Weather Modification Experiments in Korea

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1. Introduction

The object of cloud seeding is to increase rainfall amount on the ground by enhancing precipitation efficiency of clouds through seeding of artificially generated IN (ice Nuclei) or CCN (Cloud Condensation Nuclei) in a desired areas. Before cloud seeding and weather modification experiments, however, a comprehensive study of cloud microphysics, local and synoptic weather conditions is required to judge the feasibility of the experiments. Recently, Meteorological Research Institute (METRI), Korea Meteorological Administration (KMA) has been conducted several ground-based experiments and aircraft experiments in the past. METRI/KMA will try to develop the techniques of Weather Modification in Korea with more scientific methods.

Fog is well known for its impact on quality of life and public safety in transportation, tourism and outdoor activities such as open-air sports. Despite modern systems for take-off and landing with poor visibility, aircraft-running frequency is largely reduced in the presence of fogs. For an airport like Frankfurt/Main, the economic loss per fog hour is estimated at about 250,000 euro/hr (Moeller et al., 2003). Road traffic accidents due to fog may also be catastrophic. For example, on US highways, from 1981 to 1989, more than 6000 deaths were associated with such events (NCHRP, 1998). The problem is becoming more important with the increase in fog frequency associated with air pollution and climate change. On the other hand, in certain very dry areas, fog is beneficial and supplies some of the necessary moisture to vegetation (Schemenauer, 1998). Fog droplets can also be captured with nets and be used as an alternative source of freshwater.

The major objective of cold cloud seeding is to enhance the precipitation into the ground to accelerate precipitation efficiency with inputting artificially AgI particles into the seeding experiment target area. Zhidong and Pitter (1996) suggested the new ice formation mechanisms the forced condensation freezing process having the rapid process time ~ 1 min. This process has been investigated in the laboratory and field experiments.

We concentrated on basic research of cloud physics for practical use of precipitation enhancement and fog dissipation and numerical model applications through the cloud seeding experiments. To observe and analyze the change of the cloud characteristics before and after the seeding experiment, we have established the Cloud Physics Observation System (CPOS; Fig. 1).

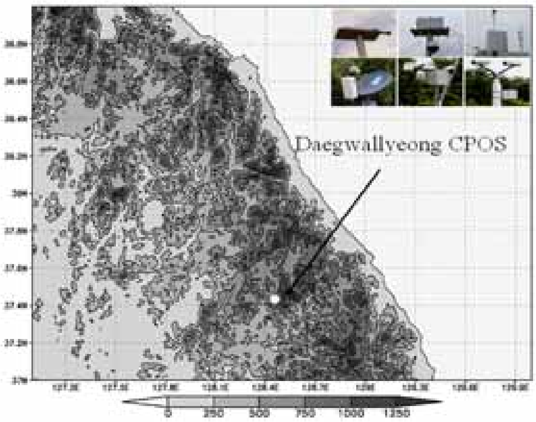

Fig 1. Location of Daegwallyeong site for Cloud Physics Observation (CPOS), Korea.

2. Cloud Modification Experiments

2.1 Warm cloud modification

Two hygroscopic-particle (mainly composed of $CaCl_2$) seeding experiments have been performed at the Daegwallyeong super site with 1-hour interval during about 2 hours in 16 June 2005 to dissipate the natural warm fog. During the hours, the particle size and number concentration have been measured by the FSSP-100 (Forward Scattering Spectrometer Probe) and then visibility obtained. The seeding gives the mean 1.38-times visibility improvement during the mean 13 minutes. The fog dissipation suggests the decrease of buoyant fog droplets by their enhancement of condensation and falling due to seeding.

To dissipate the natural fog, two experiments have been performed by using a hygroscopic flare composed of mainly $CaCl_2$ at the CPOS (37°41'N, 128°45'E) with the altitude of 842 m from mean sea level during about 2 hours in 16 June 2005 (Figure 2). The equipment primarily employed in this experiment is the FSSP-100 (FSSP) measuring the size and concentration of the fog droplets.

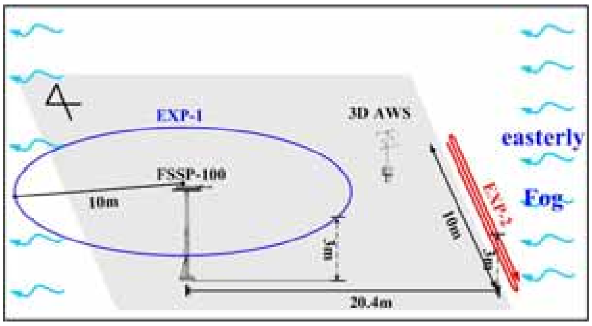

Fig 2. The two seeding paths (EXP-1 and EXP-2) used in the weak easterly-advection fog (filled arrows) are schematically shown.

