Research Article

Numerical Simulations of Airborne Glaciogenic Cloud Seeding Using the WRF Model with the Modified Morrison Scheme over the Pyeongchang Region in the Winter of 2016

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A model was developed for simulating the effects of airborne silver iodide (AgI) glaciogenic cloud seeding using the weather research and forecasting (WRF) model with a modified Morrison cloud microphysics scheme. This model was used to hindcast the weather conditions and effects of seeding for three airborne seeding experiments conducted in 2016. The spatial patterns of the simulated precipitation and liquid water path (LWP) qualitatively agreed with the observations. Considering the observed wind fields during the seeding, the simulated spatiotemporal distributions of the seeding materials, AgI, and snowfall enhancements were found to be reasonable. In the enhanced snowfall cases, the process by which cloud water and vapor were converted into ice particles after seeding was also reasonable. It was also noted that the AgI residence time (>1 hr) above the optimum AgI concentration (10^5 m^{-3}) and high LWP ($>100 \text{ g m}^{-2}$) were important factors for snowfall enhancements. In the first experiment, timing of the simulated snowfall enhancement agreed with the observations, which supports the notion that the seeding of AgI resulted in enhanced snowfall in the experiment. The model developed in this study will be useful for verifying the effects of cloud seeding on precipitation.

1. Introduction

It has been reported that cloud seeding is economically beneficial for securing water resources [1, 2]. In the winter of 2016, six airborne cloud seeding experiments were performed in the Pyeongchang region of South Korea for precipitation enhancement [3]. Ground observation equipment was used to monitor the changes in the cloud microphysical properties (i.e., particle sizes, concentrations, etc.) and the snowfall rates before and after seeding [4]. However, researchers found it challenging to distinguish natural snowfall from the effects of seeding.

In general, even in the absence of natural precipitation, it is difficult to prove that the resulting snowfalls are caused by the seeding rather than natural precipitation processes.

Furthermore, it is impossible to repeat and verify experiments under the same meteorological conditions. For these reasons, it is desirable to develop a model that can simulate the effects of cloud seeding on the microphysical processes and precipitation. If the timing of the simulated snowfall enhancement is coincident with the observation, this increases the likelihood that the precipitation was due to the seeding.

A number of numerical studies have been conducted on the effects of seeding [5–11]. DeMott [5] conducted a study on the parameterization of the four ice crystal nucleation modes, that is, deposition, condensation freezing, contact freezing, and immersion freezing, of AgI particles. Recently, numerical simulations were carried out at the National Center for Atmospheric Research (NCAR) in which an AgI (seeding material) module was inserted into the Thompson

TABLE 1: Summary of the seeding information, weather conditions, and model configurations.

	EXP1	EXP2	EXP3
Date	29 Jan 2016	6 Feb 2016	20 Feb 2016
Seeding information			
Period (LST)	1252–1336	1521–1555	1355–1432
[UTC]	[0352–0436]	[0621–0655]	[0455–1432]
AgI (g hr^{-1})	1841	2118	1946
Seeding height (km, above the mean sea level)	2.2	2.1	2.5
Seeding path (start/end point)	37°43'N, 128°55'E/ 37°49'N, 128°49'E	37°55'N, 128°36'E/ 37°51'N, 128°27'E	(1) 37°46'N, 128°45'E/37°46'N, 128°35'E (2) 37°48'N, 128°44'E/37°44'N, 128°34'E (3) 37°48'N, 128°43'E/37°42'N, 128°33'E
Weather information (CPOS site from AWS and radiometer)			
Time	0400	0630	0500
Wind speed (m s^{-1})	0.4	0	1.96
Temperature ($^{\circ}\text{C}$)	−3.7	−6.1	−1.2
Humidity (%)	97.6	95.0	61.6
LWP (g m^{-2})	577	120.3	15.6
Model configurations			
Domain area (upper left/lower right)	38°11'N, 127°58'E/ 37°11'N, 129°23'E	38°22'N, 127°50'E/ 37°24'N, 129°13'E	38°12'N, 127°52'E/ 37°14'N, 129°15'E
Period (UTC)		0000–1800	
Model top		50 hPa	
Longwave radiation		Rapid radiative transfer model	
Shortwave radiation		Goddard shortwave scheme	
PBL		YSU scheme	
Land surface		“Noah” land surface scheme	
Surface layer		MM5 similarity	
Microphysics		Morrison scheme with AgI cloud-seeding parameterization	
Horizontal grid interval		1 km	
Dimension (x, y, z)		121 × 106 × 40	
Initial and boundary condition		UM LDAPS analysis data (3 hr, 1.5 km resolution)	

microphysics scheme to study the effects of cloud seeding [6, 7]. Spiridonov et al. [8] performed a numerical simulation of hailstorm suppression using a three-dimensional cloud resolving model to simulate the effects of AgI seeding by aircraft for three distinct hailstorm cases that occurred over Greece.

