FIFTH INTER-DEPARTMENTAL CONFERENCE ON ATMOSPHERIC OPTICS AND ACTINOMETRY

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THE Fifth Inter-Departmental Conference on Atmospheric Optics and Actinometry was held in Moscow on June 24—29, 1963. Four hundred and sixty representatives of 91 institutions belonging to various departments of all the republics in the Soviet Union, as well as representatives of the German Democratic Republic, Poland and Bulgaria, took part in the Conference. On the recommendation of the previous conference the Conference was convened by the Central Board of the Hydrometeorological Service (GUGMS), the Academy of Sciences of the U.S.S.R., Ministry of Higher and Secondary Specialized Education, and the Commission on Radiation of the Meteorology and Atmospheric Physics Section of the Inter-departmental Geophysics Committee. The organizers of the Conference were the Institute of Atmospheric Physics of the U.S.S.R. Academy of Sciences, Moscow State University and the Central Aerological Observatory of GUGMS.

130 papers were heard and discussed.

In the two years since the Fourth Conference (Leningrad, June, 1961), five very representative, specialized meetings have taken place, dealing to a greater or lesser extent with problems of atmospheric optics and actinometry:

1) Problems of light scattering in the atmosphere (Alma-Ata, September, 1961).

2) Spectroscopy of light-scattering media (Minsk, January, 1962).

3) Theory of radiative transfer (Moscow, June, 1962).

4) Results of the International Geophysical Year (Moscow, January, 1963).

5) Ozonometry (Leningrad, May, 1963).

Moreover, immediately after the end of the Minsk conference, another conference on spectroscopy was held, at which papers on atmospheric optics were also presented. Nevertheless, the program of the present Conference was extremely heavy and it was not possible to include all the communications submitted on the results of new studies.

Such an abundance of scientific work proves conclusively the increasing importance of studies of atmospheric optics and actinometry, which are attracting an increasing number of workers. The Conference demonstrated clearly that the main emphasis is shifting from a descriptive approach to the study of the basis of physical relationships underlying atmospheric optical phenomena and to a quantitative analysis of the influence of various factors on these phenomena. Wider use is being made of simultaneous, combined studies of various aspects of atmospheric optical phenomena, as well as of laboratory investigations, and this has already given some new results of considerable scientific and practical importance. Another aspect of the process of overcoming the isolation of atmospheric optics and actinometry (the historical division between these two subjects has now lost its meaning) as a meteorological science and of transforming it into an important branch of modern optics became clear at the Conference: the main emphasis was on scientific problems going far beyond the original framework and being of general physical significance. The contributions of young scientists and relatively newly formed research teams, such as the teams at the Institute of Physics and Astronomy, Academy of Sciences of the Estonian S.S.R., and of the Siberian Physico-technical Institute, also increased in importance.

The chief interest of the Conference lay in the following problems:

1. Radiation losses and interpretation of observations carried out by means of artificial earth satellites.
2. Radiative conditions in a free atmosphere.
3. Scattering of light in the atmospheric layer near the earth's surface and the microstructure of aerosols.
4. The transparency and transmission function of the atmosphere in the infrared region of the spectrum and the problem of atmospheric humidity.
5. Optical properties of thick layers of the scattering medium and the surfaces under it.
6. Brightness and polarization of the daytime and twilight sky.
7. Radiation balance.
8. Actinometric apparatus.

Opening the plenary session, the Chairman of the Commission on Radiation, K. Ya. Kondrat'ev, drew attention to the possibility of using artificial earth satellites to investigate atmospheric radiation processes, which poses new problems in atmospheric optics and actinometry. In particular, one of the most important problems of atmospheric optics is the development of methods for collecting meteorological information necessary for weather forecasting, using observations made by artificial earth satellites. At the suggestion of Kondrat'ev, the Conference conveyed its greetings to the cosmonauts V. F. Bykovskiĭ and V. V. Tereshkova, who had just successfully completed their heroic, many-day flight, the program of which had included atmospheric optics observations.

The main problems of modern atmospheric optics and actinometry were outlined in the introductory address of the Chairman of the Organizing Committee of the Conference and Deputy Chairman of the Commission on Radiation, G. V. Rozenberg. In his view, these problems are:

1. Study of radiative heat-transfer between the atmosphere and its underlying surface and outer space as a weather-governing factor; this disturbs the adiabatic dynamics of the atmosphere; also methods for allowing for this factor in equations for numerical weather-forecasting.

