Determination of some parameters of radioactive aerosol removal from the atmosphere

By B. I. STYRA, E. J. VEBRA and K. K. SHOPAUSKAS, *Department of Nuclear Physics and Application of Radioactive Isotopes, Academy of Sciences of Lithuanian SSR*

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ABSTRACT

Two new methods of parameter determination of non-radioactive removal of radioactive aerosols from the atmosphere by cloud systems are discussed in the present paper. Theoretical considerations of the processes of capturing radioactive aerosols by cloud droplets are still fraught with a number of restrictions. They can be partly accounted for not only by the complication of the problem under review but also by the lack of information on microphysical characteristics of cloud systems and processes operative in them. The drawback of the present investigation is the assumption of stationarity of the processes in a cloud but the first stage of the investigation did not enable us to omit this assumption.

The parameter Λ permits us to determine experimentally the coagulation coefficient K of cloud droplets with aerosol particles.

1. Introduction

One of the main problems in the study of radioactive contamination or aerosol pollution in general is the investigation of self-cleansing atmospheric processes. One of the components of atmosphere self-cleansing is the removal of radioactive substances on the earth's surface. It happens either by means of dry deposition of radioactive substances with dust or washout by clouds and precipitation (STYRA, 1959). The main mechanism of the last two processes is the cloud and precipitation washout (STYRA, 1959; MAKHONKO, 1964; RENTSCHLER & SCHREIBER, 1962). Results have been obtained not only for nuclear fission products but also for natural radioactive substances.

The removal of radioactive isotopes from the atmosphere occurs either by capturing of radioactive aerosols by falling droplets and snowflakes or by cloud sampling.

The investigation of the two available mechanisms has shown that the capture of radioactive aerosols by cloud elements forms the main part of the specific radioactivity of precipitation and it makes up about one order more than that fraction of radioactivity, which is formed by droplet washout of aerosols from the air below the cloud layer (MAKHONKO, 1964; STYRA, 1956; KAROL, 1963). Hence, the investigation of the capture of radioactive aerosols by cloud droplets is of special urgency in the whole problem.

Since even small quantities of radioactive substances are easily detected they assume ever greater importance as tracers in the study of some problems related to cloud physics and precipitation. This problem acquires a double meaning: on one hand, it serves the practical purpose of studying mechanisms of removal of radioactive admixtures from the atmosphere; on the other hand, it reveals ever broader possibilities in making a close study of clouds and precipitation.

Experimental determination of the concentration of radioactive substances in the air of cloud systems provides us with ample opportunities in defining the parameter of non-radioactive removal of radioactive aerosols in the cloud (Λ) and the coagulation coefficient of radioactive particles with droplets (K) depending on this parameter. Some methods and results relating to these parameters will be discussed subsequently.

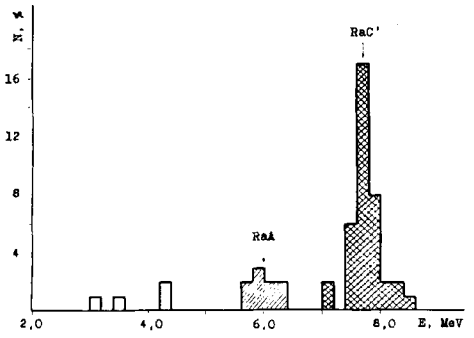


FIG. 1. The histogramme of α-tracks distribution by their energy.

2. The method measuring the concentration of radioactive substances in cloud air

The previously used method of determining the radioactive concentration in the air of the free atmosphere and of cloud systems was reported in detail (STYRA *et al.*, 1964; SHOPAUSKAS, 1964).

Radioactivity sampling was carried during aircraft flights by sucking air through the cloth ЛФС-1 or membrane filters. In those cases when it was desirable to determine the isotopic composition of radioactivity the cloth ЛФС-1 with a thickness of 0.3–0.6 $<$mg/cm^2 was used.

