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ATMOSPHERIC ELECTRIC CHARGES' FORMATION PROCESSES IN THE NEARSURFACE AIR LAYER

Berdaliyeva A.A.[1], Gorbachyov D.[1], Ilyasov T.[2]

[1]M. Auezov South Kazakhstan University, Shymkent, Kazakhstan
[2]Kazan State Power Engineering University, Kazan, Russia
E-mail: aydin_01@mail.ru, gds.dsr@gmail.com

[*]Corresponding author's e-mail: aydin_01@mail.ru

ABSTRACT

Atmospheric electric charges' formation processes in the nearsurface air layer are considered in this work. Electrical energy extraction from atmospheric charges for industrial use, as well as the management of the meteorological situation in a locally taken area, partially solves the problem of a water resources' shortage in the Turkestan region. The appearance of a negative space charge near the clouds should be accompanied by diffusion currents bringing a negative charge to the Earth. The nature of the decrease in the field strength with distance from the cloud to the ground shows that this field is formed not directly by the charges of the cloud, but by those charges that create and redistribute these clouds. Clouds do not act as field generators, but as space charge generators in the atmosphere. Depending on the cloud activity it can give discharges following each other with an interval from several seconds to several tens of seconds. Two fields of electric charge generation are considered in detail: the field in the region of the zero isotherm associated with the melting of ice aggregates, and the field in the upper part of the thunderstorm cloud associated with collisional mechanisms of charge separation. Results of numerical modelling of electric field parameters show that with weak turbulent mixing near the Earth's surface, there is a maximum of the positive space charge, and a layer with a negative volumetric charge appears above the maximum vertical distribution of the turbulence coefficient.

Key words: atmospheric charges, ionization, electrification, corona. turbulence, diffusion, convection, aerosols, clouds, field strength, generation, two-aggregate state.

INTRODUCTION

The study of atmospheric electricity processes is the first step to harnessing the vast amount of energy contained in the Earth's atmosphere. These studies are very relevant for the Republic of Kazakhstan because will allow extracting electrical energy from atmospheric charges for industrial use, as well as to control the meteorological situation in a locally taken area, partially solving the problem of water shortage in the Turkestan region.

Atmospheric electric charges' formation processes in the nearsurface air layer are considered in this work.

In weather-disturbed areas, sources of ionization other than those listed may be [1]:

1. Coronation of any kind (sharp) of sharp pointed objects near the Earth's surface (tree branches, grass, antennas, etc.), starting in electric fields with an intensity exceeding ~ 10 V / cm.
2. Electrification during the destruction and rupture of the particles contact, which usually occurs in shower and thunderclouds, dust storms and blizzards, volcanic eruptions, etc. phenomena; in thunderclouds, for example, this electrification can increase the conductivity by almost two orders of magnitude. The existence of a field in a conductive mediume causes the appearance of current. In zones of good weather, where the horizontal dimensions of the zone are much greater than the vertical, the electric field is vertical.

Since the space charges in the atmosphere are unevenly distributed, and the coefficient of turbulent diffusion in the atmosphere is very large, in some cases, in addition to the conduction current, the diffusion current as well as the convection current created by the transfer of space charge by convective flows can flow in the atmosphere [2]. Earth’s electric charge, on average unchanged over time. This means that simultaneously with the positive “current of good weather”, the Earth receives a current of negative charges, also equal to 1500A. Disturbed weather zones are a possible source of this current. In these zones, in addition to the considered currents, the exchange of charges between the earth and the atmosphere can occur with the help of lightning currents, currents arising from corona in strong fields of pointed objects near the Earth's surface, and electric currents of precipitation.

The charge carried by lightning averages about 20-30 coulombs per lightning, the corona current can reach several microamperes per tip: according to a rough estimate by Wormel [3], this can lead (in England) to a transfer from an area of 1 km^2 for a year about - 100 pendants. The precipitation current mainly carries a positive charge to the ground. Thunderstorms and heavy showers can have a current density of up to 10^{12} A / cm^2 and even exceeding this value. The electric field, diffusion and convection currents provide the vertical transfer of these space charges.

