

NOTE

Survey of the Activities of the Radiation Commissions of the International Meteorological Organisation and of the International Union of Geodesy and Geophysics

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In many scientific activities the war caused an interval of stagnation. We are now faced not only with the problem of taking up and reestablishing activities interrupted several years ago, but also with the problem of reorganizing these activities on a new basis with due regard to present needs.

With these conditions in mind an historic survey of the scope and the activities of the Radiation Commissions may be of interest.

The Solar Radiation Commission of the I.U.G.G. was established at the General Assembly of the Union at Madrid in the year 1924 with H. H. Kimball as its first president and with A. Ångström, Gorczynski, Maurain, Platania and Simpson as members. According to instructions its first activities were to be directed toward promoting pyrheliometric and other specified observations. From the report of Dr Kimball to the General Assembly at Prag in 1927 it may be seen that the work of the Commission in the three year interval between the meetings in Madrid and Prag was concentrated on the organization of a number of stations for recording total radiation from sun and sky, namely in Belgian Congo, in Samoa, on Spitzbergen and at Tromsö. In a paper in *Monthly Weather Review* for April 1927, submitted to the Meteorological Association, Kimball had given a program for the treatment of pyrheliometric measurements and records in order to get from them results of general significance.

At Prag the Solar Radiation Commission¹ was

¹ In the Minutes from Prag the Commission is for the first time referred to as the Solar Radiation Commission.

given more definite instructions and was authorized to:

(1) encourage, by all possible means, the maintenance of an international net of stations for measuring solar radiation,

(2) which ought to include as many high altitude stations as possible,

(3) take steps to insure that especially the stations at high altitudes would occupy themselves with measurements of ultraviolet radiation and of the ozone content of the atmosphere.

In a special resolution the Commission was authorized to cooperate with the Solar Radiation Commission of the International Meteorological Organization (IMO) in order to organize comparisons between pyrheliometric standard instruments used in different countries, to prepare a program and a practical instruction for daily observations and to facilitate the speedy publication of unusual results.

At the General Assembly in Stockholm in 1930 a number of papers were presented dealing with the subjects indicated above, particularly with the distribution of radiation over the earth's surface and with the ultra-violet radiation. On the initiative of Dr Dobson, and with special regard to his investigations, a subcommission of the Solar Radiation Commission was established for studying the ozone problem. This subcommission, consisting of Messrs Abbot, Ångström, Chalonge, Dobson, Fabry, Götz, Kimball and Ladenburg, was to pursue researches on atmospheric ozone mainly according to the outlines drawn up by Dr Dobson at the meeting at Stockholm. At this meeting Dr Kimball

resigned as president and was succeeded by the author of this survey.

Under the circumstances prevailing in 1930 it was regarded as an important task to insure close collaboration between the two Commissions. The IMO Commission had been established as early as 1896 in Paris. Its scope had never been very clearly defined and it had been appreciably broadened with due regard to the fact that various new radiation problems of meteorological interest had, in the course of time, been brought into the field of scientific activity. Thus in 1919 a commission of a somewhat more astrophysical character instituted in Southport 1903 by the International Union for Solar Research had been fused into the IMO Commission and its field of work seems to have covered as well the solar radiation in general as also various radiation processes within the atmosphere. It may be assumed, however, that its primary aim must have been to organize radiation measurements within the meteorological net works belonging to the meteorological institutes. But it must be admitted that this aim was very often regarded a secondary one and that with some justification the scientific aspects also by this Commission were considered of primary importance. Consequently, to great extent, the fields of action of the two Commissions were then actually overlapping. There were two means by which duplication of work could be avoided, either to make a clear division of responsibilities of the two Commissions, so that no overlapping would occur, or to collaborate so closely that they actually would function as one single Commission.