The air was sucked in through a sampler protruding 0.5 m from the craft's fuselage. A sampling pipe was bent at a right side of the aircraft and ended in the direction opposite to that of the flight. While the cloud air was sucked into the sampler during the flight cloud droplets were deviated by the socket and did not fall on the filter located near the other end of the sampling tube in the craft's cabin. This simple apparatus permitted us to carry out the sampling of air radioactivity while flying through clouds. Air radioactivity within clouds is defined here as the radioactivity of the air after removal of the cloud droplets.

To control the absence of droplets at the sampling site of a filter a mixture of erythrosin and talc rubbed into it was used. Being moistened the erythrosin was coloured bright red. During flights the filter of our installation never changed its colour. It guaranteed the liquid water content of filtered air, if any, to be less than $1 \cdot 10^{-3}$ g/m^3. Since we sounded clouds of the kind St, Sc and Cu having a considerable liquid water content and consisting of relatively large droplets we considered that we filtered droplet-free air and collected only small-size radioactive aerosols from it.

The collection time of one sample was 6 minutes and about 1 m^{3}STP cloud air was sucked through the filter during this time. The filtration was carried out by means of the vacuum cleaner system D-2-03-27v. In our experiments the efficiency of filters was 70 %. This low value can be well attributed to the high sampling velocity of about 5 m/sec. However, a reduction of the sampling was considered inexpedient as it would have resulted in a sharp increase of filtration time and, therefore, in a considerable averaging in space. By further reducing the filter efficiency and increasing the sampling rate it was managed to localize sampling to an even greater degree.

After completion of sampling the filter was taken off and (in the same craft's cabin) put in contact with the nuclear photo emulsion A-2, sensitive to α-particles. After 20-hour photoexposure the plates were developed, their original thickness was restored by impregnation in glycerine solution (POTSIUS & NEDVETSKAITE, 1960) and they were examined by means of the microscope МБИ-2.

Radioactivity was defined by the α-track concentration formed in the emulsion having been in contact with the filter. The isotope composition of a sample was determined only by air sucked through the filter ЛФС-1 as alpha-absorption almost did not take place in it due to its small thickness (0.3–0.6 mg/cm^2). After measuring the length of the α-tracks the energy was evaluated (MeV) by a calibration curve of energy dependence of α-particles on the length of tracks in the emulsion (type A-2). Finally the energy distribution of the α-particles was plotted (Fig. 1). As shown in the histogramme the greatest number of α-tracks is attributed to Po^{214}(RaC') since there are no α-emitters of other isotopes in this energy range. The small portion of α-tracks of about 6.0 MeV appears to belong to the Po^{218}(RaA).

Before every flight the plates were kept for some time in a solution of potassium ferricyanide and were subsequently washed thoroughly. This was done in order to remove the α-tracks of the background. Moreover, only surface α-tracks were measured and a blank-plate was used in all experiments together with

the signal-plates. In this way we were able to reduce emulsion background up to 4–20 α-tracks/cm^2. The number of signal α-tracks amounts usually to 70–400 α-tracks/cm^2.

3. The theory of the experiment

Radioactive sampling was carried out by filtering and by putting filter in contact with the emulsion, to fix the α-tracks on it. The particles containing Po^{218}(RaA), Pb^{214}(RaB), Bi^{214}(RaC), Po^{214}(RaC′) and other isotopes (though in less quantity) including the long-lived ones were sampled by air filtering. But only tracks of RaA and RaC′ were generally revealed under the given conditions of filtration and photoexposure.

Since RaC′(Po^{214}) has a half-life of $1.637\ 10^{-4}$ sec, its atoms captured directly from the surrounding air have enough time to decay into Pb^{210}(RaD) during the contact period with the filter emulsion.

