# RECENT STUDIES ON PRECIPITATION ENHANCEMENT IN CHINA

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## 1. Introduction

The shortage of fresh water resource has been affecting the sustainable development of regional economy and community in the Northern China. As one of the most important fresh water resources, the atmospheric precipitation has been noted. While the present water resources are reasonably utilized, it has become insistent to increase atmospheric precipitation by artificial seeding in clouds in order to lighten shortage of water resource in the Northern China.

During the national "tenth five-year program" period (2001-2005), the Ministry of Science and Technology of China supported a national key research project "*The demonstration of precipitation enhancement techniques"* with the research fund of 10.5 million RMB (about US$ 1.3 million).

In the national "eleventh five-year program" period (2006-2010), the Ministry of Science and Technology of China will continue support a national key research project "*Key Technology and Equipment Research and Development on Weather Modification"* with the research fund of 25 million RMB (about US$ 3.2 million), which will start in 2007.

## 2. The "tenth five-year" project "The demonstration of precipitation enhancement techniques"

The project designed to augment precipitation over the selected demonstrating areas has been conducting with the following subprograms:

(1) Develop detecting techniques for precipitation augment;

(2) Investigate regional cloud-water resource and its potential of precipitation enhancement;

(3) Develop numerical models for precipitation enhancement simulation;

(4) Develop catalyzing techniques for precipitation enhancement;

(5) Investigate statistical and physical evaluation techniques for effectiveness of cloud seeding;

(6) Carry out field experiments for precipitation enhancement in the demonstration regions;

(7) Integrate comprehensive techniques to set up a demonstration system for precipitation enhancement.

The main goal of the project is to produce the new techniques of precipitation enhancement suitable to the typical regions of China (especially the Northern China).

### 2.1 Comprehensive detecting techniques for precipitation enhancement

It is one of the key techniques to improve the effectiveness of precipitation enhancement that obtaining various operation-related conditions and criterions and identifying adequate time and location in clouds for operational cloud-seeding through well-designed monitoring techniques for the different targeted clouds.

In order to develop techniques for precipitation enhancement, the project puts a high priority to develop and use the advanced facilities including aircraft-based instrumentation (i.e., PMS probes), ground-based facilities (i.e., weather radar, satellite receiver, intensive observation network), airborne cloud-seeding apparatus, and to optimize and integrate

methods, software, and techniques for comprehensive observations.

*Figure 1 Photo of the aircraft for observation and cloud seeding.*

Another important work of the project is to refit a specialized aircraft for observation and cloud-seeding. The aircraft, called as XiaYan-III A, was manufactured in USA (see Figure 1),with maximum flying height of 10500m and the maximum flying time of 4.5 hours. A new type of the Particle Measuring Systems (PMS), including PCASP-100X (0.1-3.0μm), FSSP 100 (0.5-47μm), FSSP-ER (1-95μm), OAP 2DGA-2 (25-1550μm), OAP 2DGB-2 (100-6200 μm), was imported from USA and installed in the aircraft. The King LWC measuring device, the aircraft-ground data transmission system, the GPS positioning, the new airborne AgI flame seeding generator (see Figure 2) are also installed in the aircraft.

*Figure 2 The airborne AgI flame seeding device*

Six weather-radars, including two 5-cm Doppler radars (see Figure 3), one 10-cm Doppler radar, are used in the project. The airborne and ground-based radiometers are also used to detect the liquid water content in clouds. The new technique for the meteorological satellite data to derive cloud parameters is developing. Other instrumentations used in the project include lightening detecting, precipitation drop spectrum, rainfall, et al. The intensive observation of upper-air sounding is provided in a demonstrated area, with one running per three hours during the experiment.

*Figure 3 Photo of the 5-cm Doppler radar.*

**2.2 Assessment of cloud-water resource and potential for precipitation enhancement**

The project is to develop an assessment technique to evaluate regional cloud-water resources and its potential for precipitation enhancement under different cloud conditions in the demonstrated areas, by the use of data from aircraft, meteorological satellite remote sensing, Doppler weather radars, upper-air sounding, microwave radiometers, rain gauges and weather charts, et al.

**2.3 Numerical simulation for precipitation enhancement**

Several numerical models have been developing, including a non-hydrostatic cloud model with the considerations of explicit cloud and precipitation processes and cloud seeding, an improved cloud model with bin microphysics, and improved convective and stratus cloud models. These numerical models will be also

used in the assessment of regional cloud-water resource and its potential for precipitation enhancement, and cloud-seeding effectiveness.

