"WARM THUNDERSTORM" – MYTH OR REALITY

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ABSTRACT: Analysis of the works that corroborate the existence of the warm storms (WS) shows that there are no enough reliable instrument observations of the WS. And what is more, even instrument measurements carried by the great researchers in this sphere (D.R.Fitzgerald, H.R.Byers, B.Vonnegut, C.B.Moore, I.M.Imyanitov, I.M.Shwarts) that showed high values of the electric fields in warm clouds give rise to doubts, because the question of accuracy of aircraft measurements of electric field, particularly inside clouds, has not been solved till now (Yu.Michalowski, this issue). On the other hand we have carried a great number of aircraft experiments on the beginning of the convective cloud electrification. The experiments were carried in various climatic zones (from the north-west of Russia till subtropical zone of the Caucas and in Cuba), in different seasons and over different surfaces (land, sea, mountains). We have established that till the cloud top have not exceeded the isotherm minus 8^0 C (Russia) and minus 6^0 C (Cuba) any indication of charged particles in the cloud could not be recorded (field strength over cloud could not be distinguished from the back-ground values on the same altitude). Furthermore electrification wasn't recorded till large particles inside supercooled part of the cloud could be recorded by the radar. Thus, the results our experiments (first of all!) and analysis of the articles about the "warm storms" bring us to conclusion that the thunderstorm processes in the clouds without ice particles - is a myth.

1.INTRODUCTION

The warm thunder-storms are one of paradoxes of modern physics of clouds. Now overwhelming majority of the contributors considers, that the main role in electrifying clouds is played by an ice phase of a cloud. Alongside with it the possibility of existence of thunder-storms in clouds in which there cannot be ice, is not denied by anybody, at least in publications, and till now is meat on pages of textbooks and monographs. When the authors per 70 years started in researches of electrifying the convective clouds, they after their teachers (I.M.Imyanitov, V.M.Muchnik, J.A. Ghalmers) were sure, that WS was though very rare, but the substantial phenomenon. Having worked in this area almost 30 years and having flown for this time more than 3000 hours on various airplanes – labs the authors consider that this phenomenon is similar to riddles of "Bermuda triangle", i.e. pseudo-scientific myth.

One of the earliest testimonies of existence of a WS is the message by Fuster, 1950. He wrote, that from aside of an airplane he observed rather frequent (interval of 9 -11 sec) discharges in completely exotic clouds of diameter 100 - 150 meters and vertical extent about 1600 m (?!). When the zero isotherm at a level 4500 m, the isotherm of 6^0C was on the altitude of 2400 m, i.e. mean gradient about 3(?!)degrees on kilometer was observed. One more example of the testimony of the eyewitness is the article by Pietrowski, 1960. He, on the contrary, in thick (diameter 3км) cumulous clouds without rain (top was on the level of 3300 m, top temperature was 2^0C and vertical extent was 2500 m) also out of an airplane observed discharges with an interval 3 - 4 sec. Michnowski, 1963 visually observed two lightning with an interval 3 minutes in a warm, on his sight, orographic cloud in mountains of Northern Vietnam. The vertical extent of the cloud was by his own estimation less than 1 km (?!).

These and other visually-subjective testimonies of existence of a WS cause many questions about 1) accuracy of definition of top boundary of a cloud and its temperature, 2) belonging of discharges to these small warm clouds, specially accounting the circumstance, that the observations were carried in twilights or even at the night. It's very important to understand on what stage the clouds discharges were observed – on the stage of growing or, on the contrary, on the stage of destroying of normal thunderstorm clouds. Gunn, 1956 on the basis of such separate testimonies of the random spectators has declared existence of WS. And despite of objections of some scientists (Appelman, 1957), this hypothesis began to gain a view of the established fact. The very large contribution in strengthening of positions of this hypothesis have been introduced by Moor C.B., Vonnegut B., 1960. But also after reading the papers by these undoubtedly great contributors of cloud physics, the same questions arise – how they determined the level of the top boundary of a cloud that was located on the distance of 50 (?!) km from them? As follows from our experience, in any version (by the radar or visually) the error of 1 - 2 km is rather probable.

Generalizing the above, we should state, that there is not any experiment on research of warm thunder-storms that was in detail described and used instrument methods of control. Moreover, since the seventies with increase of technical security of experiments and requirements to reliability in general the papers on observations of a WS have not appeared. Though at existing technical facilities of control of clouds and discharges the carrying out of observations of a WS does not represent a problem. These investigations would either prove the possibility of WS without the ice phase or would state that WS is the consequence of experimental errors or differences in terminology. For example, the remain of large dissipating thundercloud could be taken as "warm cloud". Or "warm cloud" could be seeded with the ice particles out of anvil of a neighboring thunderstorm.