2. Extraction of meteorological information necessary for weather-forecasting from measurements carried out on a global scale by artificial earth satellites.

Rozenberg drew attention to the fact that the only source of such information was the electromagnetic radiation reflected and emitted by the earth into outer space, and that these problems are essentially astrophysical. Therefore, the information may be extracted only by spectral analysis in time, space and angular structure of the radiation field. The establishment of principles and methods of spectral analysis of optically nonuniform media, including the atmosphere, becomes the central problem, not only in atmospheric optics but in modern optics in general. To develop special methods of spectral analysis for the main problems in the practical use of weather satellites, it is necessary to study in detail the optical properties (absorption spectra, scattering matrices) of the main optically active components of the atmosphere, as well as the optical structure of the atmosphere. Equally important is the theoretical and experimental study of several problems in radiative transfer (three-dimensional problems, optics of thick layers, transport of radiation in media with randomly distributed parameters). Finally, in Rozenberg's view, the introduction of optical methods of studying atmospheric processes into practical geophysical observations is also an important objective.

Great interest was shown in the paper of A. S. Monin, who outlined the modern approach to the physical basis of numerical weather forecasting. Large-scale atmospheric formations, which determine the state of the weather, have a lifetime τ of the order of 1—2 weeks; Monin accordingly divided weather forecasts into short- and long-term, depending on whether the forecast range was short or long compared with τ. In short-term forecasts, the initial state of the atmosphere is important and the dynamic processes occurring during the first tens of hours may be considered to be adiabatic; while for longer periods, however, it is necessary to allow for nonadiabatic perturbations (radiative and turbulent heat-exchange, turbulent friction, etc.). In the case of long-term forecasts, the initial state of the atmosphere itself ceases to be important, and the evolution of the boundary conditions becomes of primary significance.

An important factor governing the nature of weather changes over long periods is, in the opinion of Monin, the exchange of heat between the atmosphere and sea surface. In this, a special feedback mechanism plays a decisive role, with clouds acting as the regulating agent, and this radically affects the heat-exchange itself, as well as the heating of the sea by solar radiation. Therefore, forecasts of cloud cover are one of the chief factors in long-term weather-forecasting. This has led Monin to a system of forecast equations, some elements of which (in particular, methods of allowing for radiative heat-exchange) have not yet been explored. The study of such elements should, in the opinion of Monin, occupy a central position in the modern theory of long-term forecasting and in the corresponding branches of atmospheric optics and actinometry.

The extensive papers of K. Ya. Kondrat'ev, "Radiation and weather satellites," and M. S. Malkevich, "Interpretation of radiation observations from satellites," gave a detailed analysis of various aspects of the problem of using artificial earth satellites for collecting meteorological information.

Using as a basis the theoretical calculations carried out under their direction and the analysis of measurements of the radiation loss field carried out by American satellites, Kondrat'ev and Malkevich discussed various possibilities of determining the temperature of the underlying surface, the temperature profile of the atmosphere, the heights of clouds and other characteristics of the state of the atmosphere from radiation measurements carried out by satellites; they also investigated the sources of error in these studies. In particular, they showed that the use of Caplan's method for determining the temperature of the underlying surface from its intrinsic radiation in the so-called "transparency window" of the atmosphere (8—12 μ) generally involved large errors, but it was possible to suggest acceptable methods for the reduction of such errors (for example, by allowing for the correlation between the temperature of the atmosphere and its humidity - Malkevich). On the other hand, one can suggest several apparently reliable methods for determining the height of the upper limit of the cloud cover.

Kondrat'ev also discussed the problem of reducing the data of measurements of radiation flux, obtained by means of artificial earth satellites, to the effective boundary of the actual atmospheric layer; he used the results of measurements carried out under his direction, using stratospheric balloons, of the dependence on height of the radiation balance and its components. Kondrat'ev and Malkevich showed conclusively that the use of artificial earth satellites for meteorological purposes was promising, but that intensive experimental and theoretical investigations were necessary to make this use effective.

