TWENTY- FIVE YEARS OF CLOUD SEEDING ACTIVITY TO MODIFY WEATHER CONDITIONS IN CITIES

Koloskov, B.P. [(1)]., Korneev V.P. [(1)]., Beryulev G.P.[(2)], Danelyan B.G.[(2)], Stasenko V.N.[(3)]

[(1)] Agency of Atmospheric Technologies (Agency ATTEX, ROSHYDROMET)
Novovagankovsky per. 8, Moscow, 123242, RUSSIA
Tel: +7(499)795-2372; Fax: +7(499)795-2134; e-mail: attech@mail.ru

[(2)] Central Aerological Observatory (CAO)
Pervomayskaya 3, Dolgoprudny, Moscow Region, 141700, RUSSIA
e-mail: secretary@cao-rhms.ru

[(3)] ROSHYDROMET, Moscow, RUSSIA

1. Introduction

During the last twenty-thirty years considerable work has been done in Russia on the development of methods and technical means to dissipate some forms of clouds and preventing or substantially reducing precipitation amount over protected areas. The practical objectives of cloud seeding activity were to reduce municipal expenses for snow removal and clearing the roads and streets in large cities, to create favorable meteorological conditions for carrying out social programs, sporting competitions or some other situations when the necessity may arise to reduce the rainfall.

The first experiment on practical application of these opportunities was carried out to mitigate the consequences of Chernobyl disaster in 1986 /Beriulev et al. 1990/. Since 1995 the organizations of ROSHYDROMET conducted more than 40 experimental projects on improvement of weather conditions in areas of the large cities – Moscow and St.Petersburg (Russia), Tashkent (Uzbekistan), Astana (Kazakhstan) /Bedritsky et al., 1996, Belyaev et al., 1996, Korneev et al., 2003, Koloskov et al., 2007/. The main purpose of these activities was the dispersal of clouds and reduction or prevention of precipitation over the protected areas. The technology of rain mitigation has been successfully used during Beijing 2008 Olympic Games opening and closing ceremonies /Zhang Qiang et al., 2011/.

Some results of twenty-five years activities on cloud seeding operations to modify weather conditions over large cities are presented in this paper.

2. Cloud seeding concepts

Four basic concepts of cloud dispersal and precipitation redistribution are generally used depending on a weather conditions, type of clouds and intensity of precipitation processes /Korneev et al., 2003, Koloskov et al., 2007/:

1. Dispersal of stratiform clouds.
2. Destruction of convective clouds or reduction of the intensity of shower rains and thunderstorms by a dynamic seeding technique /Petrov 1986, Belyaev et al. 1987/.
3. Premature initiation of precipitation from clouds on the windward side of the target area with the purpose of formation of a “precipitation shadow”, i.e. reduction of precipitation over the given site.
4. Reduction of rainfall intensity over the target area by intensive seeding the rain-producing clouds moving toward it, aimed at weakening the mechanism of precipitation generation through the “overseeding” of clouds, i.e. creating excessive concentrations of ice crystals.

All these concepts are based on the use of unstable state of atmospheric processes. Of the various types of instability, those with most potential for local modification of precipitation and cloud-formation processes are the phase instability of cloud water (existence of supercooled liquid water) and the convective instability of the atmosphere.

3. Technical means

The described methods can be implemented using instrumented aircraft of different types – IL-18, AN-72, AN-12, AN-30, AN-26, AN-28, AN-32, M-101T "Gzhel" and SU-30. Aircraft instrumentation includes data acquisition system, technical means to release silver iodide pyrotechnic flares, devices for cloud seeding using granulated dry ice, liquid nitrogen generators of ice particles and systems for dropping the packages with coarse-dispersion powders opening automatically after their release.

Each aircraft participated in cloud seeding operations is equipped with data transmission system “Land–Aircraft–Land” /Petrov, et al., 2007/. This system allows to display the locations and flight paths of aircraft on monitor of the ground based automated weather radar system, as well as send aboard the aircraft radar maps of distribution of cloud and precipitation in region of works.

Management of works and control of the results performed by MRL-5 meteorological radar equipped with the AKSOPRI or MERCOM automated radar system.

4. Results of an improvement of weather conditions

Analysis of the radar and raingauge information collected in more than 40 experimental cloud

seeding operations to modify weather conditions in cities showed that: 1) in 38% of cases (Fig. 1, area 1) there were no need to seed clouds due to the fine weather; 2) cloud seeding with 6 to 12 aircraft caused the destruction of stratiform and precipitating convective clouds in 25% of cases (Fig. 1, area 2), and 3) considerable, 3-10 times decrease of intensity and amount of precipitation (Fig. 2) was obtained over the protected territories in comparison with rain fallen over control areas in 37% of cases (Fig. 1, area 3).