Thus, the tracks of RaC′ discovered in the emulsion are formed as a result of the chain decay of RaA, RaB and RaC filtered from the air. Therefore, Po^{218} atoms captured by the filter leave two α-tracks in the emulsion: firstly, decaying as the RaA atoms, secondly, as the RaC′ atoms.

Let us calculate the atom numbers of Po^{218} (RaA), Pb^{214}(RaB) and Bi^{214}(RaC) which will have accumulated on the filter at the completion of filtering. The following equation system has to be solved for this purpose:

$$dM_i^* = \varepsilon f N_i dt - \lambda_i M_i^* dt + \lambda_{i-1} M_{i-1}^* dt, \quad i = 1, 2, 3. \tag{1}$$

The symbols 1, 2 and 3 correspond respectively to Po^{218}(RaA), Pb^{214}(RaB) and Bi^{214} (RaC). M_i^* is the atom number of the ith element accumulated on the filter during the time t, N_i is the concentration of the ith nuclide in the air, ε is the efficiency of filtering, f is the air volume filtered per second. $M_0^* = 0$ since radon does not deposit on the filter.

The integration of equations (1) if $M_i^* = 0$ at $t = 0$ results in the equation system:

$$M_n = \frac{\varepsilon f}{\lambda_n} \sum_{j=1}^{n} N_j \left[1 - e^{-\lambda_n t} + \left(\prod_{i=j}^{n-1} \lambda_i \right) \times \sum_{i=j}^{n-1} \frac{e^{-\lambda_n t} - e^{-\lambda_i t}}{\lambda_i \prod\limits_{\substack{k=j \\ k \neq i}}^{n} (\lambda_k - \lambda_i)} \right], \quad n = 1, 2, 3. \tag{2}$$

After the completion of sampling the filter is put in contact with the emulsion during the time τ, only after this the registration of alpha-decay begins. Therefore, at the beginning of the registration there is the following number of radioactive atoms of different isotopes on the filter:

$$M_n = \frac{\varepsilon f}{\lambda_n} \sum_{j=1}^{n} N_j \left(\prod_{i=j}^{n} \lambda_i \right) \times \sum_{i=j}^{n} \frac{(1 - e^{-\lambda_i t}) e^{-\lambda_i \tau}}{\lambda_i \prod\limits_{\substack{k=j \\ k \neq i}}^{n} (\lambda_k - \lambda_i)}, \quad n = 1, 2, 3. \tag{3}$$

The total number of α-tracks calculated in the emulsion can be expressed by the following sum:

$$P = \frac{2M_1 + M_2 + M_3}{2}. \tag{4}$$

This sum determines air radioactivity due to the nearest radon daughter products. Figure 2 in the denominator shows that only one side of the filter was put in contact with the emulsion. Substituting M_n from formula (3) into equation (4) the following equation combining the number of α-tracks calculated in the emulsion with the concentration of the Po^{218}(RaA), Pb^{214}(RaB) and Bi^{214}(RaC) atoms in the air can be received:

$$P = \frac{\varepsilon f}{2} \sum_{i=1}^{3} (\alpha_i + \beta_i) N_i. \tag{5}$$

The coefficients α_i and β_i are constant and depend on the condition of experiment and the constants of decay of the considered elements λ_i:

$$\left.\begin{aligned} \alpha_1 &= \frac{1 - e^{-\lambda_1 t}}{\lambda_1} e^{-\lambda_1 \tau}, \quad \alpha_2 = \alpha_3 = 0, \\ \beta_i &= \left(\prod_{j=i}^{3} \lambda_j \right) \sum_{\gamma=i}^{3} \frac{(1 - e^{-\lambda_\gamma t}) e^{-\lambda_\gamma \tau}}{\lambda_\gamma^2 \prod\limits_{\substack{k=i \\ k \neq \gamma}}^{3} (\lambda_k - \lambda_\gamma)}, \quad i = 1, 2, 3. \end{aligned}\right\} \tag{6}$$

4. The determination of the constant of non-radioactive removal of radioactive aerosols on cloud droplets

Let us make the following assumptions:

1. A cloud consists of mono-disperse droplets.
2. Radioactive aerosols are mono-disperse.
3. Droplets have no vertical motions, their fall speed is compensated by a vertical motion, their fall speed is compensated by a vertical velocity of air

$$w = C_0 r^2 \tag{7a}$$

which is the well-known Stock's law, with C_0 = constant and r = droplet radius.