Thus, the field in the atmosphere is determined by the field of the Earth's charge and the field of local charges of the atmosphere. Since the latter is very large, there is no similarity both in magnitudes and in the course of the potential of the atmosphere over various observation points. Changes in the Earth's own charge are manifested in field changes noted at different points of the earth's surface at the same time.

MATERIALS AND METHODS

Five processes can create space charges in "good" weather zones [1].

1. Separation of light ions of different signs due to the electric field.
2. Transfer of space charges from zones of "disturbed" weather.
3. Adsorption of light ions from the atmosphere on aerosol particles with subsequent separation in space due to the gravitational forces of ions of different signs associated with particles of different types.
4. The appearance in the atmosphere of particles charged upon separation from the Earth.
5. Charging of particles in the atmosphere due to their interaction with each other or due to the transfer of charge from particles to the atmosphere, followed by the separation in space of particles of different sizes charged with electricity of opposite signs.

The first process is basic only in a clean atmosphere; profiles of the first type are associated with its action. The second process undoubtedly manifests itself, for example, with field profiles of the second type, but it cannot explain the diurnal variations in the profile of space charges, the relationship of the diurnal variation of the magnitude of the measured space charges with such local characteristics of the atmosphere as the concentration of aerosols, radioactivity of the atmosphere, etc. The mechanism of the third process was discussed earlier; without raising the question of what elementary processes lead to the deposition of ions on heavy particles, it is possible to determine the value of the accumulated space charge from the data on the distribution of aerosols with height. The distribution of space charges, characteristic of the field profiles of the third type, can also arise under the influence of the fourth and fifth processes. The process of charging particles when separated from the Earth cannot manifest itself in a weak wind, over surfaces with dense vegetation.

The diurnal variation of the distribution of space charges with height also indicates that this charging process cannot be considered as the main one.

Stratus clouds extending over territories hundreds of times larger occupied by thunderclouds can be over the same point for weeks. Almost half of the Earth's surface is covered with stratus clouds. Electric charges and currents in them, albeit much less than in thunderstorm clouds, can therefore play an essential role in the general exchange of charges between the Earth and the atmosphere. However, the electrical properties of these clouds remained virtually unknown until recently. Consider the electrical characteristics of stratus clouds certain types.

a) The thicknesses of the studied clouds were in the range of 100-1000 *m*. The field strength varies mainly within the range of 3 *V/cm*

In terms of their electrical structure, the studied clouds can be reduced to four types. Positively polarized clouds were observed in 50% of cases. In addition, the presence of an excess positive charge is noted in the clouds. Negative cloud polarization was observed in 10% of cases. A number of the studied clouds were unipolarly charged. In 30% of all cases, the clouds were positively charged. The remaining 10% of the clouds were negatively charged. The variation of the electric field with height on days when only stratus clouds were noted. These clouds are associated with the appearance at the Earth's surface of a significant negative charge and a rapid decrease in the field with height. Above 3000 *m*, the field strength is close to zero.

b) Stratocumulus clouds. The thicknesses of this clouds' type lie in the range of 100-1800 *m*. Basically, the field strength in these clouds varies within the range of -2 - +3 *V/cm* (80% of cases). These clouds, as well as layered, are reduced to four types of electrical structures: positively polarized (45%), negatively polarized (13%), positively charged (23%) and negatively charged (7%).

In 12% of cases, the clouds either had small charges lying beyond the limits of measurement accuracy, or had a more complex electrical structure (in the clouds there were three charges arranged in height according to the scheme +, -, +, or -, +, -).

Variation of the electric field with height on days when only stratocumulus was observed. Just as in the previous case, a negative space charge is created under the clouds, but above them the field strength remains significant up to 6000 *m*.

c) Altostratus clouds. These clouds are created at a considerable height (over 2000 *m*), where the field of "good" weather is significantly weakened.