At that time one of the most important questions within actinometric research was undoubtedly the one concerning the comparability of results obtained in different parts of the world with different actinometers. The difference between the two prevailing scales for solar radiation, namely the Ångström scale and that of the Smithsonian Institution, was still in 1930 as large as between 3 and 5 per cent, having amounted to 9.2 per cent in 1908 and to 5.5 per cent in 1911, before some sources of error in the Smithsonian scale had been corrected. In 1914 I pointed out and investigated the existence of a small source of error of about 1.5 per cent in the Ångström compensation pyrheliometer and this result was later confirmed through an investigation by MARTEN. However, if this correction was applied, there remained nevertheless a difference between the two scales of between 2.5 and 3.5 per cent. There were strong reasons for believing this

difference not to be constant but varying with the degree of turbidity of the atmosphere and consequently also with the height above sea level, and possibly also with other factors not clearly known at that time.

For all questions concerning comparisons of actinometric measurements, touching as they do upon the possible variability of the sun and upon the possible existence of long period fluctuations in solar radiation, it seemed of fundamental importance

(1) to establish, through experiments and field measurements the real difference between the two prevailing scales, and its dependence on various meteorological factors,

(2) to establish, on the basis of a study of the errors adhering to the present scales, a true pyrheliometric scale.

This fundamental investigation falling within the field of activity given to both Commissions, it was regarded appropriate that a very close collaboration between them was established. Since 1930 the two Commissions have in fact functioned very nearly as a joint Commission of the International Meteorological Organization and of the International Association of Meteorology, this being promoted through the arrangement that practically all members of the one Commission were also members or were elected members of the other one.

The work on the pyrheliometric standard scale was thus carried on in common by both Commissions and it was to a considerable extent promoted by grants from the I.U.G.G.

A subcommission "pour la pyrhéliométrie absolue" was instituted in Frankfurt a.M. in 1932 by the IMO Commission with Professor Süring as president and Messrs Abbot, Ångström, K. Fuessner, O. Hoelper, W. Mörikofer and F. F. Volochine as members, Mörikofer being secretary. A meeting of this subcommission was held in Potsdam in February 1935. The Minutes from this meeting, at which much of the subsequent work was organized, is given as an appendix to the Minutes of the meeting of the two Radiation Commissions at Oxford 1936, where a number of rather important reports on standard pyrheliometry were given by Süring, Mörikofer and by Guild of the National Physical Laboratory, London.

The results reached at the time of the outbreak of the war were not final, but they were, as far as they had gone, highly instructive as regards the problem in view. On the basis of the results at present available, we may give the following table as

regards the relative values of the two scales, the Ångström scale being put equal to 100 %

Ångström (uncorrected).....	100.0 %
„ corrected for edge effect, according to Ångström and Marten	101.3 %
Smithsonian Scale 1913	103.5 %
Solar Radiation Commissions 1936	101.0 % ¹
Guild, Physical Laboratory 1934	101.3 %
Abbot (Smithsonian scale 1934)	101.2 %

The results of the Radiation Commissions, of Guild and of Abbot consequently agree within 0.3 per cent. The mean value 101.2 agrees further within 0.1 per cent with the value of the Ångström scale, corrected with 1.3 per cent for the edge effect pointed out by myself. The common Ångström scale generally in use, which is not corrected for the edge effect, is according to these results 1.2 per cent too low, the Smithsonian Scale of 1913, 2.3 per cent too high. It may be added that the results of the Astrophysical Observatory of the Smithsonian Institution are still, for the purpose of continuity evidently given in the scale of 1913.

It must here be emphasized, however, that these results as far as Ångström pyrheliometers and Silverdisc pyrheliometers (Smithsonian scale) are concerned refer mainly to mean values obtained at low level stations.² As the readings of the two types of pyrheliometers are to different extent influenced by the diffuse sky light entering on the side of the sun within the opening angle of the pyrheliometer, the difference between the two scales, as represented by the pyrheliometers in actual use, are to a certain degree dependent upon the state of the sky. Thus Mörikofer has found a difference between the readings of Ångström and Silver disc instruments amounting to 5—6 per cent at high level stations, at about 1,600 m above sea level. At very clear sky the difference is consequently larger than at more hazy sky and it will probably be possible to express the difference as a function of air mass and turbidity.