In Korea, cloud seeding experiments using a two-dimensional Takahashi cloud model [9] were performed to study the seeding effect of ice particles on precipitation developments for both maritime and continental clouds and to analyze cloud developmental patterns based on changes in the cloud particle volume and distribution of precipitation particles over time. In addition, Kim et al. [10] investigated the diffusion, cloud, and precipitation changes caused by the release of ice-nucleating agents using the Clark-Hall model near Pyeongchang. Kim et al. [11] modified the Morrison scheme [12] in the weather research and forecasting (WRF) model and performed numerical simulations for continental and maritime aerosols with ground-based cloud seeding experiments using AgI; however, this method is only applicable to ground-based seeding and cannot be applied in

airborne cloud seeding experiments in which the seeding point moves with time at high altitude.

In this study, numerical simulations of actual airborne cloud seeding experiments were carried out using a WRF (v3.4) model while considering changes in the seeding position and ice nucleation process according to the movement of the aircraft. We also determined the utility of the enhanced snowfall simulation for three cases of airborne cloud seeding experiments in 2016. The remainder of this paper is organized as follows. Section 2 describes the weather situation, seeding information, and design of the model for the selected case studies. Section 3 presents the numerical simulation results, observed snowfall, and simulated snowfall enhancement rate in the model. Finally, the conclusions are summarized in Section 4.

2. Experimental Design

Table 1 summarizes the three representative numerical experiments conducted in early 2016. Experiments EXP1, EXP2,

and EXP3 were conducted on January 29, February 6, and February 20, respectively. We modified the model developed by Kim et al. [11] to simulate with the actual airborne seeding heights, travel paths, and durations.

In this model, the Morrison microphysics scheme considers both the AgI release and ice nucleation processes to calculate the bulk parameters associated with the water vapor, cloud water, rain water, ice crystal, snow, and graupel. In addition, this double moment scheme was employed to simulate the particle concentration as well as the mass concentration for the microphysical parameters of the cloud and seeding material. The seeding effect can be simulated by considering the emission and concentration of the seeding material (AgI) and the nucleation processes of contact freezing, condensation freezing, and deposition.

As shown in Table 1, the seeding start and stop points of AgI flare seeding for four repeated line-type flight paths were the same in all experiments except for EXP3. In all cases, numerical experiments were carried out under the same conditions as the actual experiment for the seeding start and stop times, seeding position, and seeding amount. The reason for the difference in the AgI release rate from case to case is due to the differences in the number of flares and the release time for the individual field experimental situations such as wind speed. The observed weather information from an automatic weather system (AWS) and the radiometer at Daegwallyeong (denoted as CPOS) is listed in the second section of Table 1. In all three cases, the wind speed was less than 2 m s^{-1} and the temperature was colder than 0°C . The humidity and LWP (liquid water path) conditions were the most favorable for seeding in EXP1, followed by EXP2 and EXP3. The model utilizes the Yonsei University (YSU) planetary boundary layer scheme, the NOAH land surface scheme, the MM5 similarity surface layer scheme, the rapid radiative transfer model (RRTM) for longwave radiation, and the Goddard shortwave scheme. Note that the cumulus parameterization scheme was not used in these high-resolution (1 km horizontal) simulations [13]. To optimize the experimental simulations, the Unified Model Local Data Assimilation and Prediction System (UM LDAPS) analysis field of the Korea Meteorological Administration was used as the initial and boundary forcing. This study uses the USGS-based land use data for domains and the 30-second resolution data (e.g., topo_30 s, soiltype_top_30 s, etc.) and Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) sea surface temperature data for the static fields in the domain.

