A NEW 1M^3 ISOTHERMAL CLOUD CHAMBER FOR THE INVESTIGATION ON CLOUD PHYSICS

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1. Introduction

A technical workshop was held to review areas and goals of laboratory research in cloud physics and cloud chemistry, define the basic and practical utility of in terms of past accomplishments and future potential, assess the status and needs for existing and new facilities, and recommend future direction for laboratory research and corresponding facilities development in the disciplines of atmospheric science affected by cloud processes (R. List, 1986). Recently, some new useful facilities have been developed in China. Such as, a device for drop freezing experiment was improved, which consists of the cold-cavity, thermometer, controller of temperature, recorder of signals, cold sink, and environment box. His experimental results show that there is obvious deference in temperature spectra of freezing nuclei for different precipitation samples (Yang, 2005). A 15-liter mixing cloud chamber is developed to improve the creditability of data and test the ice nuclei effectiveness of “the 37 model silver iodide shell” (Yang, 2007a). In order to measuring the relative concentration of freezing nuclei in hydrometeors, based on Vali’s even drops freezing experiment methods, a new system of automatically detecting drop frozen signals and processing test data have developed (Yang and Feng, 2007b).

Introducing either artificial ice nuclei (AIN) or cooling materials into super-cooled water cloud to initiate ice formation and Bergeron-Findeison process is now still the basic approach in the experiments and operations of weather modification. Since the first discovery of AgI as an efficient ice nuclei by Vonnegut in 1947, a great deal of theoretic and experimental work on ice nucleation has been conducted around the world. The measurement of ice nuclei can be mainly made with simulating and mechanism methods. Many kinds of instruments and facilities have been used. However, so far, there is none to be able to entirely simulate the conditions occurring in the natural atmosphere and responding to all ice nuclei which nucleate ice through different nucleation modes (mechanisms). The tests of artificial ice nuclei play an important role in weather modification. In China, many such tests have been done in the past 40 years (testing group, 1975; Zhang and Huang, 1979; Shi. et al, 1982; Chen and Feng, 1985; Feng. et al, 1995; Su, 2000), and some guiding results have been obtained for the manufacture of AgI-containing gun shell and small rocket and for the organic ice nuclei. The isothermal cloud chamber at the cloud physics process, cloud simulation and aerosol research is still used as one of very useful equipments. Based on the key techniques of the 2 m^3 and 96 m^3 cloud chambers in CAMS, we originally constructed a new 1m^3 isothermal cloud chamber (ICC).

The new 1m^3 ICC mainly for ice nucleation study is described in this paper. Its structure, attached instruments and experimental procedures are also presented. The experiments of determining the ice nuclei effectiveness for the AgI-containing aerosols produces by 5 kinds formulations have been conducted and the results have been compared with those of two different burning rooms. All experimental results show that the chamber has advantages of stable performance and reproducibility. It would be expected to become a calibration standard for ice nucleation investigation in China.

2. Facilities and their function

Fig.1. A photograph of 1m^3 Isothermal cloud chamber (ICC) in CAMS

The equipment for ice nuclei test includes cloud chamber, fog generator, ice nuclei generator, measuring instruments, clean air source, dilution wind tunnel and aerosol sampling syringe.

The main body of the cloud chamber is a cylindric jacket tank with top and bottom and all made from stainless steel, with internal diameter 0.88 m, height 1.76 m and volume 1m^3(as shown in Fig.1). More than 95% areas of the chamber surface are covered with jacket except the entrances and holes. Its measuring system includes:

- The fog is generated by an ultrasonic nebulizer.
- aerosol dilution and sampling
- temperature measuring system
- counting of ice crystals
- spectrum and concentration of fog droplets
- transparency, and so on.

3. Experiment procedures

General procedures for ice nuclei tests are as follows：Cooling cloud chamber → Sending fog（to clean the background ice nuclei and increase LWC）→generation ice nuclei aerosols diluting aerosols in wind tunnel →sampling（or diluting again）→injecting aerosol sample into cloud chamber→ taking out the slides from chamber and counting ice crystals under microscope →monitoring LWC and chamber temperature during whole test process.

Due to overcoming the limit of cooling system is not automatically controlled in the chamber, the isothermal state is achieved after we improved the temperature controlling system of the ICC.