4. The processes are stationary.
5. Aerosol deposition on droplets is described by Smolukhovsky's formula:

$$\frac{dN}{dt} = -KnN, \tag{7b}$$

where N is the radioactive concentration in a cloud, n is the concentration of droplets, and K is the coagulation constant.

6. The cloud is horisontally isotropic.

The concentration variation of any ith element of the radon chain under standard conditions can be described by the following differential equation for unit volume of air:

$$\frac{\partial(N_i w)}{\partial z} + \lambda_i N_i + KnN_i - \lambda_{i-1} N_{i-1} = 0. \tag{8}$$

The first term is the divergence of the ith element (taking into account condition 6), the second term is the radioactive decay, the third term is the number of atoms deposited on droplets and the last term gives the number of atoms produsded by the mother substance, λ_0 being the decay rate of radon and N_0 its concentration.

Applying equation (8) successively to the RaA, RaB and RaC atoms and assuming in the first approximation that radon concentration in the cloud does not vary with height (as shown later it is approximately justified) and supposing that near the lower boundary of the cloud radon is in radioactive equilibrium with its nearest decay products (Shopauskas, 1964) we can integrate this equation by height and deduce the formula for the N_j distribution in the cloud:

$$N_j = \lambda_0 N_0 \left\{ \left(\prod_{i=1}^{j-1} \lambda_i \right) \left[Kn \sum_{i=1}^{j} \frac{\exp\left(-\frac{\lambda_i + Kn}{w} z \right)}{\lambda_i (\lambda_i + Kn) \prod_{\substack{k=1 \\ k \neq i}}^{j} (\lambda_k - \lambda_i)} + \frac{1}{\prod_{i=1}^{j} (\lambda_i + Kn)} \right] \right\}; \quad j = 1, 2, 3 \tag{9}$$

N_0 is the radon concentration in the air, λ_0 is the radon decay constant.

It is known (Jacobi & Andre, 1963) that radioactive equilibrium between radon and its nearest decay products is disturbed near the earth's surface but is reached at some (comparatively small) height above the surface. This height depends upon turbulent exchange intensity and convective mixing processes in the atmosphere. At any rate for the cloud level the condition

$$N_i \lambda_i = \text{const} \tag{10}$$

for radon and its three nearest decay products can be considered valid. Determining air radioactivity near the lower boundary of the cloud by the above-mentioned method equation (5) (taking into consideration condition (10)) can be written in the form:

$$P_0 = \frac{\varepsilon f}{2} \lambda_0 N_0 \sum_{i=1}^{3} \frac{\alpha_i + \beta_i}{\lambda_i}. \tag{11}$$

While sounding a cloud at an altitude z above its base we determine the concentration of the Po^{218}, Pb^{214} and Bi^{214} atoms described by equation (9). However, the calculations show that if $z > 15$–20 m (in practice sounding is always carried out at some height above cloud base) all the terms except the last one of the system of equations (9) can be neglected. This is true for every available value of w, expressed by the Stock's law. Then equation (9) is transformed into the following system:

$$N_j = \lambda_0 N_0 \frac{\prod_{i=1}^{j-1} \lambda_i}{\prod_{i=1}^{j} (\lambda_i + Kn)}, \quad j = 1, 2, 3. \tag{12}$$

