Some Results From The Polish Solar Radiation Expedition to Siam and Java. (March-August, 1923)

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The principal task of this scientific expedition was to make—between Europe and the Equator—investigations of the intensity of solar radiation after it had passed through the atmosphere to the surface of the earth. These intensities are little known outside the continents of America and Europe. Up to the present time they have been but little investigated either in the hot zones or at sea, and especially on equatorial seas.

The Polish Expedition to Siam and adjacent equatorial regions, undertaken under the auspices of the Central Meteorological Institute at Warsaw, has succeeded not only in making numerous measurements, but also in ascertaining certain new facts. One of the most important results of this—as far as we know—first actinometric sea voyage to the equatorial regions, is the establishment of a gradual decrease of intensity within the red part of the solar spectrum in proportion to the total solar radiation intensity. The proof that this decrease of intensity exists in agreement with the observations made between Antwerp and Siam, is furnished by the observations obtained on the return voyage from Java to Marseilles.

In the accomplishment of the task of studying the solar radiation in the above-mentioned regions, I owe a particularly great debt of gratitude for efficient help and kindness to the different Royal Siamese Central Offices in Bangkok. My great thanks are due also to the Danish East Asiatic Company in Copenhagen and its Agencies in Siam, Singapore and Penang.

I

The scientific equipment of the Polish Expedition consisted of:

(a) 2 bimetallic actinometers, Michelson type, with coloured light-filters.

(b) 1 large support with Cardan's suspension and counter-weight; further, 1 small sea support, especially constructed for actinometric measurements at sea.

(c) 1 apparatus for nocturnal radiation (Angstrom "tulipan").

(d) A full set of instruments for meteorological observations, namely: 1 small thermometer screen, 2 psychrometers with Assman's aspiration, 1 hygrometer, 1 mill-anemometer of Richard's type, and pluviometers.

(e) Self-registering instruments,: barograph, thermograph, hygrograph.

The main result of the observational work was founded on constant measurements of the solar radiation intensity, other observations having rather an auxiliary character. In so far as the sky continued sufficiently clear, our work lasted from sunrise to sunset, sometimes without being discontinued. This was effected by the collaboration of the two observers, especially on board M. S. Jutlandia, where, with the assistance of Professor Sawicki, my companion during the voyage from Antwerp to Siam, the actinometer was in constant use without the least interruption all the day long. With the exception of this period of 6½ weeks, during which I could avail myself of Prof. Sawicki's aid, I was obliged during the remaining time to allow short interruptions. Sometimes this all-day work in the sun's heat was particularly trying. Especially was this the case in connection with measurements made on the return trip across the Red and Mediterranean Seas, from July 27 to August 11, 1923, as the sky remained almost constantly clear and the work lasted from 5 a. m. till even 7 p. m. Moreover an exceptional heat, reaching 40° Cent. was then prevailing on the Mediterranean Sea and in Southern Europe. After the nearly uniform air temperatures on the Indian Ocean, where there was no conspicuous divergence from 28° C., the highest temperatures during the whole expedition of 6 months were observed in the South of Europe.

The number of actinometric measurements executed during the whole voyage from March to August 1923 inclusive is summarized below:—

	March	April	May	June	July	August
Days of Observations	26	14	19	13	13	15
Total number of Measurements	13969	3455	6396	3506	2461	5718
Total measurements, with filters	4035	836	1815	301	561	1659

There were altogether 100 observing days, during which 35,505 measurements of the total solar radiation intensity were made, and in connection with these there were 9,907 measurements of the partial intensity through light-filters.

These numbers take no account of Prof. Sawicki's supplementary series on his return voyage; together with these the total number of measurements executed during the Polish Actinometric Expedition in 1923 will exceed 42,000.

The circumstance that I had but 100 observing days in the course of six months of the expedition is to be explained not only by a certain number of cloudy days, but also by the fact that it was difficult to make actinometric measurements while lying in the various seaports, during journeys by land, or on mountain trips. Generally the observations were made from sunrise to sunset, if possible without interruption. The number of such days, 31 in all, are enumerated below.

Summary of days with number of daily measurements above 500:

1923	March	April	May	June	July	August
Days	17	2	5	1	1	5

The following statement shows the number of days in seaports and on land journeys:

Departure from Warsaw February 28, 1923, to the harbour of Antwerp.

