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Study of the Effects of Acidic Ions on Cloud Droplet Formation Using Laboratory Experiments

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Abstract

Atmospheric aerosols affect climate of the Earth, scatter sunlight and serve as cloud condensation nuclei (CCN). Yet the reason for many observed events of new aerosol formation is not understood. One of the ideas put forward to explain these events is that the presence of SO_4^{2-} can enhance the formation of aerosols. These sulphate aerosols form partly during the oxidation of the oceanic emission Dimethyl sulfide (DMS) into the atmosphere and partly from volcanoes, plants and soils, fossil fuel combustion, and biomass burning. In this paper, laboratory experiments on warm cloud formation with different acid ion density are presented. The results show that the lifetime of cloud is reduced by increasing density of SO_4^{2-}, but this changes is not significant (significance level, P=0.578), while the cloud concentration is significantly changed with the decreasing of density of SO_4^{2-} (P=0.001). There is also a good significant correlation between cloud concentration with the maximum temperature change, with correlation coefficient, r=0.646 (p=0.004).

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Keywords: Cloud chamber, nucleation, acidic ions, so_4^{2-} , experiments.

1. Introduction

Aerosols are present throughout the atmosphere and affect the climate of the Earth by varying cloud properties [1]. Researches show that the presence of ions may enhance the formation of aerosols [2]. The role

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of ions in the production of aerosols is among the least understood, while being an important, process in the Earth's atmosphere. The nucleation rate is usually proportional to the ion density and the negative ions are important in nucleation [2]. One of the negative ions in the atmosphere is SO_4^{2-}, observed as sea and non sea salts (SS-SO_4^{2-}, NSS-SO_4^{2-}, SO_4^{2-} = NSS-SO_4^{2-} + SS- SO_4^{2-}). NSS-SO_4^{2-} is that fraction of marine SO_4^{2-} aerosol that is not derived from sea water aerosol droplets. NSS-SO_4^{2-} plays a key role in radiation and cloud processes. Hence, it is important to understand the factors affecting its distribution over the oceans. NSS-SO_4^{2-} is a major acidic aerosol species in the atmosphere; over large areas of the world. The pH of aerosols and precipitation is largely controlled by the density of NSS-SO_4^{2-} and ammonium. NSS-SO_4^{2-} aerosol over the oceans has two major sources: the oxidation of Dimethyl-sulfide (DMS) emitted by marine organisms and pollution transported from the continents [3]. Experimental evidence for a microphysical mechanism has been reported in different papers [2, 4, 5, 6 and 7]. However, the role of ion sulfate has not been explored extensively in the laboratory or in field observations. The goal of the current paper is to report some results of the study the effects of sulfate aerosol on the warm cloud formation using laboratory experiments.

2. Experimental methods

The measurements were performed in a 20 litter reaction glass chamber shown schematically in Fig.1. Commercially available sulphuric acid was used to generate SO_4^{2-} for the experiments.

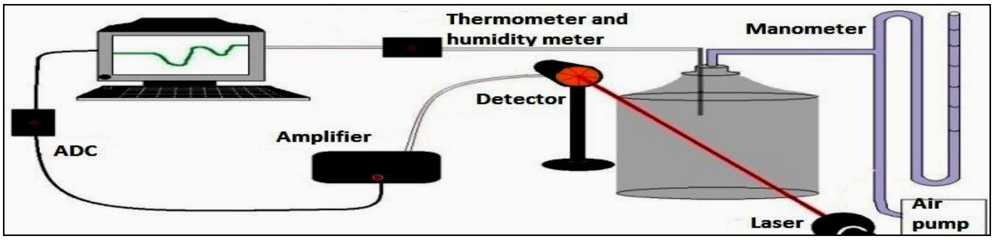

Fig. 1. Schematically figure of the experimental set up.

Table 1. Density of acid was tested and their relevant PH.

Density of sulfuric acid(PPM)	PH	
333.58 450.8	6.8 6.35	
647.53	5.6	
1039.98 1628.65	3.6 3.35	

In order to study the cloud lifetime, cloud concentration and maximum temperature change, five different densities of $H_2SO_4$was added in 1 litre of water at the bottom of the chamber (Table 1). The pressure was increased up to 103 mmHg in the cloud chamber, and then aerosols were allowed to settle to a new steady state for a period of 10-15 minutes. After that the gases was affected under free expansion by opening the chamber valves, this resulted in formation of cloud droplet with a certain density. Cloud concentration was measured by a laser system including a detecting device that detects the opacity of the cloud chamber to laser light; cloud lifetime was estimated by responses of laser system too. A fast response temperature sensor measures the temperature in the chamber. The experiments were repeated for 4 times in each density of acid