Putting into equation (5) the values of N_j from formula (12) and substituting $\lambda_0 N_0$ from

equation (11) we get an expression combining the measured values of radioactivity under the cloud and at some altitude (above 15 m) in the cloud with the removal parameter ($\Lambda = Kn$) of radioactive aerosols on droplets:

$$\frac{P}{P_0} = \frac{\sum_{j=1}^{3} (\alpha_j + \beta_j) \frac{\prod_{i=1}^{j-1} \lambda_i}{\prod_{i=1} (\lambda_i + Kn)}}{\sum_{j=1}^{3} \frac{\alpha_j + \beta_j}{\lambda_j}}. \qquad (13)$$

Since P and P_0 in this expression can be measured, the parameter $\Lambda = Kn$ can be determined from equation (13) experimentally. From this the coagulation coefficient K can be obtained if the droplet concentration n is known.

Equation (13) is calculated assuming that radon concentration in the cloud does not change with increasing altitude. If we suppose that the radon concentration in the cloud varies exponentially according to

$$N_0 = N_{0,0} e^{-xz}, \qquad (14)$$

then expression (13) will be transformed into

$$\frac{P}{P_0} = \frac{\sum_{j=1}^{3} (\alpha_j + \beta_j) \frac{\prod_{i=1}^{j-1} \lambda_i e^{-xz}}{\prod_{i=1} (\lambda_i + Kn - xw)}}{\sum_{j=1}^{3} \frac{\alpha_j + \beta_j}{\lambda_j}} \qquad (15)$$

Fig. 2 represents the curves of ratio P/P_0 calculated by formula (13) for different available K and n values. In calculations t was taken equal to 360 sec and τ to 30 sec. The ratio of α-tracks registered by sampling in the cloud at an altitude exceeding 15 m above the base of the cloud to the analogus measurements made below the cloud boundary in the layer near the cloud's base enables us to determine Λ and K if n is known.

The parameter of radioactive aerosol removal on droplets can also be determined if the number of α-tracks formed by Po^{218}(RaA) and Po^{214} (RaC′) is measured and if one makes use of the condition of so-called non-radioactive equilibrium.

In cloud air radioactive isotopes are removed as a result of two processes: radioactive decay and coagulation of radioactive aerosols with

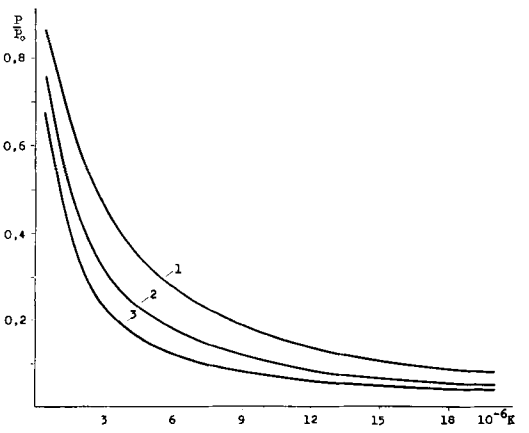


FIG. 2. The graph of relative air radioactivity dependence in a cloud air on the coagulation coefficient (1, at $n = 100$ cm^{-3}; 2, at $n = 200$ cm^{-3}; 3, at $n = 300$ cm^{-3}).

droplets. The coagulation process can be expressed by equation (7b). The integration of this equation under the assumption that n is independent of t results in

$$N = N_0 e^{-Knt} \qquad (16)$$

which resembles the radioactive decay law, where $Kn = \Lambda$ is analogous to the radioactive decay constant. Λ is a parameter which controls the radioactive aerosol removal rate.