They also have four types of distribution. Positive polarization is noted in 30% of cases, negative - in 25% of cases, positively charged clouds - in 12% of cases, and negatively charged clouds - in 13% of all cases. In addition, weakly charged clouds were observed in 10% of cases and clouds with a complex structure of charges of the +, -, +, or -, +, - type were observed in 10% of cases.

In these clouds, negative polarization is observed more often, and the clouds themselves have an excess negative charge

d) Cirrostratus clouds (Cirrostratus). These clouds are located high above the Earth's surface at a level of 5000*m* and higher. However, they noticeably reduce the field strength at the Earth's surface. The field in them is usually negative.

In addition to the previously noted types of polarized clouds, two more types are often found, when positive charges are located in the upper and lower parts of the clouds, and negative charges in the middle (distribution of the type +, -, +) and when a distribution of the type - > +> -.

Stratus non-rain clouds have a significant effect on the electrical characteristics of the atmosphere. First of all, attention should be paid to the significant values of volumetric electric charges arising from these clouds - from 3 eV/m^2 to tens of eV/m^2. The density of the Earth's surface charge is about 3 eV/m^2, and its change in the course of a unitary variation is only about 20% of this value.

The variations in cloud charges are much larger than the observed unitary variations in the earth's charge. It should also be taken into account that layered clouds cover almost 50% of the Earth's territory. Therefore, the total contribution that they make to the exchange of charges between the Earth and the atmosphere can be very large. The appearance of a negative space charge near these clouds should be accompanied by diffusion currents bringing a negative charge to the Earth. The nature of the decrease in the field strength with distance from the cloud to the ground shows that this field is formed not directly by the charges of the cloud, but by those charges that create and redistribute these clouds [4]. Clouds do not act as field generators, but as space charge generators in the atmosphere. Only high clouds of the cirrostratus type do not create significant volumetric negative charges at the Earth's surface. Stratus clouds significantly affect the potential of the atmosphere at an altitude of 6000 *m*. They create relative changes in this potential, much greater than its changes associated with unitary variation. Thus, stratus clouds, apparently, play an essential role not only in the formation of the disturbed weather field, but also in the field of "good" weather.

The mechanism for creating space charges in this case is completely unclear. The charges on the droplets of these clouds are small and the spectrum of positively charged droplets is approximately similar to the spectrum of negatively charged droplets. In this case, it is impossible to assume that the gravitational coagulation of small drops ensures the accumulation of charges on large drops, since the merging of drops under such conditions will lead to a relative decrease in charges on the drops. It can be assumed that in these clouds, under certain conditions, an intensive exchange of charges occurs between drops of different sizes or drops and air.

One of the possible mechanisms of this kind was considered by V. Ya. Nikandrov [5], who suggested that, due to the different mobility of anions and cations in a liquid, evaporation can lead to its charging. In addition, precipitation particles falling out of them can play a significant role in the electrification of high stratus clouds and stratus-cirrus clouds.

e) Nimbostratus clouds (Nimbostratus). The appearance of precipitation from the cloud contributes to the accumulation of electricity in it. The electrical structures of Ns clouds are very diverse and complex. Along with the four noted species, there are clouds with three or even four charge layers.

RESULTS AND DISCUSSION

The measured variation of the field strength with the height for these clouds coincides, in general terms, with the field profile proposed by Chalmers [6] for stratus clouds.

The measured field profiles coincide with those obtained under the assumption that the space charge carried by the rain is positive, and the melting of the snowflakes from which the droplets are formed occurs in the upper part of the cloud.

Nimbostratus clouds exhibit higher field strengths than other types of stratus clouds. These clouds change the sign of the field strength near the Earth's surface and create a positive space charge near the Earth. The charge of these clouds is predominantly negative. The average charge of a drop of precipitation near the Earth's surface varies within the range of 10^{-4}-10 *eV*> 10V, and the negative charge is slightly greater than the positive one. On the whole, however, the charge carried by precipitation from these clouds is positive. For example, 1 g of positively charged droplets transferred 0.21 *eV*, and on negatively charged droplets 0.08 *eV*. These numbers in individual rains can change tens of times.

