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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Studying an effect of salt powder seeding used for precipitation enhancement from convective clouds" *by* A. S. Drofa et al.

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We thank the reviewer for the constructive comments. Following are our responses:

Pg. 10743:

Description of the various hypothesized ways by which hygroscopic seeding might be working was added to the introduction. The findings and hypothesis of Mather (1997) are also referenced in this context.

Pg. 10748:

The following addition is made in the article: ”The initial stage of cloud formation is simulated in the BCC at updraft velocities usually of 1-2 ms^{-1} for warm continental clouds. The cloud drop size distribution formed is determined by the physicochemical properties of condensation nuclei and the water vapor supersaturation in the chamber. The cloud drop concentration depends on maximum supersaturation. Water vapor supersaturation is not measured in the BCC, but in our experiments realized are cloud drop concentrations observed in continental convective clouds.”

Pg. 10751:

The following addition are made in the article: “As it has been mentioned above, in the BCC the initial stage of convective cloud microstructure formation is modeled. The simulation of the raindrop embryo effect is likely to be impossible. But, as it is shown in Drofa (2006), the transformation of a cloud drop spectrum as a result of the introduction of hygroscopic particles at the initial stage of cloud formation plays the crucial role in the effect of modification. The size spectrum of the droplets formed in the initial stage of cloud origination determines the subsequent development of cloud microstructure, rate of large drop formation, development of coagulation processes and precipitation formation. This Section presents the measurement results of changes of the cloud microstructure in the cloud chamber at the introduction of the salt powder and the estimations of the impact of the salt powder based on the observed changes of the cloud microstructure.”

"More than 1 mg m^{-3} of salt powder is required for starting the competition effect with $N_B/N > 1.1$. This means that when dispersed homogeneously at this concentration, 1 kg of salt powder would fill a cloud volume of 10^6 m^3 or 10^{-3} km^3. Actual measurements of dispersion of seeding material showed a dispersion greater by a factor of 10^3 at 1 km above cloud base (Rosenfeld et al., 2010) leading to a respectively smaller concentrations of the seeding agent. Furthermore, as will be shown in the next section, the tail and rain embryo effects of the salt powder totally dominate the rain production at the initial concentrations where $N_B/N > 1$. "

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Pg. 10755:

It was mentioned in the article that the computation results obtained with a one-dimensional warm cloud model (without ice processes) were used for comparative assessing of the efficiency of hygroscopic seeding agents. The given model calculates that warm clouds with H < 3.5 km do not produce precipitation with the background aerosols. Rain can appear in such clouds only as a result of seeding with the salt powder. The following text was added to the article: “In this paper we shall theoretically study the efficiency of cloud modification by the salt powder with the use of a one-dimensional convective cloud model developed by Drofa (2007, 2008, 2010). In these articles, an analysis of evolution of cloud microstructure and precipitation in response to the introduction of hygroscopic particles is made, and the efficiency of hygroscopic seeding of clouds is studied depending on cloud parameters and physicochemical properties of the hygroscopic agent. Similar studies made with the use of a 3-D model are made in the recently published paper (Kuba and Mukarami, 2010). The results of this work are in complete agreement with the conclusions drawn earlier. As in all the works cited in the given paper that concern numerical simulation of hygroscopic seeding of clouds, the 1-dimensional numerical model presented does not consider ice processes. Therefore, the conclusions are limited to the effects of hygroscopic aerosols on initiating warm rain. In tropical and sub-tropical summer convective clouds the distance between cloud base an the 0°C isotherm level can reach 4 km, with additional 1-2 km of supercooled cloud above this level, where precipitation initiation is dominated by warm rain processes.”

Pg. 10763:

The statement was changed to the following text in the revised paper: "In summary, the experimental data and the results of numerical simulations presented here and elsewhere show that a salt powder milled to size of several microns is more effective in initiating warm rain than hygroscopic flares. The calculated amounts of seeding material reach an order of 10 kg salt per km^2 of seeded cloud. The needed mass is

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even larger for a smaller effect when using hygroscopic flares. This requires seeding amounts of hundreds of kg per a seeding flight. Dispersion of such quantities is not feasible with hygroscopic flares, but has been demonstrated practical with salt powder (Rosenfeld et al., 2010)."

Pg. 10745, Ln.12:

This is a Russian peer reviewed journal. If the Reviewers do not find this article I can send to them copies.

Pg. 10746:

Unfortunately, the descriptions of devices for measurements of particle microstructures are published only in Russia. We give in the article the principles of measurements with the use of these devices and their technical characteristics. Additionally several technical peculiarities of the devices are given in detail. We believe that the description presented is sufficient for the comprehension the sense of the article. The addition is made in the text: “In both devices described above electric signals from the photodetectors, proportional to the intensity of light scattered from a separate light particle, go to the amplitude pulse analyzer and then to the computer. In the computer, the particles sizes are calculated according to the operating characteristic of the analyzers and the particles size distribution function is constructed. The particle concentrations are determined from the frequency of pulses of light scattered from every particle. The integral parameters of the size distribution function such as mass concentrations and effective radii of the particles are also calculated from the analyzer data. Both photoelectric analyzers are calibrated against round particles with the known sizes and the known light refraction index.” The mentioning of “an airborne instrument” is excluded as not concerning the scope of the article.

All the other technical corrections of the Reviewer are taken into account and necessary corrections are introduced into the article.

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