The conditions of non-radioactive equilibrium can be written in the form:

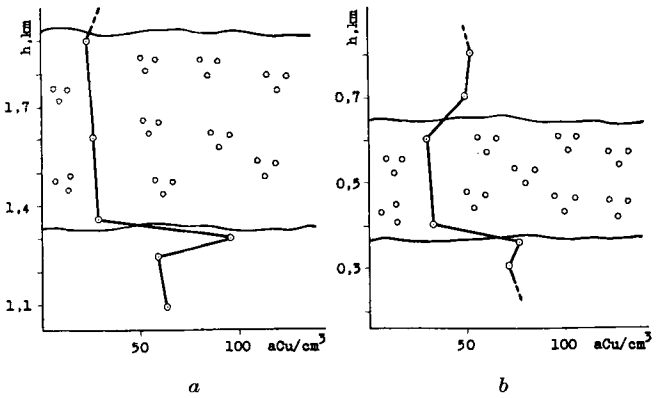
$$\left.\begin{aligned} \lambda_0 N_0 &= (\lambda_1 + \Lambda) N_1, \\ \lambda_1 N_1 &= (\lambda_2 + \Lambda) N_2, \\ \lambda_2 N_2 &= (\lambda_3 + \Lambda) N_3. \end{aligned}\right\} \qquad (17)$$

It was assumed by writing these equation that Λ is independent of the nature of isotopes. This assumption seems to be rather reasonable as different isotopes can be present on the same aerosols.

Solving equation (17) relatively to N_i and by expressing them by N_0 we get:

$$N_j = \lambda_0 N_0 \frac{1}{\prod_{j=1}^{i} (\lambda_j + \Lambda)}, \quad i = 1, 2, 3. \qquad (18)$$

Equation (18) enables us to make up the following ratio:



a *b*

FIG. 3. Air radioactivity profiles obtained by intersecting clouds; the air (*a*) on December 7, 1960, and (*b*) on April 13, 1963, in Vilnius district.

$$\frac{N_1}{N_2+N_3}=\frac{(\lambda_2+\Lambda)(\lambda_3+\Lambda)}{\lambda_1(\lambda_2+\lambda_3+\Lambda)}. \tag{19}$$

Let us express $$\frac{N_1}{N_2+N_3}=S. \tag{19a}$$

S can be determined experimentally by M_i. Substituting into equation (19a) the values N_i received after solution of the system of equations (3) we get (after non-complicated algebraic transformations):

$$S=\frac{aM_1}{dM_1+b(M_2+cM_3)}, \tag{20}$$

where a, b, c and d are numerical coefficients which can be expressed by radioactive decay constants t and τ.

Finally, solving equation (19) the removal parameter Λ can be determined and turns out to be

$$\Lambda=\tfrac{1}{2}\{\lambda_1 S-(\lambda_2+\lambda_3)+\sqrt{(\lambda_2-\lambda_3)^2+\lambda_1 S[\lambda_1 S+2(\lambda_2+\lambda_3)]}\}. \tag{21}$$

The radical has the positive sign before it as Λ is physically positive value.

5. The results of the experiment

A few series of cloud soundings have been carried out and profiles of radioactivity with altitude have been obtained by the above-mentioned method. By passing the lower air-cloud boundary air radioactivity reduces steeply but does not reach zero. In cloud air radioactivity variations with height are small and can often be attributed to errors in measurements. Therefore, it enables us to consider in the first approximation that radioactivity concentration is constant with height. The profiles of air radioactivity variation by intersecting clouds are illustrated in Fig. 3.

The decrease of radioactivity concentration during the transport of air into the cloud to the constant value of radioactivity concentration in the cloud takes place in a thin layer. This decrease with height has been calculated by formula (9) and by taking into consideration the system of formula (3). The results of these calculations are plotted in Fig. 4, from which we can conclude that not only the system of equations (9) as a whole but also the simplified formula (12) can also be used for determining the removal parameter Λ.

It follows from Fig. 4 that radioactive aerosols entering the cloud coagulate with droplets in its lower layers. Natural radioactivity of higher cloud layers depends upon the radon concentration and does not vary with altitude if the radon concentration is constant with height but should decrease if the radon concentration decreases. Furthermore, radioactivity of cloud air is dependent upon the parameter Λ and decreases with its increase.