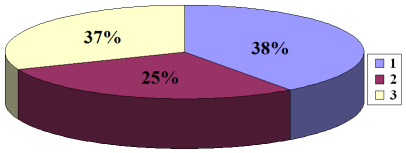

Fig.1. Results of works on cloud seeding to modify weather in cities.

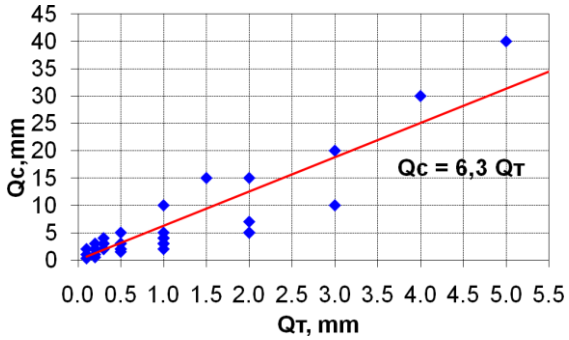

Fig. 2. Precipitation over the protected (Q_T) and control (Q_C) areas.

The results obtained demonstrate perspectivity of the methods and technical means developed in Russia for redistribution summer and winter precipitation. The problem of redistribution and reduction of precipitation in a given area is very important when working to eliminate the consequences of accidents at nuclear power plants, particularly the disasters at Chernobyl (Soviet Union) in 1986 and Fukushima I (Japan) in 2011.

References

Bedritsky A.I. and Chernikov A.A. Cloud seeding to protect Moscow from rain on 9 May 1995 – *WMO Bulletin*, Vol. 45, No 1, 60-64, 1996.

Belyaev V.P., Zatsepina L.P., Zontov L.B., Petrov V.V., Seregin Yu.A. Some results of field experiments designed to reduce convective activity of multi-tower clouds. – *Trudy CAO,* issue 164, 3-10, 1987 (in Russian).

Belyaev V.P., Beriulev G.P., Vlasyuk M.P., Danelyan B.G., Koloskov B.P., Korneev V.P., Melnichuk Yu.V., Chernikov A.A. A case study of cloud seeding over Moscow on 9 May 1995. – *Russian Meteorology and Hydrology*, No.5, 47-55, 1996.

Beriulev G.P., Zatsepina L.P., Zontov L.B., Sergeev B.N., Seregin Yu.A., Chernikov A.A., Kornienko E.E., Maksimov V.S., Khusid S.V. An experience of artificial regulation of precipitations with the purposes of eliminating the consequences of disaster on Chernobyl nuclear power plant. – *Weather Modification on hydrometeorological processes. Proc. of the All-Union Russian Conference*, L., Hydrometeoizdat, 233-238, 1990 (in Russian).

Koloskov B.P., Korneev V.P., Petrov V.V., Beriulev G.P., Danelyan B.G., Chernikov A.A., Shchukin G.G. Cloud seeding operations to modify weather conditions over cities: 2003-2006. – *Proc. of Ninth WMO Scientific Conference on Weather Modification (Antalia, Turkey, 22-24 October 2007)*, WMP - No.44, 2007.

Korneev V.P., Petrov V.V., Diadyuchenko V.N., Stasenko V.N., Beriulev G.P., Koloskov B.P., Chernikov A.A.Results of cloud seeding operations to modify weather conditions over cities. – *Proc. of Eight WMO Scientific Conference on Weather Modification (Casablanca, Morocco, 7-12 April 2003)*, WMO/TD-No.1146, 227-230, 2003.

Petrov V.V. An investigation of the evolution of horizontal wind field near convective cloud tops seeded with powders in a coarsely dispersed aerosol. – *Trudy CAO,* issue 162, 49-57, 1986 (in Russian).

Petrov V., Egorov O., Melnik S. and Skuratov S. “Land – Aircraft – Land” data transmission system. – *Proc. of 9th WMO Conf. on Weather Modification (Antalia, Turkey, 22-24 October 2007)*, WMP - No.44, 2007.

Zhang Qiang, H. He, M. Huang, H. Y. Li, J. Z. Liu, X. Ma, Koloskov B.P., Korneev V.P. Brief introduction of the rain mitigation operations during Beijing 2008 Olympic opening ceremony. - *18th Conference on Planned and Inadvertent Weather Modification (Seattle, Washington, 23–27 January 2011), 2011.*