amount of 1,3-D from farther sources to the sampling site. WBAN 93193 estimated that the contributed concentrations from Source Group 2 and 3 were about 9 and 2 times of the estimates of CIMIS #39.

Contour plots of both meteorological files showed that the 1,3-D air concentrations traveled from the treated fields towards the sampling site in the west and could lead to high concentrations near the sampling site during 10/9 – 10/10 (Figure 4).

Table 2. Time weighted average concentrations at Parlier monitoring site during the sampling period.

	Weather A: WBAN 93193			Weather B: CIMIS #39 + WBAN 93193		
Source Group	Conc ($\mu g/m^3$)	Conc (ppb)	%	Conc ($\mu g/m^3$)	Conc (ppb)	%
1	118.6	26.1	74	131.5	29.0	96
2	40.5	8.9	25	4.3	1.0	3
3	2.1	0.5	1	0.9	0.2	1
Sum	161.3	**35.5**	100	136.7	**30.1**	100

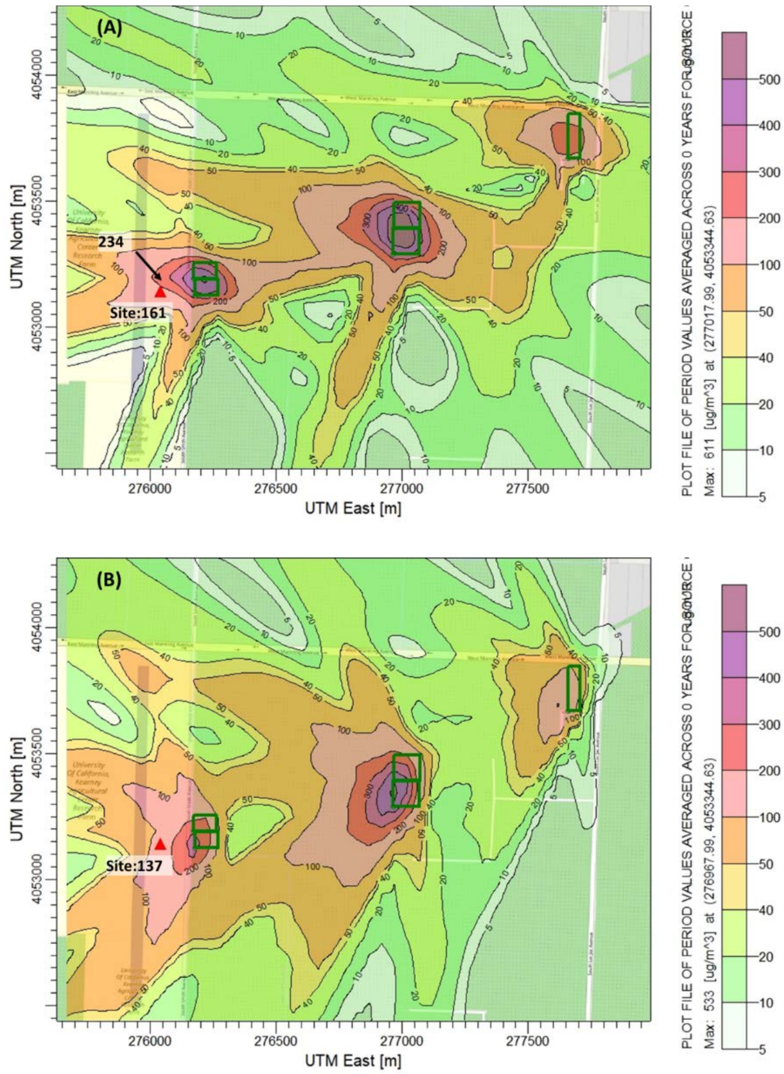

Figure 4. Contour plots of 1,3-D 24-hr average concentrations (μg/m^3) estimated by AERMOD using meteorological data compiled with surface station (A) WBAN 93193 and (B) CIMIS #39 + WBAN 93193 during the sampling period .