E. M. Feĭgel'son described the present state of knowledge on the optical and radiation properties of clouds. Bearing in mind the far from satisfactory position of investigations of the absorption spectra of water in its gaseous and liquid-drop phases, and the insufficient data on the scattering of light by water drops, Feĭgel'son considered in detail the problem of radiation transport in a cloud. Analysis showed that the widely used "two-stream approximation" did not give satisfactory results in any of its modifications. At the Institute of Atmospheric Physics of the U.S.S.R. Academy of Sciences, three methods had been developed for solving the transport equation for thick layers of a strongly scattering medium (L. M. Romanova, G. V. Rozenberg and E. M. Feĭgel'son), and these gave results in good agreement with each other and with experiment. The use of these three methods made it possible to obtain a clear idea of the main optical and radiation properties of stratus clouds, including the angular dependence of these properties and their dependences on thickness and wavelength. In particular, the reflectivity and emissivity spectra of a cloud show clearly the absorption bands of water drops and water vapor, and these should be allowed for in the analysis of radiation measurements made by artificial earth satellites. Feĭgel'son draw attention to other features of the optical and radiation properties of clouds which might be used in interpreting the weather-satellite data and in calculating the influence of clouds on the radiative heat-exchange. Unfortunately, experimental investigations of the optical and radiation properties of clouds lag greatly behind theory.

The paper of Yu. D. Yanishevskiĭ, Yu. K. Ross and M. A. Sulev contained an analysis of the present state of measurements of the radiation balance and its long-wavelength components at the surface of the earth. The existing instruments for measuring this balance and pyrheliometers do not satisfy the growing requirements of present-day actinometry. Systematic errors due to the selectivity of the coatings of receiver surfaces, and to the sensitivity of the instruments to wind, velocity and direction, reach several per cent or even tens of per cent. Moreover, they are not weather-resistant. There are very large errors in the determination of their sensitivity to long-wave radiation. There is no instrument which could be used as a standard. Yanishevskiĭ, Ross and Sulev believe that, in addition to the necessary development of essentially new instruments, special attention should be paid to the development of apparatus for calibrating these instruments, to the improvement and standardization of the receiver surface coatings, and to the organization of comparisons of the instruments under various climatic and weather conditions.

A separate session dealt with the problem of radiation losses, i.e., radiation reflected and emitted by the earth into the cosmos, in connection with problems of interpreting radiation data obtained by means of artificial earth satellites.

M. K. Markov, A. V. Liventsov, Ya. I. Merson and M. P. Shamilev reported the results of a study of the angular distribution of thermal radiation of the earth by means of geophysical rockets. Considerable deviations from theoretical predictions were found which the authors believe should be ascribed to radiation from the atmosphere itself above 35 km.

A series of theoretical papers, presented by the Department of Atmospheric Physics of Leningrad State University (K. Ya. Kondrat'ev et al), the Institute of Atmospheric Physics, U.S.S.R. Academy of Sciences (M. S. Malkevich et al), the Main Geophysical Observatory (K. S. Shifrin et al) and the Institute of Atmospheric Physics of the Estonian Academy of Sciences (O. A. Avaste, Kh. Yu. Niĭlisk et al) outlined a sufficiently clear picture of the angular and spectral structure of the lost radiation field, both for long and short wavelengths. The influence was found of the temperature profile of the atmosphere, the distribution with height of the optically active components and the state of the earth's surface and the cloud cover. A study was made of a wide range of models, reflecting possible variations in atmospheric conditions, to be used under various conditions of measurement (various spectral ranges, use of wide-angle and narrow-angle receivers, variations in the height of the sun, brightness profile of the horizon, etc.). The results of calculations carried out mainly by means of electronic computers allowed the authors to propose certain ideas on the limits of applicability and the degree of reliability of various methods of determining the state of the atmosphere from satellite data.

The possibility of using space spectra of the radiation loss field for the objective determination of parameters of cloud cover and for the determination of weather conditions (including atmospheric turbulence characteristics) was discussed in the paper of M. S. Malkevich, I. P. Malkov, G. V. Rozenberg and G. P. Fareponova. Novel optical apparatus for the study of space spectra of radiation, using photographic images, was described in the paper of E. O. Fedorova and the late N. S. Shestov.

A. A. Dmitriev analyzed the possibilities of re-establishing the structure of the radiation field from measurements with wide-angle radiation receivers.