Table 1 gives the data of the parameter Λ and of the coagulation coefficient calculated for

average values of the droplets concentration in clouds given by MASON (1961), KHRGIAN (1961), ZAITSEV & LEDOKHOVICH (1960). Calculations have been made by the formula (13) by means of determination of radioactivity in two points under the cloud and at an altitude z within the cloud. The measurements have been carried out in Vilnius district and the data under numbers 8–10 have been obtained in the Caucasus.

The main experimental parameter is a coefficient of non-radioactive cleanout of radioactive aerosols by droplets from the cloud Λ. As it is shown in the series of numbers given in the table the value Λ varies only slightly though the measurements are separated not only by time (1960, 1962, 1963) but also by space location (The Caucasus, The Baltic States). The most frequent value is $6 \cdot 10^{-4}$ sec^{-1}, average value is $7.6 \cdot 10^{-4}$ sec^{-1}. This value slightly exceeds radioactive decay coefficients of RaB and RaC and turns out to be less than that of RaA. The life of non-radioactive half-removal of radioactive aerosols calculated by the average value of Λ turns out to be 15.2 min. Hence, it can be concluded that, if Λ is the same for RaA, RaB and RaC, then Po^{218}(RaA) is removed in general by radioactive decay whereas Pb^{214} (RaB) and Bi^{214}(RaC) mainly by coagulation on droplets in clouds.

During a number of flights air was sucked in through the filters ЛФС-1 for isotope composition determination of radioactivity. A histogramme of α-track distribution by energy is illustrated in Fig. 1. The large column to the right represents α-tracks left by Po^{214} and the small peak to the left those of Po^{218}. Due to the smaller number the error in the determination of the α-tracks of Po^{218} is larger and can reach 30–40 %. Therefore, M_1 will have a great error by the definition of S in formula (20). Moreover, we determine Pb^{214} and Bi^{214} atom numbers, i.e. $M_2 + M_3$, by the difference of the α-track numbers defined by Po^{214} and Po^{218} columns. The sum $M_2 + M_3$ is a part of formula (20) where $c = 1.137$ under the conditions of experiment. By calculations we succeeded in proving that the measured value $M_2 + M_3$ differs negligibly from $M_2 + cM_3$. The last value increases with decreasing Λ. For possible variations of Λ from 10^{-2} to 10^{-4} sec^{-1} the ratio

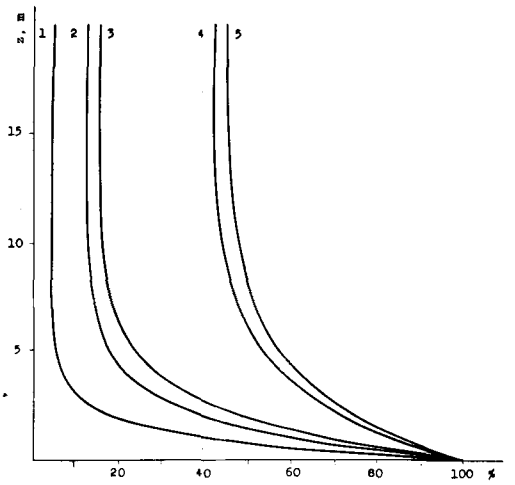


FIG. 4. Air radioactivity variation in the cloud with height at different coagulation coefficient and droplet concentration values (at $n = 200$ cm^{-3}: 1, $K = 7 \cdot 10^{-6}$ cm^3 sec^{-1}; 3, $K = 2 \cdot 10^{-6}$ cm^3 sec^{-1}; 5, $K = 0.5 \cdot 10^{-6}$ cm^3 sec^{-1}; at $n = 300$ cm^{-3}: 2, $K = 2 \cdot 10^{-6}$ cm^3 sec^{-1}; 4, $K = 0.5 \cdot 10^{-6}$ cm^3 sec^{-1}).

TABLE 1. *The values of washout parameter* Λ *and of the coagulation coefficient* K.