Figure 1 shows the model domains, seeding paths, and wind directions for the three cases. To optimize the performance of the model, the centers of the seeding paths were located in the central part of each domain. The start and end points of the seeding as well as the path were applied as model input values. EXP3 was run with three seeding paths in accordance with what occurred during the actual experiment.

In Figure 2, the conditions of EXP included easterly-northeasterly prevailing winds at 850 hPa in the domain due to the influence of a low-pressure system passing over Japan. The main wind direction at the seeding height (2.1 km MSL) in EXP2 was from the north due to a high-pressure system in the northern part of China. EXP3 experienced westerly winds

at the seeding height (2.5 km MSL) and a pressure of 850 hPa caused by a low-pressure system in Japan and a high-pressure system in the central region of China.

3. Results and Discussion

3.1. Performance Evaluation of the Numerical Simulation. To verify the performance of the original WRF model used in this study, the simulated precipitation and LWP in the three experiments were compared with observations (Figure 3). First, to evaluate the simulated precipitation, the cumulative precipitation from rain gauges and the nonseeded (NOSEED) simulation were compared ((a), (b), and (c)). Figure 3 shows that the amount of precipitation was somewhat different from the observation; however, the simulated precipitation pattern was consistent with the observations. In EXP1 and EXP2, the precipitation in the coastal areas was slightly underestimated while it was overestimated in the mountainous areas. In EXP3, the simulations produced little precipitation, which was consistent with the actual observations. When the observations at 32 stations were compared, the root mean square error (RMSE) was 6.79 (EXP1), 5.71 (EXP2), and 6.83 mm (EXP3). The critical success index (CSI) was 0.65 (EXP1), 0.72 (EXP2), and 0.61 (EXP3) when the threshold value was 0.1 mm.

In order to verify the simulation of the LWP, the simulated hourly LWP (g m^{-2}) was calculated at CPOS where the radiometer was operated. The simulated LWP is defined as follows:

$$\text{LWP} = \int_0^z \rho_{\text{air}} Q_c dz, \quad (1)$$

where z is the height (m) of model top (50 hPa), Q_c is the mixing ratio of cloud water (g kg^{-1}), and ρ_{air} (kg m^{-3}) refers to the density of dry air. Hourly averaged data are calculated and compared with the observed LWP from the radiometer. In the figure, OBS refers to the observed LWP, and MOD is the LWP calculated by (1) from the NOSEED simulation. The 1-hour averaged LWP at 0900 LST was calculated from 0900 LST to 0959 LST (OBS) and 0955 LST (MOD). The observations were at 1-second intervals, and the model data was generated at 5-minute intervals.

In EXP1, in which the cloud liquid water content was the largest, the differences between the observed and simulated values were large. In this case, the numerical simulation of the amount of cloud from the East Sea due to the effects of the prevailing easterly-northeasterly winds may be somewhat different than what was observed, which resulted in LWP differences. The lack of in situ sea surface data may have also contributed to the LWP biases. With the exception of EXP1, the simulated LWP compares well with observations in terms of its magnitude and temporal variations.

3.2. Diffusion of Seeding Materials. Figures 4 and 5 show the simulated diffusion range and time of the arrival of the seeding material, respectively. In Figure 4, EXP1 and EXP2 reasonably simulated the spread of the seeding materials from the seeding area to downwind target areas (CPOS,

FIGURE 1: Topography of the experimental region. The OD, YP, and CPOS are the observation sites at Ode mountain, Yongpyeong, and Daegwallyeong, respectively, with the snow-depth meter, MRR (Micro Rain Radar), PARSIVEL (particle size and velocity disdrometer), and AWS (Automatic Weather System, which included measuring the temperature, wind, humidity, and a rain gauge). The seeding flight paths were repeated four times perpendicular to the direction of wind at the seeding height, except for EXP3 where the seeding path was changed during the seeding period. The heights of the three observation sites are 960 m (OD), 843 m (CPOS), and 771 m (YP) above mean sea level.

YP, and OD) in accordance with the wind. In EXP3, the seeding materials were rapidly transported toward the East Sea instead of toward the destination.