Model Uncertainties

Several uncertainties in this modeling case could cause the discrepancy between the estimated and monitored results:

(1) Representative weather station.
As shown in Figure 3, wind conditions recorded by the two stations were different. WBAN 93193 is 17 miles away from the site. While CIMIS #39 is located closer, its anemometer height is only 2 m. The anemometer height of 10 m is usually required for the air dispersion modeling (USEPA, 2018). Neither of them may perfectly represent weather condition of the modeling domain area.

(2) Wind condition.
AERMOD uses hourly weather data and its output has a minimal interval of an hour. The wind direction shown in Figure 2 was an average or an observation of an hour, which did not reflect accurate instantaneous wind direction and could cause uncertainty in the magnitude and location of the estimated concentrations. In addition, under stable light wind conditions, modeling results do not perform well to match the monitoring concentration paired in space because of potential high degree of variability existing in the modeling domain and the microscale influences on air transport and dilution (USEPA, 2017). Figure 4(A) shows that the concentration of a location near the site and about the same distance from Source Group 1 was estimated at 234 $\mu g/m^3$ (52 ppb), which was 1.5 times of the estimate at the site and could occur at the site.

(3) Flux profile.
The actual 1,3-D emission fluxes of the applications are unknown. The flux profiles generated by HYDRUS used soil characteristics of 16 types of agricultural soils sampled in previous fumigant field studies conducted by DPR. These soils types may not represent the actual soil conditions of the treated fields on 10/09/2018. Different soil conditions could cause variation of the fluxes and subsequently the air concentrations. For example, if reducing the organic matter content of soil #5 to 0, which was possible especially when turning over older orchards for replant, the new flux values would lead to 41 ppb estimated at the sampling site. In addition, the flux was generated for the application time at 8 AM and could change for the applications at noon because of the effect of diurnal temperature fluctuation on emission rates.

(4) Application information.
The exact location and shape of the treated area is unknown. Sometimes the application time recorded in PUR may be inaccurate. For example, the applicators may input an incorrect application time; or they input a planned start time, instead of the actual application completion time that was used by the modeling as flux starting time. Five treatments had recorded application time between 10 AM – 1PM, when the flux estimated the lowest concentrations. Assuming that the flux profile would not change for different application time, the estimated concentrations of the sampling site were around 41 ppb for applications completed in the early morning at 5AM or in the afternoon at 4 PM.

All the above factors could interact with each other and bring more complexity to this case.

Rolling Average Concentrations

Hourly concentrations and their rolling averages were calculated and plotted on Figure 5. Although results of two sets of meteorological data had different temporal patterns, they both estimated the highest 24-hr average concentrations during the sampling period. The highest 72-hr average concentrations were estimated at 14.5 ppb (65.7 μg/m^3) and 12.3 ppb (55.9 μg/m^3), about 13% and 11% of DPR acute health screening level of 110 ppb for 1,3-D. For the meteorological data of WBAN 93193, a 72-hr period ending at 1AM of 10/13/2018 produced the highest concentrations. Results of the meteorological data including CIMIS #39 presented five continuous 72-hr periods producing the same highest concentration. Figure 6 presents the contour plots for the 72-hr period that estimated the highest concentration.