When dropped on the ground, positively and negatively charged droplets meet simultaneously. However, under the clouds, basically all droplets are charged in the same way. Thus, when dropped, some of the drops are recharged. The current carried by precipitation from clouds is about $5\text{-}10^{16}$ and 5x10-15 A/cm^2

That is, the values of the average and maximum charges of both positively and negatively charged droplets increase and decrease simultaneously, that is, there is no significant removal of charges by precipitation even in separate areas of clouds.

Cumulus and powerful cumulus clouds are of particular interest, as they develop into showers and thunderstorms, which give the strongest electrification in the atmosphere. Many characteristics of powerful cumulus clouds (turbulence, water content) are similar to those observed in thunderclouds. Powerful cumulus clouds are assumed to be some kind of thundercloud model. Studies of cumulus clouds have shown that their field is very heterogeneous; during one flight through a cloud, a number of field extrema can be encountered - both positive and negative. The average field strength in cumulus clouds is generally positive. Negative values were observed in about 25% of cases; usually they were associated with the appearance of large drops in the clouds and the beginning of precipitation. Research results show that powerful cumulus clouds, just like cumulus clouds, are bipolar. Typically, there is a positive charge at the top and a negative charge at the bottom.

Research results show that powerful cumulus clouds, just like cumulus clouds, are bipolar. Typically, there is a positive charge at the top and a negative charge at the bottom. Against the background of these relatively small charges, which have a volume density of the order of several tenths or even hundredths of eV/m^3, regions with negative and positive space charges with a high density are randomly located in the cloud, averaging several tenths or even units of eV/m^3. The length of these areas varies from several tens to several hundred meters and is closely related to convective processes. The rate of accumulation of charges in cumulus and powerful cumulus clouds can be calculated from the data obtained in the study of intramass clouds. Since a noticeable increase in the density of space charges with the development of clouds is not observed, we can assume that the total amount of free charges accumulated by a cloud is proportional to its volume. For all stages of the development of powerful cumulus clouds, the rate of increase of the main space charges is in the range of 10^5 - 10^8 eV/m^2sec.

A powerful cumulus cloud accumulates such a small fraction of those charges that then appear during a thunderstorm that we can confidently assume that the charges in it do not play a role in the preparation of thunderstorm processes. The variation of the electric field with height in cumulus clouds is in many ways similar to that observed in stratocumulus clouds. A maximum of the field and the appearance of a negative space charge at the Earth's surface are noted under the lower boundary of the clouds. Above the clouds, the electric field is positive.

The charges of droplets in convective clouds can reach hundreds of elementary charges. In some parts of the cumulus cloud, the fields can reach values at which the efficiency of coagulation of drops is noticeably increased

A powerful cumulus cloud (if it does not dissipate) turns into a storm cloud or a thunderstorm. In the development of the thunderstorm part of the cloud, three stages are distinguished: the growth stage, the main stage, and the decay stage. The growth stage includes a period of rapid growth of a powerful cumulus cloud and the process of transition from a cumulus cloud to a torrential or thunderstorm. At this stage, updrafts prevail in the cloud. The main stage is characterized by the greatest electrification and is associated with the appearance of strong downgrades in the cloud along with the ascending air currents. Finally, at the stage of decay, the electrification processes greatly weaken (although the field in the cloud can be very large due to unscattered space charges), and the entire cloud as a whole is covered by a single powerful descending stream. In some parts of the thundercloud, the so-called "cells", thunderstorm processes can occur at different times, therefore, although the entire life cycle of one cell takes about 1 hour, a thundercloud can generate lightning for hours. The horizontal linear dimensions of the cells are between 1.5 and 10 *km*. The transformation of a cumulus cloud begins with the fact that an area with enlarging particles appears in it; the horizontal dimensions of this area are about 500 *m*.