In Figure 5, the time at which the seeding materials reached each point after each seeding pass was determined based on the time that a nonzero concentration of seeding materials first appeared. In EXP1, approximately 10, 18, and 25–30 min were required for CPOS, YP, and OD, respectively, for the seeding materials to reach each point after the seeding started at 1252 LST. In EXP2, the time required for the seeding materials to reach each spot was approximately 20, 50, and 60 min for OD, CPOS, and YP, respectively, after the seeding started at 1521 LST (Figure 5(b)). In EXP3, the materials disappeared relatively quickly at YP and CPOS due to strong westerly wind.

In EXP1 and EXP2, the concentration of seeding materials was approximately 10^3 to 10^5 m^{-3} or higher at CPOS, YP, and OD until 6 hours after seeding (Figures 5(a) and 5(b)). Xue et al. [7] suggested that the concentration of AgI particles for optimal AgI nucleation is at least 10^5 m^{-3} . According to the

results by Xue et al. [7], the start time of the optimal AgI concentration (more than 10^5 m^{-3}) for nucleation for EXP1 was about 1312–1315, 1330, and 1335 LST at CPOS, YP, and OD, respectively. For EXP2, these times were estimated as 1555, 1640, and 1650 LST at OD, CPOS, and YP, respectively. In EXP3, the optimum AgI concentration for nucleation occurred only at OD at 1400 LST. If the results proposed by Xue et al. [7] are correct, the time required to reach optimal nucleation can be used as the starting point for the changes in the cloud microphysics.

3.3. Seeding Effect. The accumulated precipitation difference between the SEED and NOSEED runs increases with time in all experiments except EXP3 (Figure 6). In EXP1, precipitation enhancement appeared at about 38 min (1330 LST) after the start of the first seeding. Approximately 2 hours after the start of seeding, a simulated precipitation enhancement of 0.5 mm or more appeared at 1430 LST near the target areas (CPOS, YP, and OD) (Figures 6(a) and 6(b)). In EXP2, the first precipitation enhancement appeared at 1700 LST, most

FIGURE 2: 850 hPa synoptic charts at 1500 LST of (a) EXP1, (b) EXP2, and (c) EXP3 from the Korea Local Analysis and Prediction System (KLAPS). The box denotes the simulated domain, and the arrow is the wind direction at the seeding height.

of the enhanced precipitation occurred to the east of CPOS at 1900 LST, and precipitation did not increase in YP (Figures 6(c) and 6(d)). Precipitation increases did not occur in EXP3 (Figures 6(e) and 6(f)). Since SEED-NOSEED was positive, precipitation was enhanced by the seeding in EXP1 and EXP2. Precipitation increases in most regions but there are very small regions of decreased precipitation.

To investigate the processes related to the precipitation enhancement in Figure 6, we examined the temporal differences in the microphysical variables of the SEED and NOSEED runs for the area where these precipitation increases occurred (Figures 7 and 8). EXP1 shows the greatest decrease in the amount of liquid cloud water and water vapor near 1400 LST, which was about 20 min after the seeding

FIGURE 3: (a, b, c) The 18-hour accumulated precipitation (mm) of the NOSEED simulations and AWS rain gauges that include a heating device to melt snow in (a) EXP1, (b) EXP2, and (c) EXP3. The model precipitation is color-shaded and is overlaid with the AWS precipitation in the color-filled circles. (d), (e), and (f) indicate the time series of the 1-hour averaged LWP from the radiometer (OBS) and NOSEED simulations (MOD) at CPOS.

FIGURE 4: The accumulated AgI number concentration (m^{-3}) for the SEED simulations from the surface to 3,000 m (MSL) for EXP1 (a, b), EXP2 (c, d), and EXP3 (e, f). The vector represents the wind field at the seeding heights.

FIGURE 5: Time series of the vertically accumulated AgI number concentration (m^{-3}) for the SEED simulations from the surface to the top level of the model in (a) EXP1, (b) EXP2, and (c) EXP3.

ended, and correspondingly the increase in the amount of ice and snow in the cloud. Thus, seeding of ice nuclei (AgI) increased the amount of snow and ice at the expense of liquid cloud water and water vapor, as was found in Xue et al. [7]. As atmospheric water vapor and supercooled water droplets in the seeded clouds are consumed in the process of ice nucleation, the generation (growth) of cloud ice (snow particles) increases, which causes the precipitation (snowfall) to increase. Figure 8 shows that, in EXP2, the amount of cloud

liquid water and water vapor decreased to a minimum and the amount of ice and snow increased to the maximum at about 1730 LST, which was about 90 min after the seeding end time.