At a session dealing with the radiation conditions in a free atmosphere, the results of measurements of the sky brightness in various parts of the visible range of the spectrum were reported as a function of height; they were obtained by means of geophysical rockets for heights up to about 500 km (A. E. Mikirov) and by aircraft for heights of 8—17.5 km (A. B. Sandomirskiĭ, N. P. Al'shovskaya, and G. I. Trifonova). The important result of these studies was the confirmation of the aerosol nature of scattering at all heights and the existence of aerosol layers, as well as (in the case of the aircraft measurements) the determination of the seasonal variation in the sky brightness. M. S. Kiseleva,

E. D. Sholokhova, B. S. Neporent and E. O. Fedorova carried out similar measurements in the range of the spectrum from 1 to 3.5 μ, using stratospheric balloons up to a height of 17 km; they simultaneously investigated the variation with height of the direct solar radiation spectrum, which made it possible to determine the variation with height of the atmospheric transparency inside and outside the absorption bands of water vapor.

The important influence of stratification of the atmosphere on the measured value of the radiation temperature of the earth's surface, in the case of aircraft measurements in the "transparency window," and the strong dependence of the cloud radiation in the 8—12 μ region on the cloud thickness and state of its upper surface, were reported by V. L. Gaevskiĭ, Yu. I. Rabinovich et al. A group of workers at the Institute of Atmospheric Physics of the U.S.S.R. Academy of Sciences, cooperating with B. P. Kozyrev, constructed and tested in the summer an aircraft instrument for measuring the radiation balance in the spectral ranges 0.3—3, 0.7—3 and 2.5—40 μ. These measurements provided the aerosol absorption in the 0.3—0.7 μ range and gave the space spectra of the radiation reflected by clouds of various types. The method and results of a study of the spectral and angular distribution of the thermal radiation of the atmosphere, observed from the earth, were reported by S. V. Ashcheulov.

Theoretical calculations of the role of the absorption band of carbon dioxide in the region of 15 μ under the thermal conditions in the mesosphere were reported by G. M. Shved. L. V. Petrova and E. M. Feigel'son calculated the influence of radiation on the process of cloud formation.

One of the sessions on the problem of the scattering of light in the lowest layer and the microstructure of aerosols was devoted completely to investigations of the influence of aerosols on the transparency of the atmosphere for a directed light beam. The greatest attention was attracted by the paper of K. S. Shifrin and A. Ya. Perel'man, "Calculation of the particle spectrum from data on the spectral transparency." They showed that if the attenuation of the light beam was due to the presence of non-absorbing spherical particles in its path, the size distribution of these particles could be determined uniquely from the spectral dependence of the transparency; they suggested a simple algorithm for finding the spectrum of the particle, which requires knowledge of the transparency in a relatively small number of narrow spectral ranges. However, these ranges should cover a sufficiently wide band of wavelengths, depending on the size distribution of the particles (under atmospheric conditions this band should extend from 0.2 to 25 μ). Otherwise the problem cannot be solved, which invalidates the numerous attempts to determine the particle size spectrum from measurements of the spectral transparency over narrow ranges of wavelength.

A lively discussion also arose out of the papers of K. S. Shifrin and G. M. Aĭvazyan, "Allowance for the scattering function in measurements of the transparency," M. V. Kabanov and S. D. Tvorogov, "On the dependence of the attenuation coefficient on the photometric thickness of the medium," and M. V. Kabanov, "Diffuse transmission of radiation in the atmosphere in the case of single scattering."

These papers gave theoretical and experimental analyses of the problem of the influence of single scattering through small angles on the magnitude of the light flux reaching a receiver in measurements of the brightness of a directed light beam passing through a scattering medium. A study was made of the influence of the receiver aperture, angular dimensions of the light beam, distance between the source and receiver, and the form of the scattering function (i.e., the dimensions of the particles and wavelengths). It has been shown that under the conditions of actual measurement, single scattering introduces very important errors, reaching tens of per cent, in the measured attenuation coefficient, and the values of such errors depend strongly on the absorption conditions and have a definite spectrum, which depends on the size distribution of the particles.