Table1. The results of cooling capability of the new 1m^3 cloud chamber

	T1 (℃)	T2 (℃)	T3 (℃)	T4 (℃)	Time (hh:mm)	rate (℃/min)	Cooling mode
1	-25.0	29.3	26.60	-24.48	5:37	0.147	double
2	-10.0	29.0	13.05	-9.19	2:23	0.156	double
3	-10.0	31.0	-0.65	-8.47	0:57	0.137	double
4-1	-15.66	31.0	-8.86	-12.73	1:49	0.036	single
4-2		31.0	-12.73	-13.31	0:09	0.076	double
5	-8.68	31.0	-2.47	-7.56	0:49	0.104	double
6-1	-20.69	31.0	-7.58	-12.92	2:29	0.036	single
6-2		31.0	-12.92	-19.13	0:57	0.109	double

From the cumulative number of ice crystals and mass of ice nucleant injected in the chamber the nucleation effectiveness can be calculated

$$N = \sum n \times \frac{V_1}{V_2} \times \frac{S_1}{S_2} \times \frac{1}{m}$$

Where N is active ice nuclei produced by one gram nucleant at temperature t , $\sum n$ the cumulative number of ice crystals in one viewfield of microscope from all sampling slides in a test. Generally, it lasts less than one hour for each test. The rate of ice nucleant can be studied from the cumulative number of ice crystals as a function of time.

4. Some results

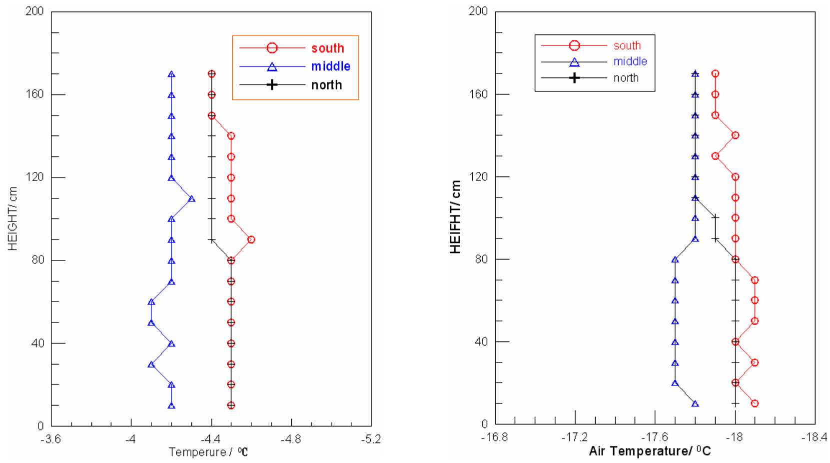

Fig.2. Temperature distribution in the cloud chamber during the investigation (a,-4.4℃; b,-18.0℃)

The best advantage of the cloud chamber is its temperature controlling system. It is entirely automatic, you just set the cloud chamber which you need simulating the fog environment, it will run by its system, and keep it for a long time during the experimental studies. The measurements show that the temperature of the chamber is stable well, its difference inside the chamber is less than 0.3℃.

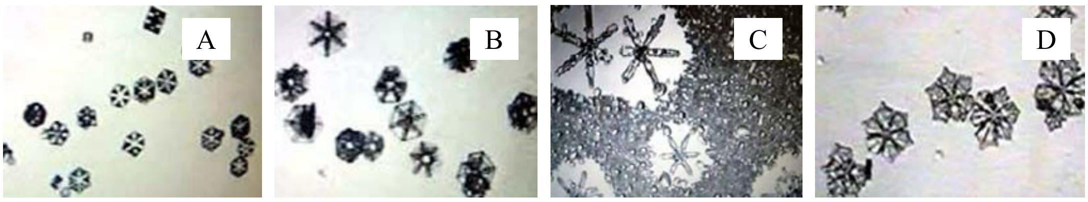

Fig.3. The shape characteristics of ice crystal in the cloud chamber(A-10℃;B-12℃;C-16℃;D-18℃)

5. Discussion

(1) Although the test of AIN is difficult, the comparing experiments and other experiments done in 1m^3 ICC show that the tests have good experimental performances and small data variances. It indicated that the design of cloud chamber structure is rational and the system is highly steady. It gains an advantage over the other cloud chambers ever used in China. The cloud chamber would provide a useful test facility for studying on Cloud Physics process, improving the seeding method, device and formulation of generating ice nuclei and for the research of seeding materials.

(2) The improvement is needed in sending fog unit and sampler diluting unit. The size distribution of fog droplets is great on the small slid for the used nebulizer. And the pre-cooling fog still remains to be solved.

(3) To study the artificial ice nuclei is the main aim of this chamber. The natural ice nuclei, new seeding agents, aerosol and some cloud physical processes cloud also be investigated under the stable environmental temperature, humidity and fog conditions provided.

Key Words: cloud chamber, test, artificial ice nuclei, mechanism investigation

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