Based on an average over the three points (CPOS, YP, and OD) in Figure 5, the AgI concentration reached 10^5 m^{-3} at 1320 in EXP1 and at 1610 LST in EXP2. This time nearly coincided with the sudden change in the microphysical parameters shown in Figures 7 and 8. The microphysics and precipitation changes due to this nucleation were in

FIGURE 6: (a, b, c, d, e, f) Differences between the accumulated SEED and NOSEED precipitation (mm; SEED – NOSEED) from the start of model run until (a) 1330 LST and (b) 1430 LST in EXP1, (c) 1700 LST and (d) 1900 LST in EXP2, and (e) 1600 LST and (f) 2000 LST in EXP3. (g, h, i) Accumulated precipitation in NOSEED run from the start of model run until (g) 1430 LST in EXP1, (h) 1900 LST in EXP2, and (i) 2000 LST in EXP3.

FIGURE 7: Time series of the total amount difference (SEED – NOSEED) of (a) the cloud water mixing ratio, (b) cloud ice mixing ratio, (c) water vapor mixing ratio, (d) snow mixing ratios, (e) latent heat flux, and (f) temperature, which are horizontally and vertically integrated in the verification zone (the box area in Figure 6(b)) for EXP1. The seeding period is shaded in light blue.

FIGURE 8: Same as Figure 7 except for the box area in Figure 6(d) in EXP2.

TABLE 2: Summary of the seeding experiments: seeding conditions and duration of the observed and simulated enhanced snowfall, respectively.

		Number of EXP		
		EXP1	EXP2	EXP3
Seeding conditions				
LWP ¹ (g m^{-2})		220	100	0
AgI residence time ² (min)		70	150	20
Wind speed ³ (m s^{-1})		4	6	12
	Site	Duration* (LST, hh mm)		
Snowfall				
Observation ⁴	CPOS	1400–2300	1100–2300	-
	YP	1300–2200	1400–2200	-
	OD	1200–2300	1400–2100	-
Simulation ⁵ (enhanced)	CPOS	1300–1500	1700–1800	-
	YP	1300–1500	-	-
	OD	1300–1500	-	-

¹The averaged value at the center of the seeding path during the seeding period in the NOSEED simulation. ²The period above the averaged optimum AgI concentration for the sites (see Figure 5). ³Averaged value for the NOSEED simulation over three hours after seeding at the seeding height in the domain area.

⁴Observation by the snow-depth meter. ⁵Calculated from the SEED-NOSEED simulation. *Defined as the start and end times of the snowfall. “-” indicates that snowfall did not occur.

agreement with the optimum concentration suggested by Xue et al. [7]. The ice formation from the supercooled water due to the seeding induced a latent heat release, which increased the temperature.

Figure 9 shows the hourly observed and simulated snowfall enhancement (SEED-NOSEED) by calculating the area-averaged snowfall (assuming 1 mm of simulated precipitation as 1 cm snowfall) in the $10 \text{ km} \times 10 \text{ km}$ region centered at each observation site. To compensate for the low spatial accuracy of the simulated precipitation in the model, it is common to use the mean precipitation in an area [14]. Figure 9 shows that, in EXP1, the time at which the simulated snowfall enhancement appeared nearly coincided with the beginning of the observed snowfall. In EXP2, the duration of snowfall in the simulation was shorter than that in observation. It is difficult to conclude that precipitation was a consequence of seeding when the start time of the actual snowfall is much earlier than in the simulation. If there is an overlap with the natural precipitation, it is difficult to determine whether or not the seeding effects appeared in the simulation. Based on the simulated effect, we deduced that at least some of the observed precipitation was caused by the seeding. To obtain a more reliable verification, a large number of similar seeding experiments and simulations are needed. In EXP3, there was no snowfall or snowfall enhancements in either the observations or the simulations.

An analysis of the intensity of the enhanced snowfall due to seeding in each experiment is as follows. In Figure 10, compared to EXP1 and EXP2, EXP3 shows that there was not enough cloud water, and thus enhanced snowfall is not simulated. In Figure 10, the position of point A was at the middle of the seeding line, and point B was arbitrarily chosen as one position in the downwind region to investigate the LWP situation in the diffused region of seeding material. The average LWP at the center of the seeding path during the seeding

period was about 220 g m^{-2} for EXP1 (Figure 10(d)), and the average LWP of EXP2 was about 100 g m^{-2} (Figure 10(e)). For EXP2, the LWP value was less than EXP1 during the seeding period; therefore, it seems that a small amount of enhanced snowfall was simulated at CPOS.