Further investigations have shown that unless certain precautions are taken some minor sources of error are liable to affect as well the reading of the Ångström pyrheliometers as the Silverdiscs. Dr Curvoisier at the observatory of Davos is now, with a grant from the Swedish National Board of

Scientific Research, occupied with a detailed study of this matter. His investigations, which to large extent have been planned in collaboration with the president and secretary of the Radiation Commission, are now devoted to the purpose of building a *permanent standard pyrheliometer* founded on the principle of electric compensation, with avoidance of sources of error adhering to older types. He proposes also, on the basis of researches already to large extent carried out, an accurate determination of all secondary effects, such as convection, reflection power of black surfaces, etc., which arise in the measuring device.

On the side of these studies, the Radiation Commission was rather early brought to investigate the question of the *turbidity* of the atmosphere. The matter was brought before the Commission through several reports and papers especially by Linke and Ångström, later by Hoelper, Kimball and Götz. The Commission stimulated these works through special meetings and discussions. The clear definitions of the “Trübungsfaktor” of Linke and of the “turbidity coefficient” of Ångström have been of value for illuminating the turbidity conditions of various air masses at different altitudes and latitudes, and comparative studies of the conditions of turbidity at different parts of the world have been made possible.

Another question taken up by the Commission refers to the standardization of glass filters used in actinometric measurements for studying different parts of the spectrum. The Commission promoted the introduction of certain standard types, stimulated exact measurements and information concerning their transmission, through the Meteorological institute at Potsdam it arranged to keep in store considerable blocks of glass of certain given properties for use in glass filters delivered on demand. This work was interrupted and seems partly to be in disorder after the war.

The Commission has promoted the work on an international bibliography on actinometry. This task was as a consequence of a resolution carried at the meeting at Stockholm in 1930 and was undertaken by M. Volochine. The work has been supported through several grants from the Union. The bibliographical cards at present distributed cover the time 1900—1929 (without abstracts) and 1930—35 (with abstracts). As several meteorological and geophysical journals now have the publishing of abstracts on their program, a continuation of this work by the Commission seems scarcely to be justified.

¹ 2.2 per cent lower than Smithsonian scale.

² A special report on the Davos's studies on standard pyrheliometry will be given by Dr W. MÖRIKOFER. See especially Mörikofer 1939, pp. 4056—57.

As a consequence of an application (1936) of the Radiation Commission to the President of the Association of Oceanography, a small grant was given to a subcommission of the "Conseil permanent pour l'Exploration de la Mer" to carry out investigations of methods for submarine light-measurements and of the best methods for standardization of instruments involved. The work was carried out in intimate collaboration with representatives of the Radiation Commission and the results are published in a couple of papers by Johnson and Olsson,¹ in which methods for calibration and use of photoelectric cells for the said purpose are described.

As may be seen from the survey given above the activity of the Radiation Commission has been concentrated on problems of a fundamental nature, namely *standardization and development of instruments and methods*. The rather unsatisfactory state of conditions prevailing concerning instruments and methods in the field of radiation, and the necessity to bring about an improvement in this regard, has formed a justification for treating more superficially such questions as the organization of a net work of actinometric stations and promoting measurements at high levels and measurements in the ultraviolet. Before such measurements are organized in large scale, it seems necessary to require that the instruments and methods used must give results which are strictly comparable. To furnish a more solid basis in that respect has been the chief aim of the Commission.

Having thus given a summary of the work of the Solar Radiation Commission in the past, I finally propose to express in a few words my opinion concerning the development in the future.

It seems evident that the work now in progress for the purposes of establishing a standard pyrheliometric scale and creating real standard instruments which can be kept at one or more observatories or institutes as normals, that this work must be continued and pursued vigorously through international cooperation. Some kind of permanent supervision and guidance with regard to the matter of instruments and methods in the field of radiation is also necessary.

The entire question has to some extent come in a new position through a recent action by the International Meteorological Organization. At the meeting in London 1946, the first after the end of

the war, the IMO Conference of Directors took up the question of reorganizing the body, especially with regard to its commissions. In London the Solar Radiation Commission was, together with a number of scientific commissions, not reestablished. Some of the duties of the old Solar Radiation Commission were instead laid upon a new Commission on Actinometry instituted in Toronto with myself as president, as a subcommission under the *Commission for Instruments and Methods*, which already had been established in London.