As it will be in detail shown below, during detailed and careful researches of warm convective clouds we did not manage to detect even their gentle electrifying. There was an inconsistency with previous results by I.M.Imyanitov and I.M.Shwarts, 1972, etc. The joint efforts made it possible to install that the high values of electrical fields in warm cumulus are a consequent of errors of measurements E inside clouds. And it happened in the case when .Imyanitov,1957,1976 was one of the best experts of that time in the world in measuring the parameters of atmospheric electricity. The measurements were conducted with the help of a system of aircraft flux meters, the deformation factors for sensors were determined in the flat electrostatic condenser and other methods. But even in these conditions the level of errors has remained to be very high. The technical and methodical support of aircraft measuring of E carried by the other contributors (D.R.Fitzgerald, H.R.Byers, 1958, B.Vonnegut, C.B.Moore, 1961) at that time was even less reliable. It is enough to indicate that Moore and B.Vonnegut have utilized a collector method of measuring E. And its limitations in comparison with measurements by flux meters are well-known. Allowing these circumstances it is necessary, apparently to recognize that high (about 1000 V/m) values of E in warm cumulus, measured above mentioned contributors, are, most likely, consequent of errors of measurements.

Thus it turns out that we have no the authentic testimonies even of gentle electrifying of warm convective clouds, the moor so of discharges. And on the contrary, as it will be shown below, we have the authentic testimonies of those absence.

2.EXPERIMENTAL EQUIPMENT AND OBSERVATIONAL TECHNIQUE

Studies in Russia were conducted from the board of aircraft meteorologic laboratories (AML) IL-14, IL-18, AN-12, AN-26 and YaK-40. However principal results were obtained in flights of the "Cyclone" AN-12. AML outfitted with: 4 field mill sensors to measure the vector of electric field tension (E) and the plane self-charge (Q); an on-board meteorologic radar (BMR) (wavelenght 2 sm.) sighting to nadir and yielding vertical radar cross-sections of cloud from above; instrumentation to measure temperature and humidity, and other instruments. Calibration of the field mills sensors was carried out in the laboratory standard condenser developed in the MGO. Amplifier sensitivities were routinely controlled during the experiments using particular plates inside the sensors. Form factors were derived from the aircraft model, confirmed thereafter (by flights in the electrical fields of the earth or cloud or another aircraft, as well as from aircraft charge variations etc.). To reduce Q to zero special discharges were used. For more details on this point one can refer to the article by Michalowski in this issue. Absolute radar calibration was performed in the field by a metallic sphere. The sensitivity was controlled with special devices in the course of the experiments. The aircraft radar calibration was also confirmed by results from experiments and by ground locators MRL-2 and MRL-5 meteorological polygon in Turgoshi. A positive direction of the vertical E component was chosen to be the one coinciding with the "fair weather E ", that is from plus to minus downward. Flying outside clouds and applying specially designed techniques the MGO field mills were capable of measuring E within 10 to 250000 V/m. Signals from top and bottom field meters were summarized by the analogue device using appropriate coefficients. Values Ez, Q, Eside, and Etail were tape recorded. The changing of E over a small isolate convective cloud was simple and smoothed and similar to those over a monopole charge or a dipole. Visual observations of clouds and their photographic imaging were also taken from board the AML. Visually the state of the top VST was defined to correspond to: 1 - no crystallization, the top was completely water droplet - bright and brilliant, "gloria" was observed; 2 -

start of crystallization, separate "jets" were observed; 3 - crystallization intensely developed, numerous jets were observed, the top was "torn" and "tousled"; 4 - completely crystallized top - dull, flat, "false sun" was observed. Observation technique foresaw tracking of cloud during the whole of its life-span. Observations commenced at the Cu cong or Cu med stage, when the temperature at clouds top was $Tt > 0^o$ C, $Z < 0$ dbZ, E=0 and ended when the cloud disintegrated. Single cell separate clouds were mostly chosen for such observations. We conducted measurements during successive step by step flies-over the center top, 10 to 50 m above it, depending on the cloud development stage and its top height. Thus the process of ECC is characterized by the E vector above cloud, formation of large ice particles (precipitation) - by cloud radar reflectivity Z. Having Tt and VST one may estimate the process of crystallization in the cloud, and by the increase of its top height, Ht judge on the cloud dynamics. A technique was specifically designed to measure charge structure inside the cloud by measuring vector E, but the first attempt of its application indicated that it should be further upgraded, and that the accuracy of measurements of the E vector should be additionally analyzed. The vertical component Ez appeared to be sufficient to provide the answers to questions stated above, that's why for this task we used Ez to characterized the electric field of the cloud.