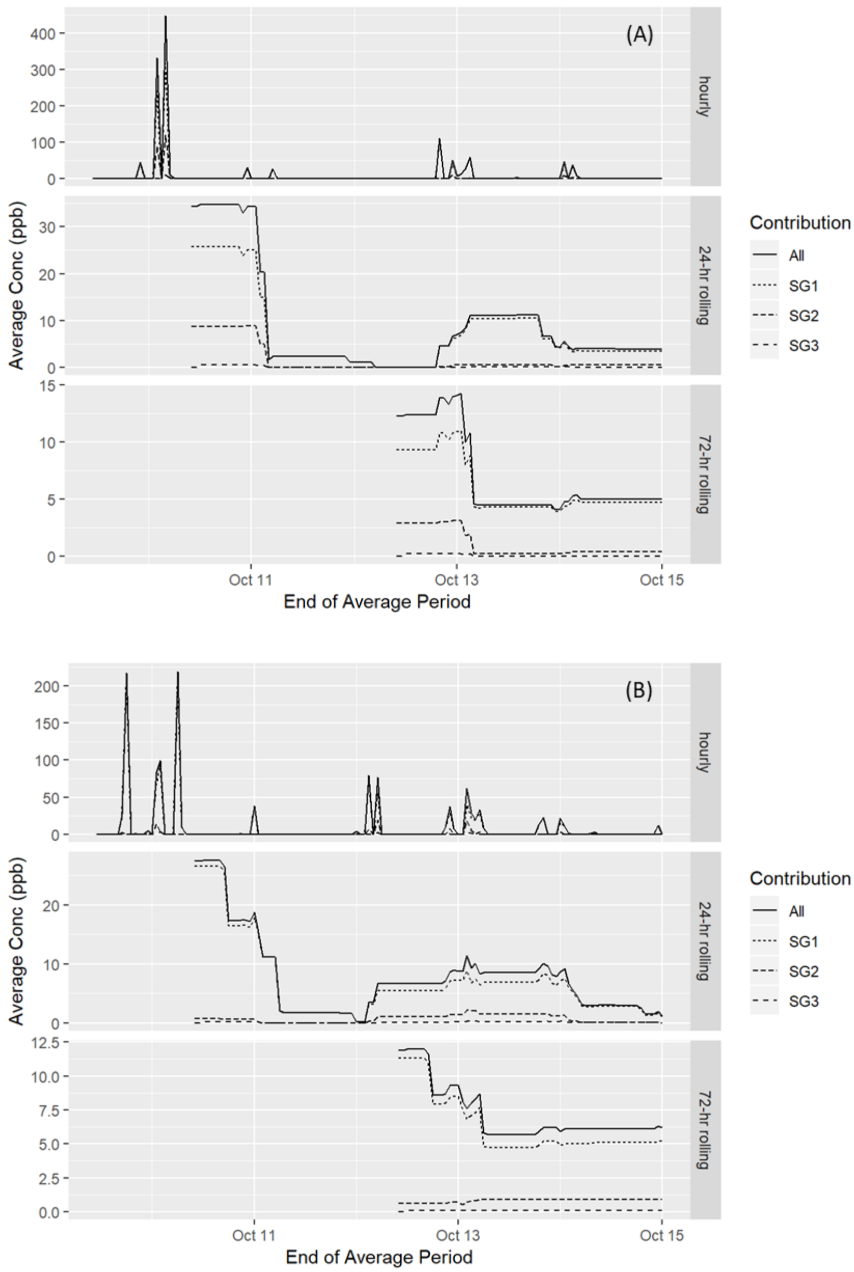

Figure 5. Hourly and rolling average concentrations estimated at sampling sites using meteorological data compiled with surface station (A) WBAN 93193 and (B) CIMIS #39 + WBAN 93193