In strong air currents, the speed of which can reach 15 *m/s*, the enlargement process is very fast. Positive charges in the upper part of the cloud prevail at altitudes of more than 7 km at negative temperatures, less than 20°C, but not higher than -10°C. Negative charges are located at altitudes between 2 and 7 *km*, their center usually lies slightly above the region zero isotherm. The lower positive charge is associated with the zone of intense precipitation and is usually located in the zone of positive temperatures, so that the center of the upper positive charge is displaced relative to the center of the lower one in the direction of the wind, and the centers themselves are located on average at heights of 2.5 and 4 *km*. According to Barnard's data [7], obtained in studies of field changes at three ground stations, the distance between the centers of the main positive and negative charges averages 5.2 *km* and varies from 2.5 to 8.7 *km*. According to Gann's data obtained from direct measurements of the field in the clouds, this distance is about 3 km. At the same time, Malan and Shoiland, based on ground field measurements, came to the conclusion that in thunderstorms in South Africa, a negative charge is located in a vertical column bounded by isotherms of 0-40°C, and this column is discharged by successive lightning strikes starting from the base. The magnitude of the charges in the clouds, according to the data of different authors, is very different. So Workman and Golzer [8] give the values of charges carried by lightning from 10 to 190 *Cl*, and the most often noted values from 20 to 50 *Cl*. The work gives a range of charge variations from 4 to 40 *Cl* (the average change in the electric moment of the cloud was 182.5 *Cl/km*). In work, the charges of the cloud are estimated at 20 *Cl*. In addition to the polarity of the clouds, the opposite polarity is also possible in shower and thunderclouds. It is especially often observed in storm clouds. When measuring the electric fields above the tops of about a hundred shower and thunderstorm clouds, it was found that in about 40% of cases the clouds are negatively polarized, and usually shower clouds are negatively polarized.

Depending on the activity of the cloud, it can give discharges following each other with an interval of several seconds to several tens of seconds. There are clouds that give only 1-2 thunderstorm discharges, and they can occur inside the cloud. Clouds of alternating polarity often stretch along the thunderstorm front, such an arrangement of clouds can lead to the appearance of lightning with a length exceeding 50 *km* and even 150 *km*. The life span of a thunderstorm cell in the main stage lasts up to 20-25 minutes. During this stage, the cells enlarge to the sizes indicated above and heavy precipitation comes from the cloud. Studies carried out in thunderclouds have shown that near the zero isotherm, solid precipitation was observed in 93% of cases, mainly in the form of snow grains and soft hail. In the main stage, a powerful ascending air flow at a speed of ~ 10 *m/s* passes through the cell as a whole, along with the appearance of descending movements in the upper part of the cloud. In severe thunderstorms, the flow rate can be much higher. With the termination of the discharges, the stage of decay sets in, while the field strength and the intensity of precipitation rapidly decrease. The field often changes sign to the opposite, which is apparently associated with the removal of negative charges by precipitation particles from the cloud. 15-30 minutes after the end of the thunderstorm, the cloud is "washed away", leaving only the "anvil" - an elongated strip of ice crystals in the upper part of the cloud. In "anvils" electric charges and, accordingly, electric fields are small. The development of one cell can, apparently, facilitate the development of new cells. The domes of powerful cumulus clouds can receive ice crystals from the icy top of the cell in the main or last stages. These crystals accelerate the glaciation of the dome and the onset of the second stage. The electric fields of the developed cells can play a certain role in accelerating the development of new cells, if the coagulation of drops or the processes of electrification in clouds are associated with the action of electric fields.

The strength of the electric fields above the clouds is on average about 100 V/cm. The field often rises and falls smoothly. Three conditions must be met for appearing lightning.

1. A sufficient number of charges must be created in a thundercloud,
2. The oppositely charged particles must be separated by sufficiently large distances.

3. The fulfillment of both conditions should be accomplished in a sufficiently short period of time, so that before reaching the critical values of the charge and field strength for the occurrence of lightning, the processes of generation and separation of charges in the cloud proceed faster than the processes of recombination and association of charges.