Two seeding experiments of hygroscopic material mainly composed of $CaCl_2$ (150g; about 2.5 min. flaring) have been performed to investigate into their effect on the natural fog during the foggy hours (about 2 hours of 16 June 2005) at Deagwallyeong site.

2.2 Cold cloud modification

We confirm the Zhidong and Pitter's forced condensation process by the small-scale (about $1.25x10^5$ m^3) AgI seeding experiments. The 13 physical cloud seeding experiments were conducted for the optimized atmospheric conditions, characterized by easterly fog flow, during the period Jan. ~ Feb. 2006, and then we found that the snow enhancement is observed for the 6 experiments using the small amount of AgI when the fog exists in Gangneung.

Wintertime cloud seeding experiments have been performed by using AgI ground-generator at the CPOS during 18 Jan. ~ 19 Feb. 2006. Cloud seeding experimental results were observed particle size, number concentration, rain rate, PWV (Precipitable Water Vapor), LWC (Liquid Water Content), and LWP (Liquid Water Path) (Cha, et al., 2005).

Figure 3 shows schematic diagram of wintertime cloud seeding experiments. Wintertime orographic cloud seeding experiments performed easterly fog flow and air temperatures below -5 . The 30-minutus ground-based AgI generator-seeding experiments are conducted 13 times (AgI burning: 9 times and propane combustion: 4 times) and AgI consumption was large and small.

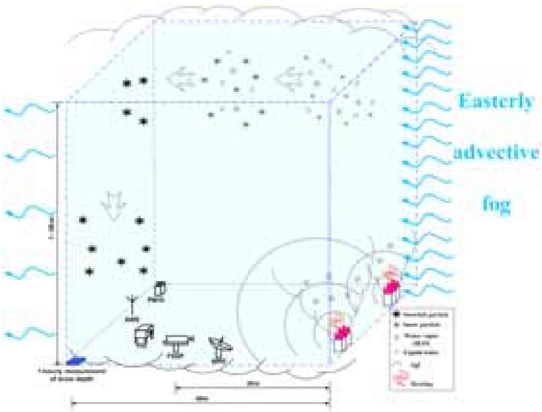

Fig 3. Schematic system for the winter weather modification experiment at the Daegwallyeong site.

Table 1 shows the experimental weather situation and the observed increment of snowfall. The enhancement of snowfall is detected in 6 of 13 experiments at Daegwallyeong weather office. In the initial (~10 min.) AgI seeding experiments, most reflectivity profile of Micro Rain Radar is abruptly increased and the droplet concentration of FSSP decreases.

Table 1. Brief description of the wintertime AgI seeding experiments for the weak easterly advection cloud.

	Date	Exp. Time (period : min.)	Seeding Procedure	Daegwallyeong Wind Direction/Wind Speed(m/s)	Gangneung Vis.(km)	Increment of 1-hr Accumulated snow (cm)
1	2006. 1. 18	23:23 ~ 23:47	Small AgI	NE / 0.5	1.2	0.1 → 0.2
2	2006. 1. 19	00:38 ~ 01:08	Large AgI	E / 0.8	1.2	
3	2006. 1. 19	09:24 ~ 09:58	Small AgI	E / 2.5	1.2	0.4 → 0.6
4	2006. 1. 19	10:28 ~ 10:58	Small AgI	ENE / 1.4	2	
5	2006. 1. 19	15:56 ~ 16:27	Small AgI	NNE / 0.8	3	0.1 → 0.2
6	2006. 1. 31	19:22 ~ 19:52	Only Propane	ENE / 1.1	6	
7	2006. 1. 31	20:57 ~ 21:27	Small AgI	-	6	
8	2006. 1. 31	22:27 ~ 22:57	Large AgI	-	6	
9	2006. 2. 1	07:20 ~ 07:50	Only Propane	ENE / 2.3	3	0.4 → 0.7
10	2006. 2. 1	09:00 ~ 09:30	Small AgI	ENE / 2.3	7	
11	2006. 2. 1	10:30 ~ 11:00	Large AgI	ENE / 2.1	7	
12	2006. 2. 1	12:10 ~ 12:55	Small AgI	-	7	0.0 → 0.1
13	2006. 2. 15	17:05 ~ 17:35	Only Propane	ENE / 1.6	8	0.0 → 0.1

3. Summary

To dissipate the fog, we have performed the two $CaCl_2$ seeding experiments, which gives the averaged 1.38 times improved visibility during the averaged 13 min. This result suggests that this $CaCl_2$ seeding has the potential to dissipate the fog.

The 13 physical cloud seeding experiments were conducted over the Daegwallyeong CPOS (Cloud Physical Observation System) for the easterly fog flow during the period Jan. ~ Feb. 2006, and then we found that the snow enhancement is observed for the 6 experiments using the small amount of AgI when the fog exists in Gangneung, which will be useful for the large scale water resource supply.

4. Reference

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