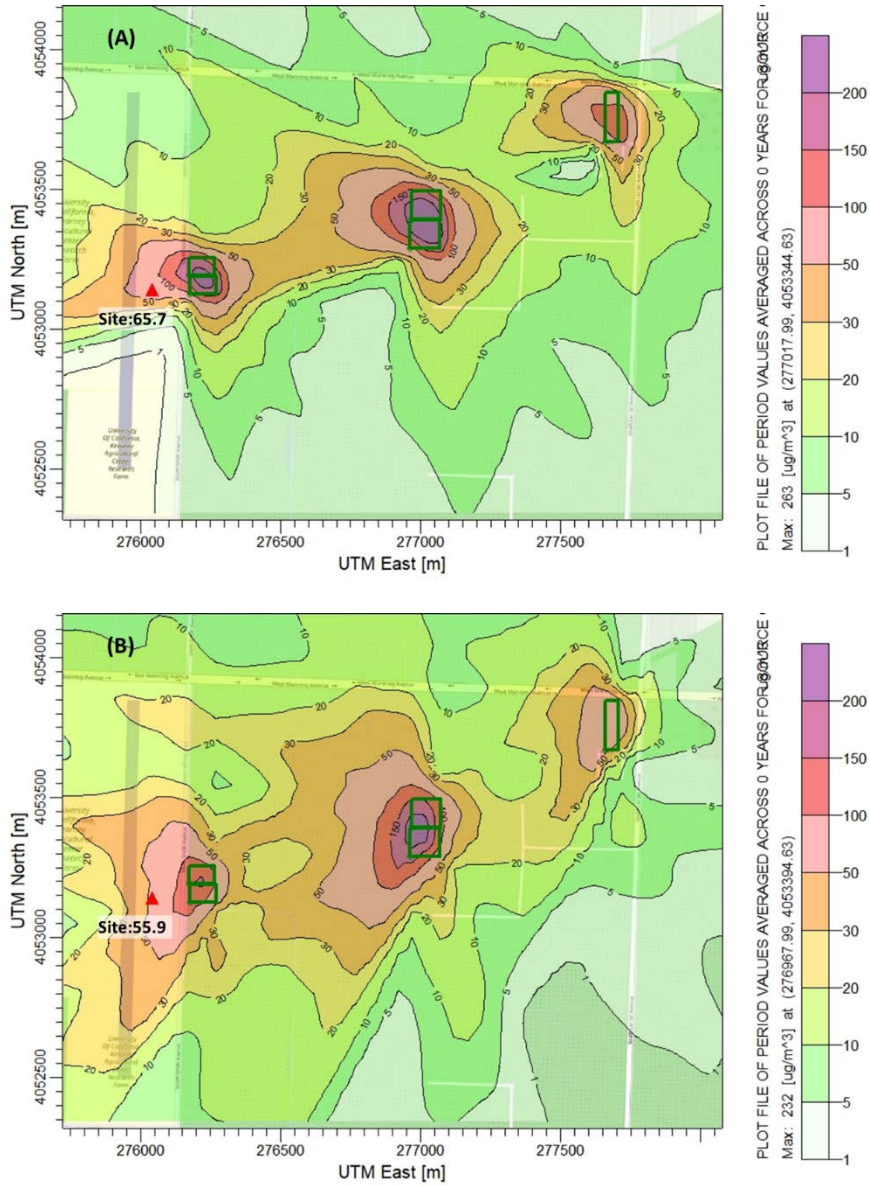

Figure 6. Contour plots of 1,3-D maximum 72-hr average concentrations (μg/m^3) estimated by AERMOD using meteorological data compiled with surface station (A) WBAN 93193 and (B) CIMIS #39 + WBAN 93193.

Conclusion

This analysis used AERMOD to simulate five 1,3-D applications near the Parlier sampling site of DPR Study 309 on 10/09/2018. With the available application and meteorological data, the modeling estimated the average concentration as 30.1 – 35.5 ppb during the sampling period, about 27% - 32% of the monitoring result. Several uncertainties are discussed regarding the discrepancy between the modeling and monitoring estimates. Despite the underestimated concentrations, the modeling results showed that the 1,3-D traveled from the treated fields towards the sampling site and could cause high concentrations collected at the site. In addition, this analysis estimated 24-hr and 72-hr rolling averages for 7 days following the reported applications. The sampling on 10/9/2018 – 10/10/2018 appeared to be one of the 24-hr periods that collected the highest 1,3-D concentrations after these particular applications. The modeling estimated the highest 72-hr average concentration as 12.3 – 14.5 ppb, about 11 – 13% of the DPR target concentration 110 ppb.

Acknowledgements

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