After a sharp change in the field, during a lightning, a relatively slow recovery of the field follows, lasting a second, and it is assumed that this process of recovery of the field reflects the recovery of the electric moment *M* of the cloud. For a time of about 10 seconds, an electrical moment is restored in the cloud after a lightning strike. The electric moment of the cloud, neutralized by lightning, is on average about 100 *Cl/km*. The charge neutralized by lightning is on average 20 *Cl*. Changes in the cloud dipole moment after a lightning strike should occur either due to an increase in the number of separated charges, or due to an increase in the dipole arm. If we assume that the separation of charges of different signs occurs under the influence of gravity, then the separation speed *W*, even for large particles, is unlikely to exceed 10 *m/s*. Thus, in a time T = 10 *sec*, the charges that create the dipole can be displaced by about 0.1 *km*. Thus, in the main, the field is restored due to the fact that charges of about 20 *Cl* appear from above and below in layers not exceeding a thickness of about 100 m. In order for these charges to appear, it is necessary that undivided charges with the same density exist throughout the entire volume of the cloud. If the cross-section of a thunderstorm cell has an area of about 10 km^2, and the distance between the centers of the main charges is 5 *km*, then in the cloud, to restore the electric moment, about 1000 coulombs of electricity must exist on the particles, which is 20 Cl/km^3. A natural question arises whether these charges were brought into the cloud in advance, or whether they should be created in a time comparable to the relaxation time of the electric moment.

It is usually assumed that all these charges are acquired by the cloud at the previous stage. But there were cases that at the previous stage the charges of the cloud were several orders of magnitude less than required. In addition, it can be assumed that under conditions of high concentrations of particles of opposite signs with their intense mixing, the recombination of particles of different signs would quickly neutralize the "introduced" charges. Charges of different signs, therefore, can exist in the cloud only if they are continuously intensively generated. This explains the large values of the rate of generation of charges and the space charges themselves in thunderclouds.

In those cases, when the field after a lightning strike drops to zero and when one can be sure that this field was created only by the charges of the investigated cloud, by measuring the rate of field recovery at the moments immediately following the lightning strike, one can determine the cloud charging current. According to Mason [9], this current is approximately 3*A*.

It can be assumed that the separation of charges in a cloud occurs not under the influence of gravity, but under the action of air currents that ascend and raise the positive charge upward, and descend, lowering the negative charge downward. Since air velocities can reach 30-40 *m/s*, this immediately reduces the requirement for the amount of charges accumulated in the cloud. However, until now, it has not been recorded that charges of different signs are located in oppositely directed flows. In addition, in clouds where the air flow velocity is -10 *m/s*, the above estimates of the required charge density would not change

Even with showers, the precipitation and the surrounding air contain charges that are close in magnitude to those that should exist under the action of the separation mechanism based on the force of gravity. For the correct choice of dozens of possible mechanisms of elementary electrification of those that create thunderstorm processes, it is necessary to know not only the intensity of electrification, but also the conditions in which they occur. In particular, it is very important to answer the question at what moment in the life of a cloud the intense charging characteristic of thunderclouds begins. Usually, the increased charging of the cloud is noticed at the moment that coincides with the time of the beginning of the enlargement of particles in the cloud, when their sizes become of the order of 100 *microns* or more. Such an enlargement immediately follows the glaciation of the tops of the clouds, while it remains unclear: what plays the main role in the electrification of the cloud - the rapid coagulation and the fallout of small, like-charged droplets or the electrification associated with the two-aggregate state of the cloud. At the beginning of the growth stage, space charges are small, therefore, the coagulation mechanism cannot lead to a rapid increase in charges when particles grow larger, since coagulation, in the presence of oppositely charged particles, leads to a relative decrease in the charge of large particles. Therefore, an attempt was made precisely at this stage to introduce solid carbon dioxide into the cloud, creating conditions for the rapid appearance of a two-aggregate state and revealing its role in electrification. As you can see, the electrical state of the clouds lends itself to external influence. The change in the potential difference at the boundaries of the cloud upon exposure can be estimated at about 25 million volts. The possibility of managing thunderstorm activity was noted by Langmuir [4].