Therefore, the methods and results of transparency measurements in scattering media require serious review, for the purpose of which it is necessary to carry out an extensive program of special studies. In the discussion, G. V. Rozenberg drew attention to the necessity of an additional allowance for the effect of coherent scattering of light at small angles, and of multiple scattering in the forward direction.

Experimental investigations and theoretical calculations of the relationship between the spectral transparency and microstructure of artificial fog, carried out at the Siberian Physico-technical Institute (V. E. Zuev et al) have shown that there is good agreement between the experimentally observed and theoretically expected dependences of the attenuation coefficient on various parameters. At the same time, the experimentally determined absolute values of the absorption coefficient are systematically greater than the calculated values, and the greater the optical density of the fog, the greater the difference. Zuev et al. suggest that the reason for this should be sought in the defects of microphysical measurements, although the latter were carried out by three independent methods.

Various experimental studies of the conditions of propagation of a directed light beam in a turbid medium of large optical thickness were carried out at the Physics Institute of the Belorussian Academy of Sciences (A. P. Ivanov et al). Quantitative dependences were found for the spreading of the beam as a result of multiple scattering of the light, and the influence was determined of the parameters of the medium and the light-beam diameter on the illumination and angular structure of the light field at various depths.

M. A. Gol'dberg described apparatus for measuring the range of visibility at night from the brightness of back-scattered light from a projector beam. S. D. Tvorogov reported calculations of the coefficient of light attenuation by two-layer spherical particles. The pressure of light on a drop of water was calculated by K. S. Shifrin and I. L. Zel'manovich.

A special session was devoted to studies of scattering functions and their use for the study of aerosol microstructure.

Calculations of cooperative (collective) effects in the scattering of light by a random assembly of particles were carried out by O. A. Germogenova, using the group-integral method. An experimental study of the scattering functions of absorbing particles, having an irregular shape, carried out by Ivanov et al, showed that these functions were essentially different from those for spherical particles. Therefore, the widespread use of the Mie theory for the description of light scattering in a medium consisting of randomly oriented particles of irregular shape is completely unjustified.

Apparatus for measuring the size distribution of particles by observing the scattering functions in the region of the solar halo was described in the papers of S. S. Khmelevtsev (laboratory instrument with a small base) and Yu. S. Lyubovtseva (field apparatus with bases of 60 and 250 m). Lyubovtseva obtained monochromatic scattering functions over angles from 10′ to several degrees for various states of the lowest layer of air and studied their variations during the process of formation of a fog and its subsequent changes.

Some results of measurements of the solar halo were reported in the papers of T. P. Toropova, Ya. A. Teĭfel', Yu. S. Georgievskiĭ and G. F. Sitnik.

A. Ya. Driving, I. M. Mikhaĭlin and G. V. Rozenberg investigated the angular dependences of the polarization of effectively monochromatic light scattered in the lowest layer of air under misty conditions. It was found that the angular dependence of polarization in the rainbow region was very sensitive to change in the scattering-particle dimensions. Some properties of the aerosol scattering function and of the polarization of light, in the case of scattering in the lowest layer of the atmosphere, were also investigated by T. P. Toropova. G. I. Gorchakov measured the angular dependences of all the 16 components of the scattering matrix for an atmospheric mist and showed that in a thick mist the scattering matrix was close to the expected one for spherical particles.

As in earlier years, much attention was given to investigations of the brightness and polarization of the daytime and twilight sky, chiefly from the point of view of investigating the optical properties of the atmosphere.

K. Lenz reported the main results of studies carried out in recent years at the Institute of Optics and Spectroscopy of the Berlin Academy of Sciences (German Democratic Republic) under the direction of Professor Feuzig. These extensive investigations have shown the important features of polarization of the daytime and twilight sky and have yielded several spectral and other dependences which require special analysis. The results of polarization measurements on the daytime sky were reported by E. V. Pyaskovskaya-Fesenkova, P. N. Boĭko et al. It was clearly shown that the polarization was affected strongly both by multiple scattering and by the aerosol composition of the atmosphere and state of the earth's surface.

Comparison of the theoretical and empirical data with daytime sky brightness led G. Sh. Livshitz to the conclusion that the intrinsic absorption (mainly by ozone) must be allowed for. The results of a calculation of the spectral distribution of the brightness of a cloudless sky at various heights were reported by M. S. Averkiev, L. A. Biryukova, V. K. Kagan and E. P. Ryabova.