Table 2 summarizes the seeding conditions and enhanced snowfall times in the simulations. Table 2 suggests that the main factors for simulated enhanced snowfall were the LWP in the experimental area, the AgI residence time in the target areas, and the wind speed at the seeding altitude. According to the results of the simulation, the conditions for snowfall enhancement by airborne cloud seeding in the Pyeongchang region (YP is the Alpine skiing playing field of the 2018 Winter Olympics) are considered to be over an LWP of 100 g m^{-2} , AgI residence time of the optimal concentration (10^5 m^{-3}) over 1 hour, and wind speeds of less than about 10 m s^{-1} , although the number of simulated cases was not sufficient to definitively confirm this. If the observed precipitation time and the simulated time of the snowfall increase in the target almost coincide (i.e., EXP1), this can be used as reliable evidence for the effect of seeding in enhancing snowfall.

4. Conclusions

To assess the effects of airborne cloud seeding on precipitation in field experiments, numerical simulations were conducted based on data from actual experiments conducted over the Pyeongchang region using the modified WRF model. The following three cases from 2016 were selected and analyzed: an experiment on January 29 where the start time of snowfall and the time of the simulated snowfall enhancement almost coincided (EXP1), an experiment on February 6 when natural snowfall overlapped with snowfall enhancement in the simulated results (EXP2), and an experiment on February 20 in which no snowfall was either

FIGURE 9: The hourly simulated (SEED-NOSEED; dot-solid) and observed (bar) snowfall by snow-depth meter in EXP1 ((a) CPOS, (b) YP, and (c) OD) and EXP2 ((d) CPOS, (e) YP, and (f) OD). The dashed lines denote the hourly simulated AgI concentration. All the simulated values were calculated in each $10 \text{ km} \times 10 \text{ km}$ box centered at the observation site.

FIGURE 10: (a, b, c) Distribution of the 1-hour vertical accumulation of cloud water mixing ratio (g kg^{-1}) from the seeding start time and (d, e, f) time series of the hourly liquid water path for the NOSEED simulation in EXP1 (a, d), EXP2 (b, e), and EXP3 (c, f). The blue and red lines in (d), (e), and (f) indicate the values at A and B in (a), (b), and (c), respectively.

observed or simulated (EXP3). For EXP1 and EXP2, it was confirmed that the seeding materials reached the target area in the downwind side and increased the snowfall. As shown in EXP1, if the time of precipitation increases coincides with the simulated precipitation time, the probability for successful enhancement or initiation of precipitation by seeding is high. For EXP2, the observed precipitation may have been a combination of natural precipitation and seeding-induced snowfall. It is difficult to quantify the effects of seeding from the observations in EXP2; however, the simulation suggests that the seeding at least partially affected the precipitation in EXP2.

In EXP1 and EXP2, the numerical experiments show that the amount of precipitation and atmospheric solid particles increased due to the seeding at the expense of liquid cloud water and water vapor because the atmospheric water vapor and supercooled water droplets were consumed in the nucleation processes to generate snow and ice particles. The increase in ice particles caused the precipitation increase by seeding. For EXP3, the seeding material was transported rapidly northeastward toward the sea by strong westerly winds. An analysis shows that the snowfall enhancements did not occur in this case due to relatively short AgI residence time of the seeding material required for the nucleation and growth processes, as well as the small LWP.

The model that was developed to simulate the effects of airborne cloud seeding can be employed for qualitative evaluations of the effects of seeding. When natural precipitation occurs in the target area, it is difficult to pinpoint the effect of enhanced snowfall with only observational data. However, if the simulation shows enhanced snowfall due to seeding, this suggests that the precipitation was affected by seeding despite the lack of quantitative verification of the seeding effect (EXP2). In addition, if simulations are performed prior to cloud seeding, it is possible to increase the success rate of seeding by identifying information for optimizing the seeding (e.g., locations, timing). In future work, the real-time simulation system will be further studied.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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