N	Sampling date	Clouds type	Measured values P/P_0	Λ sec^{-1}	Mean values cm^{-3}	K cm^3 sec^{-1}
1	July 11, 1960	Sc	0.26	$9 \cdot 10^{-4}$	300	$3 \cdot 10^{-6}$
2	Aug. 8, 1960	Sc	0.35	$6 \cdot 10^{-4}$	300	$2 \cdot 10^{-6}$
3	Dec. 6, 1960	St	0.30	$6 \cdot 10^{-4}$	200	$3 \cdot 10^{-6}$
4	Dec. 7, 1960	St	0.29	$6 \cdot 10^{-4}$	200	$3 \cdot 10^{-6}$
5	Sept. 12, 1962	Cu	0.23	$9 \cdot 10^{-4}$	300	$3 \cdot 10^{-6}$
6	March 5, 1963	St	0.14	$16 \cdot 10^{-4}$	200	$8 \cdot 10^{-6}$
7	Apr. 13, 1963	Sc	0.35	$6 \cdot 10^{-4}$	300	$2 \cdot 10^{-6}$
8	June 22, 1963	Sc	0.35	$6 \cdot 10^{-3}$	300	$2 \cdot 10^{-6}$
9	June 26, 1963	Sc	0.32	$6 \cdot 10^{-4}$	300	$2 \cdot 10^{-6}$
10	June 27, 1963	Cu	0.32	$6 \cdot 10^{-4}$	300	$2 \cdot 10^{-6}$

$(M_2+cM_3)/(M_2+M_3)$ changes from 101.4 to 114.0 % which enables us to take the value 107 % in our calculations and to increase by using formula (20) the experimental value M_2+M_3 by 7 %. Furthermore, this value corresponds to the increase of M_2+cM_3 at the average value Λ obtained by the first method.

Consequently, the determination of Λ by the second method is fraught with a lot of errors whereas the accuracy of radioactivity determination by α-tracks number (it was used in the first method) is rather good and the radiometric error does not exceed 8–10 %.

On the basis of data obtained during the flights the average value $M_1/(M_2+cM_3)$ was calculated and the constant of non-radioactive removal of radioactive aerosols from cloud air was determined by formulas (20) and (21); this constant proved to be equal to $2.7\cdot10^{-3}$ sec^{-1}. It is approximately 2–4 times higher than the values obtained by the first method and it can be partly accounted for by inaccuracies in the isotope composition determination of air radioactivity.

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ОПРЕДЕЛЕНИЕ НЕКОТОРЫХ ПАРАМЕТРОВ УДАЛЕНИЯ РАДИОАКТИВНЫХ АЭРОЗОЛЕЙ ИЗ ВОЗДУХА

Приводятся два метода для определения параметра нерадиоактивного удаления радиоактивных аэрозолей на капли облака и коэффициента коагуляции капель с аэрозолями. Первый метод основан на решении дифференциального уравнения для стационарных условий в облаке при отсутствии турбулентного перемешивания и при наличии сведений об измерении концентрации радиоактивных веществ в воздухе под и внутри облака. Второй метод основан на решении системы уравнений нерадиоактивного равновесия для Rn, Po^{218}, Pb^{214} и B^{214}; в зоне облака.

Профили распределения радиоактивности в воздухе при прохождении облака получены с помощью установки, которая отфильтровывала капли и давала возможность измерить концентрацию радиоактивных веществ в воздухе облака. Датчиками служила ядерная эмульсия типа А-2. По данным о концентрации α-следов в эмульсии определялась радиоактивность пробы, а по распределению длин α-трековизотопный состав радиоактивных веществ. По данным экспериментальных измерений и теоретическим схемам получены значения параметра удаления $\Lambda=(6\div16)10^{-4}$ 1/сек и коэффициента коагуляции радиоактивных аэрозолей с каплями $K=(2\div8)10^{-8}$ см^3/сек.