Investigations of electrification of the convective clouds (ECC) at Cuba were carried out in July - August 1991 by means of aircraft AN-26 and radar MRL-5 at meteopolygon Camaguey (Cuba). The aircraft was equipped with 2 field mills and microwave radiometer. It measured the vertical component of electric field E, beside the cloud on the level of zero isotherm, and liquid-water-content of the cloud W in the layer $0 \div -15^0$C. Two field mills, constructed in MGO, were installed at the top and at the bottom of fuselage near the centriplain. They measured the vertical component Ez of the electric field and the charge of the aircraft Q. Form factors were defined using the shape similarity of aircrafts AN-26, AN-24, IL-14 and the technique, expounded in paper by Michalowski, this issue.

Liquid-water- content W in a tilted section of a cloud was determined by microwave radiometer with wavelenght 8 mm. It was maintained in a window on the left side of aircraft at an angle of 30 degrees. The technique of investigation of clouds with radiometer was described earlier (Koldaev, 1990). Radar MRL-5 with wavelenght 5 sm equipped with automatic system of processing information was placed in the center of meteopolygon (airport Camaguey). We could receive spase-and-time variations of reflectivity Z and select separate convective cells.

The technique was in step-by-step passes beside a cloud on the altitude of zero isotherm and in control of E,W. The studies began on the earlier stages of cloud's development ($Tt > 0^o$ C, E = 0 V/m, $Z < 0$ dbZ). The level of top Ht was determined visually on the earlier stages and by radar when $Z > 0$ dbZ.

3.RESULTS AND DISCUSSION

The experiments were conducted at various latitudes (from Batumi up to the Leningrad area, Cuba), in a various season (since March till November), above various underlying surface (continent, sea, mountains). For the analysis the results more than 50 experiments above territory of the USSR (2 – over the Black Sea) and 14 above territory of Cuba were utilized (4 – over Caribbean Sea).

As it was indicated above our study technique in Russia envisaged observing the cloud through the whole of its life span. It was taken flies-over 10-50 m above the cloud top during the initial stages of its development. Under these conditions we took that the initial moment of ECC coincided in time with that fly-over, during which significant values of E were observed over the cloud, (E over the cloud exceeded the value of fair weather E on the same altitude by the factor of 3-5). A precondition to that was that no such values of E were recorded during the previous fly-over. Since we tried to start our observations during the stage when E = 0, such a regime was indeed available for most of the clouds. In experiments we established, that while the top of a cloud has not exceeded the isotherm $-8\ ^0$C there were not observed the values of electrical field $10 \div 100$ meters above the clouds that could be distinguished from background values at the same altitude and at the same accuracy of measurements. Moreover, the fields were not marked till in the supercooled part of a cloud there were no large particles that could be found out by an meteorologic radar ($Z > 0$ dbZ). Cloud parameters fixed in that fly-over were assumed to yield those of the start of ECC.

We recived, that - ECC is not observed till Tt remains above -8^0C and is always observed if Tt drops below -22^0 C; - it is never observed if precipitation reflectivity below the cloud is lower than 0 dbZ ($Zr < 0$ dbZ) while it is always observed if $Zr > 40$ dbZ. Similar relations are found to relate

ECC to the thickness of its supercooled part (dH). As it follows from those relations the organized ECC starts only when the cloud reaches the stage of its development, at which large ice particles may appear inside the cloud (Tt < -8^0 C, Z > 0 dbZ, dH > 1.4 km).

Investigations of the early stage of ECC in the tropics (Cuba) showed that the necessary conditions for onset of these clouds electrification were also the conditions for appearance of ice particles. We can see, that the electrification of convective tropical clouds didn't occur until Tt > - 6^0 C, Z < 0 dbZ, dH < 1.0 km. These conditions are similar on to those obtained above for convective clouds in the former USSR and didn't verify the hypothesis of "warm thunderstorm". It should be marked that the electrification starts earlier in convective clouds over the see then over land. For example, according to the previous data the conditions for ECC in continental clouds for the territory of the former USSR are the following: Tt < -12 ^{0}C, Z > 0 dbZ, dH .> 1.8 km, and for Cuba: Tt <-8^{0}C, Z > 0 dbZ, dH > 1.4km.

CONCLUSION.

Thus, results of own experiments (first of all!), the analysis of studies by the supporters of existence of warm thunderstorms, own experience and intuition cause us to think, that thunderstorm processes or even simply the organized elecrification in clouds where is no ice phase is nothing but myth.

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