### 2.4 Catalyzing techniques

Based on the present cloud-seeding techniques (i.e., airborne and ground-based AgI generators, “37” artillery with AgI seeding, rocket launcher), the project has taken more attention to develop new prescription of AgI-explosive mixture of artillery shells and rockets to get high seeding rate, and new seeding devices including airborne generator of liquid-nitrogen and mixture of dry-ice and liquid-nitrogen, and AgI flame. An unmanned aircraft for AgI flame seeding (see Figure 4) has been developed and used to field experiments. A comprehensive seeding technique has been provided to get more efficient seeding effectiveness based on the cloud conditions.

*Figure 4 Photo of the unmanned aircraft for AgI flame seeding.*

### 2.5 Evaluation technique for precipitation enhancement effectiveness

The project is to improve statistical test technique to be fitted to the demonstrating areas, and develop a comprehensive technique combining statistical, physical and numerical simulation methods. The comprehensive evaluation technique has been used in Henan demonstration area.

### 2.6 Field demonstration experiments

Several areas have been chosen as demonstrating experimental regions in this project, such as the ones located in Henan Province, central part of China; in Qinghai Province, north-west part of China; in Gansu Province, north-west part of China; and Beijing, north-central part of China. Specific scientific purposes and preparation of observation and seeding experiments were designed. The Qinghai demonstrating area is designed as precipitation enhancement for water-store-up, and the Henan demonstrating area as for against-drought. Figure 5 shows the example of Henan demonstrating area.

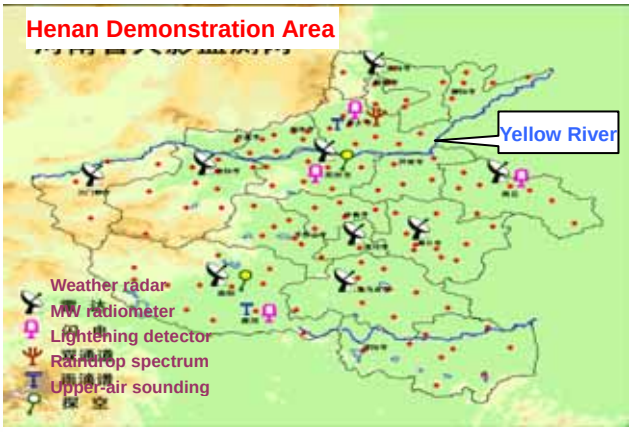


*Figure 5 Diagram of the Henan demonstrating experimental area.*

### 2.7 Integrated comprehensive techniques and demonstration system for precipitation enhancement

The comprehensive techniques for precipitation enhancement developed in this project has finally integrated into a demonstration system in Beijing area and has been elementarily used in precipitation enhancement operation in this area.

## 3. The “eleventh five-year” project “Key Technology and Equipment Research and Development on Weather Modification”

During the “eleventh five-year program” period (2006-2010), a new national key research project “*Key Technology and Equipment*

*Research and Development on Weather Modification"* will be supported by the Ministry of Science and Technology of China again. It will start in the early of 2007. This new project consists of following seven subprograms:

(1) Study on cloud and precipitation structure and process;

(2) Study on precipitation enhancement techniques for cumulus-stratiform mixed cloud;

(3) Study on precipitation enhancement techniques for warm cloud;

(4) Study on fog dispersion techniques around Beijing area;

(5) Study on cloud seeding techniques by unmanned aircraft;

(6) Study and develop equipment for precipitation enhancement and fog dispersion;

(7) Integration and demonstration on comprehensive precipitation enhancement techniques.

## 4. Summary

The past key research project "*The demonstration of precipitation enhancement techniques"* is a comprehensive research and demonstration project with the use of new observational and experimental facilities, and high-performance numerical cloud models. It has made much progress in precipitation enhancement in China. However, the limit time of field experiments requires more scientists to join the project and work hard, more present achievement in this field to be contributed to the project, more cooperation with other agencies.

The coming key research project "*Key Technology and Equipment Research and Development on Weather Modification"* will lead Chinese research on precipitation enhancement to a deeper bourn. We hope we can find and recognize more and more advanced and useful methods and techniques on weather modification by study under this new project.

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