There are several dozen elementary mechanisms for electrifying particles of a thundercloud. Each of them inevitably became the basis for the creation of another theory of thunderstorm electricity. We will not dwell on these mechanisms in detail here. Let's just try to compare the possible rate of charge generation in thunderclouds using some of these mechanisms with the observed rate of charge generation in thunderclouds. A number of elementary charging processes are associated with the capture of ion clouds by particles from the surrounding air. This capture can occur due to the difference in the attachment energies of positive and negative ions, as suggested by Ya. I. Frenkel [5], due to the difference in the rates of diffusion of ions to the droplet surface, due to the difference in fluxes of positive and negative ions moving in the electric field directed along the direction of motion of the falling drop (Wilson's mechanism [9]), etc. the most effective mechanisms are mainly associated with electrification that occurs in a two-aggregate cloud at the water-ice interface. This circumstance coincides with the known facts that the greatest electrification begins at the moment the ice phase appears in the cloud and the main electric charges are located in the cloud zones where water and ice particles exist simultaneously. A lot of electrification processes, noted at the water-ice boundary, are actually reduced to 2-3 physical processes. Researchers of this type of electrification usually describe and base the classification on the conditions in which electrification is manifested, and not on the physical process that causes it. Electrifying drops when they are destroyed in an electric field can be very effective.

A detailed study of macro- and microprocesses in thunderclouds should clarify the question of what are the mechanisms of electrification and how they work in thunderclouds.

Among the most obscure areas of the physics of thunderstorms is the question of how lightning arises and how it is maintained. The electric field strength in thunderclouds does not exceed 2000 *V/cm*, while the development of a spark at an altitude of the order of several kilometers requires intensities of ~ 10 000 *V/cm*. On the other hand, the discharge conditions in the cloud should be difficult compared to the discharge from metal electrodes connected to a relatively powerful power source, for which the indicated value of the breakdown voltage was obtained. To elucidate the role of droplet singularities, a study of the droplet behavior in strong electric fields was carried out. It turned out that the drops in the field are strongly elongated and the corona of Mecca can begin from them [3], a dependence was obtained for the critical field strength by EQF, at which the drops begin to elongate. During the existence of lightning, that is, for a time of the order of milliseconds, the field of the cloud can drop to zero. Thus, all charges collected in an area of 1 km^3 on droplets located at an average distance of -10 cm and therefore well isolated from each other are collected by this lightning.

How this sudden transformation of a collection of isolated drops into a single association occurs is not very clear. Lightning even in the main channel has a diameter of about 1 m, and even smaller in the branches. According to Loeb's assumption, at the moment of discharge, positive streamers appear in the cloud, discharging the cloud. However, the existence of such streamers has not yet been observed, although radar measurements should have shown that at some point in time the entire volume of the cloud is ionized.

CONCLUSION

A system of quasi-hydrodynamic equations for the electric field, charges and concentrations of cloud particles and light aerons of air as applied to mesoscale convective systems was proposed in this work, which, under reasonable assumptions about the nature of electrification during collisions and melting of cloud particles, has fairly simple solutions describing the structure and dynamics of spatially separated regions electric charge in the cloud.

The electric field significantly affects the speed of movement of light air ions in the air flow, and at large fields it almost completely determines it. With the induction mechanism of electrification, the electric field also determines the magnitude of the charge shared during the melting of hydrometeors. Therefore, taking into account nonlinear effects leads to the formation of a complex structure of electrical layers.

Two regions of electric charge generation are considered in detail: the region in the region of the zero isotherms associated with the melting of ice aggregates, and the region in the upper part of the thunderstorm cloud associated with collisional mechanisms of charge separation. The possibility of the formation of shielding layers from light air ions at certain air flow velocities is shown. In times of the order of 30 minutes, electric fields with a strength of up to 100 *kV/m* are achieved

The results of numerical modeling of the electric field parameters show that with weak turbulent mixing near the Earth's surface, there is a maximum of the positive space charge, and above the level of the maximum of the vertical distribution of the turbulence coefficient, a layer with a negative space charge appears. In the daytime, with an increase in turbulent exchange, the maximum of the positive space charge shifts upward, and the layer of negative space charge disappears, and an exponential decrease in the space charge with height is observed.

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