A lively discussion was caused by the papers of L. B. Gusakovskaya on polarization observations at twilight, N. B. Divari on the investigation of optical properties of the atmosphere by the twilight method, D. G. Stamov on the influence of inhomogeneities of the atmosphere on twilight polarization of the sky and Gnilovskiĭ on the infrared spectrum of the twilight sky. The very interesting observational data reported by these workers (and by K. Lenz) proved conclusively the sensitivity of twilight phenomena to variations in the optical structure of the atmosphere; the data illustrated clearly that to interpret the twilight measurements reliably, it was necessary to measure simultaneously several related parameters and to develop further the theory of the twilight method for probing the atmosphere. The latter problem was discussed in a paper by G. V. Rozenberg, which contained a detailed analysis of the nature of various twilight phenomena.

The papers of V. A. Belinskiĭ et al and of A. D. Zaĭtseva contained the results of an experimental study of the direct and scattered ultraviolet radiation of the sun.

The important problem of the spectrum of solar radiation outside the atmosphere, its transformation by the atmosphere and of the spectral transparency of the atmosphere was discussed in the papers of G. F. Sitnik and L. V. Daeva, as well as by D. S. Aksenov, V. V. Kol'tsov and D. N. Lazarev. The determination of the height of the ozone layer from observations of direct solar radiation was described by G. I. Kuznetsov.

Studies of the transparency and transmission function of the atmosphere in the infrared region have shown that although there are some successes in this subject, they are far from sufficient, bearing in mind the importance of this for the solution of problems arising in connection with the use of artificial earth satellites for meteorological purposes. The results of spectral measurements of atmospheric absorption in the infrared region were reported in papers presented by the Department of Atmospheric Physics of Leningrad State University (I. Ya. Badinov et al). Data were also obtained on the absolute spectral brightnesses of solar radiation outside the atmosphere. Experimental studies of the transmission function of the atmosphere were reported by A. M. Bronshteĭn and K. V. Kazakov, as well as by V. E. Zuev et al, who also carried out calculations of atmospheric transparency for infrared radiation.

V. P. Kozlov reported on a study of the allowed infrared spectra for the calculation of internal transmission.

Considerable success has been achieved in the use of spectroscopy for the study of atmospheric humidity.

The different variants of the measurement method and the results of measurements of humidity at various heights were discussed critically in the paper of M. S. Kiseleva. B. S. Neporent et al described an optical hygrometer for measurements of humidity at the earth's surface. An automatic recorder of the total water-vapor content of the atmosphere was constructed by I. Ya. Badinov et al. Measurements of the absorption of solar radiation by water vapor were carried out by G. F. Sitnik et al.

Using a small optical hygrometer, L. G. Elagina was able to investigate, for the first time, the frequency spectra of turbulent pulsations of the absolute humidity as a function of atmospheric conditions, obtaining good agreement with theoretical expectations.

At the session on the optical properties of thick layers of the scattering medium and the underlying surface, a lively discussion arose in connection with the paper of Yu. K. Ross on the mathematical statement of the problem "Radiation conditions and photosynthesis of vegetation cover."

Having pointed out the important influence of radiation conditions in vegetation cover on the processes of photo-synthesis and moisture transpiration, as well as the dependence of radiation conditions on the structure of the vegetation cover and the biological state of green plants, Ross formulated in general terms the problem of radiation transfer in the vegetation cover. For a mathematical statement of the problem, it is necessary to allow for three factors:

1) The considerable optical anisotropy of the medium.

2) The random nature of the distribution of scattering and absorbing regions (leaves, stalks, etc.).

3) The vertical nonuniformity. This leads to a general class of problems in transfer theory which have not yet been investigated and which go far beyond the problem of radiation conditions in the vegetation cover.

There was general interest in the paper of O. A. Germogenova, who investigated the possibility of solving the converse problem of the theory of radiative transfer in a layer of scattering medium. Germogenova showed that, in many cases, it was possible to suggest a relatively simple algorithm for determining of the scattering function from the angular dependence of the brightness of the light reflected or transmitted by a not-too-thick layer of the scattering medium.

The conditions for propagation of radiation in a medium with a reflecting base were discussed in the paper of A. M. Samson and K. S. Adzerikho.