The instructions given by the Head commission included for the Subcommission on Actinometry the following duties:

- (a) To recommend the most suitable equipment for measurements of solar and atmospheric radiation at meteorological stations.
- (b) To insure that radiation measurements in different countries be made on a uniform and immediately comparable basis by arranging for the establishment of international standard scales and for inter-comparison of sub-standards.
- (c) A continued investigation in order to establish pyrheliometric standard scales and investigations of errors adhering to radiation instruments in current use.
- (d) An investigation of the sensitivity of different sunshine recorders in current use. It is desirable that standard colorimetric specifications for the cards used with the Campbell-Stokes Sunshine Recorder be introduced.
- (e) To prepare a terminological list on various names entering into work on radiation, especially as regards instruments.
- (f) To prepare instruction for the use and standardization of radiation instruments in current use.
- (g) To make recommendations, in collaboration with the Climatological Commission, on questions of time, observations, and form of publication concerning data on radiation.

For my part I consider the step taken by the IMO to mean a development toward a clearer and more effective organization, *provided* that some of the duties of the old Solar Radiation Commission which are not covered by the Commission on Actinometry are cared for by some other international body. Such a body exists already in the International Union for Geodesy and Geophysics. Through the establishment of the Radiation Commission of its Meteorological Association, an international body

¹ Johnson and Olsson (see appended list of Minutes and Reports). The result of this research have been of great use, especially during the Albatross expedition under the direction of Prof. Hans Pettersson.

is already in existence with principal duty to cover the scientific field of the problems of radiation.

The action taken by the International Meteorological Organization invites to a clear separation between the more technical side covering instruments and methods within actinometry and the more scientific one, dealing with the scientific problems and their solution.

For the technical part the Commission on Actinometry is the right forum. It ought to concentrate especially on instruments and methods which are suitable for stations within the meteorological network.

The more scientific part falls very naturally under the Meteorological Association of the I.U.G.G., the work of which according to its instruction "should primarily lie in the discussion of scientific subjects". (See Resolution IV of the Meteorological Section at its meeting in Stockholm 1930.)

The scientific problems with which the commission of the Union has to deal cover at present a rather wide field of research. Investigations of the variations of the solar constant in various parts of the solar spectre, studies

of the ultraviolet radiation and its variation with various factors, high altitude investigations of outgoing and incoming radiation, the ozon layer and its influence on the radiation balance, may be especially mentioned here. It seems clear, however, that the work of the commission of the Union for promoting the study of these and related questions must consist chiefly in a stimulation of interest through discussion and addresses and through personal contacts, than through an organization and administration involving the introduction of routine methods.

It is evident to my mind that great precaution must be taken in the attempts to obtain general acceptance of routine methods and standard instruments in fields where the scientific basis must still be worked out. In cases where the scientist himself, occupied with the solution of a scientific problem asks for help through international administration, such a help ought certainly be given after due consideration, but the desires to organize ought not to press themselves upon the scientific activity.

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 2. Procès-verbaux (de la même section) Troisième Ass. Gen. à Prague — Septembre 1927, Rome 1928.
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 5. Report of the President of the International Commission for Solar Radiation, Meeting at Copenhagen, 1929, Utrecht 1930.
 6. Protokolle der Sitzungen der Internationalen Strahlungskommission in Frankfurt a/M — September 1932, Leyde 1933.
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- In the following list the reports are marked with letters, which refer to the meetings at which the report was presented, and in the Minutes of which the report consequently is printed. The letters (M), (P), (S), (L) and (E) indicate thus that the report is printed in the minutes of the Meteorological Association of the International Union for Geodesy and Geophysics from Madrid (M), Prag (P), Stockholm (S), Lisboa (L) and Edinburgh (E), the letters (C), (F) and (O), that the report is printed in the Minutes of the Solar Radiation Commission of the International Meteorological Organization from Copenhagen (C), Frankfurt (F) and Oxford (O).
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