An experimental study of the optical properties of thick layers of a scattering medium as a function of the specific absorption, thickness of the layer and depth in the layer, carried out by A. P. Ivanov et al, confirmed several predictions from the theory of Rozenberg and made it possible to determine some parameters which occurred in Rozenberg's formulas.

Investigation of the spectral and angular optical characteristics of snow, carried out by I. P. Malkov, also showed agreement with Rozenberg's theory and with Feĭgel'son's calculations, and led to a determination of several parameters in Rozenberg's formulas.

Variations in the reflection function of snow were reported by L. B. Krasil'shchikov and V. I. Korzov.

Yu. R. Mullamaa carried out extensive calculations of the angular dependence of the brightness and polarization coefficients of the light reflected from rough sea waves as a function of the velocity and direction of wind and of the directions of incidence and reflection of light.

The relationships found in this way showed that it should be possible to determine the velocity and direction of wind at the sea surface from the parameters of the solar streaks on the sea surface observed from artificial earth satellites. The effect of waves on the albedo of the sea surface was also calculated.

The results of measurements of the albedo in a mountainous region, carried out by means of a helicopter, were reported by I. P. Belyaev.

An experimental study of the reflection of light by rough surfaces led A. S. Toporets to an important conclusion: irrespective of the nature of the surface, specular reflection appears at angles of incidence (reflection) i satisfying the simple relationship $\bar{h} \cos i = \lambda$, where $\bar{h}$ is the average height of the microroughness of the surface and λ the wavelength of light.

At a session on radiation balance, S. Kh. Lingova described the radiation conditions in Bulgaria. The results of actinometric measurements from an aircraft over the Antarctic and actinometric observations at sea were reported by V. I. Shlyakhov. Theoretical and experimental investigations of the balance of long-wavelength radiation in a layer next to the sea surface were described by V. S. Samoĭlenko; N. E. Ter-Markaryants reported on a method and results of calculations of the long-wavelength balance at sea.

N. I. Goĭsa and L. I. Sokali investigated the relationships between the transparency coefficient of the atmosphere and the coefficient of turbulent exchange in the lowest layer, and between the balance of long-wavelength radiation and temperature gradient in that layer. The role of the effective surface in the establishment of radiation balance was investigated by G. V. Kirillova.

K. A. Tavartkiladze described methods he had developed for calculating the effective radiation for the Trans-Caucasus.

I. Yu. Undla used the data of seven years of actinometric observations at Tartu to investigate the variation of the solar radiation sums. The results of measurements of radiation fluxes for differently oriented surfaces and of the determination of the influence of cloudiness and screened horizon were reported by K. Ya. Kondrat'yev and M. P. Fedorova; Yu. L. Rauner and N. I. Rudnev investigated experimentally the vertical distribution of the radiation balance components in a deciduous forest.

At a session on actinometric apparatus, P. V. V'yushinov and Yu. A. Sklyarov reported on their bolometric pyrheliometer for absolute measurements of the direct solar radiation. A fast-acting automatic spectrophotometer for combined studies of short radiation fluxes in the atmosphere was described in the paper of V. V. Mikhaĭlov. The construction of an absolute inertial pyrheliometer and some experimental results were described by E. F. Babenkov; L. V. Gul'nitskiĭ et al reported a determination of the intensity of radiation by the method of varying the state of the receiver surface. A study of the dependence of the sensitivity of actinometric instruments on pressure and temperature was carried out by G. N. Gaevskaya and M. P. Fedorova.

Experiments on the use of automatic integrators in actinometry were reported by Yu. M. Reemann; Kh. Yu. Niĭlisk described his photo-actinometric spectrophotometer and photometric rack for measurements of the radiation field in the vegetation cover.

At the final plenary session, the Conference passed a resolution which, in particular, mentioned: the necessity for concentrating efforts on the most pressing problems of atmospheric optics and actinometry; the necessity for a closer coordination of studies carried out at different institutions; the need for establishing a centre for checking and comparison of actinometric apparatus; the need for uniform terminology, in keeping with the present state of the science, etc.

The Conference requested the Institute of Physics and Astronomy of the Estonian Academy of Sciences to organize the Sixth Conference on Actinometry and Atmospheric Optics in 1965 in Tartu.

Translated by A. Tybulewicz