(A) Voyage on board "Jutlandia" (M. S. of East Asiatic Co. in Copenhagen) from Antwerp to Bangkok (Siam) March 4 to April 17 (45 days). Sea distance about 16,000 Km. with the partial voyages: Antwerp to Port Said, Port Said to Singapore, Singapore to Island Kohsichang to Bangkok.

(B) Stay in Siam (Bangkok) April 18 to June 1 (45 days).

(C) Voyages Bangkok-Singapore (S. S. "Tranquebar"), Singapore-Batavia (S. S. "Giang-Seng"), Batavia-Singapore (S. S. "Prinsess Juliana"), and stay in Batavia with excursion to the peak of Mount Pangerango (3 km. above the sea).

(D) Journey by land through British India and Ceylon, July 5 to July 15 (11 days) with the following route:

French harbour, Pondichéry, stop at the Solar Observatory in Kodaikanal (South India), Madura-town, crossing via Danushkodi to Ceylon, Kandy-Mountains (Ceylon) and stop at the Meteorological Observatory in Colombo.

(E) Return voyage on board M. S. "Falstria" from Singapore (June 26) via Penang, Pondichéry, Colombo, Suez, Port Said, Marseilles (August 12), from there by land via Montpellier (measurements at the "Station Météorologique Agricole"), Le Vigan, Paris (Parc St. Maur Observatory) to Warsaw (August 28, 1923.)

A total of about 36,500 km. was traversed, of which only 4,000 km. were by land.

II.

Concerning the results of the Polish Actinometric Expedition, it should be mentioned first of all that it is not yet possible to elaborate the vast material (over 40,000 measurements) collected during the voyage of six months (March-August, 1923) on account of the short time that has elapsed since the conclusion of the journey.

The principal questions considered in the course of the Polish Expedition are the following:

(a) Studies to determine if the intensity of solar radiation in the successive parts of the spectrum, measured after passing through the atmosphere, differs in the progressive geographical latitudes between Europe and the equator, and to what degree.

By using special coloured-glass filters (red, green and violet) a new fact was discovered and established, namely, that the intensity of the red part of the solar spectrum gradually decreased from Europe toward the equator (vide Table attached).

(b) Monthly and diurnal variations of the solar radiation intensity, both as to the total, and also the intensities in the different parts of the spectrum.

TABLE.

Progressive decrease to the Equator of the intensity in the red and infra-red part of the solar spectrum in relation to the total solar radiation intensity.

Date 1923	At noon: Zenith Distance of the Sun	At noon: Air Temp. Cent.	11–13 hours: Total Intensity (Maximum value)		11–13 hours: % of the intensity in red and infra-red		Remarks (Ship's position)
A) On board M/S "Jutlandia", motor-ship of the Danish East-Asiatic Co.							
March 8	43°	16°	1.39		64		Atlantic Ocean (38°N)
,, 13	39°	15°	1.39		64		Mediterranean Sea
,, 18	30°	21°	1.22	decrease	61	Equator	Suez Canal
,, 20	22°	28°	1.24		60		Red Sea (22°N)
,, 28	6°	31°	1.36		58		Indian Ocean (10°N)
B) Actinometric measurements in Siam.							
Mai 5	2°	32°	1.15	De-	58	to	City of Bangkok (14°N)
,, 21	6°	33°	1.22		56		
C) Mount Pangerango (Java). Height 3,023, metres.							
June 15/17	30°	14°	1.6		55		Latitude 6° 45′ South
D) On board M/S "Falstria" (Danish East-Asiatic Co.)							
July 22	16°	29°	1.20		58		Indian Ocean (4°N)
August 1	3°	32°	1.17	crease	60	Europe	Red Sea (22°N)
,, 9	22°	28°	1.28		63		Mediterranean Sea
E) Continent of Europe.							
August 13	39°	34°	1.30	In-	64	to	Montpellier (France)
Septem. 17	50°	22°	1.17		67		Warsaw (Poland)

Note. The maximum values of the total solar radiation intensity are given in gramm-calories per cm^2 and minute. The percentages of the intensity in the red and infra-red part of the solar spectrum are obtained with a red-glass filter.

Although it is generally known that the sun appears more red in proportion as it approaches the horizon, yet these variations have not been quantitatively established till now, especially on the vast territories from Europe across the equator to the island of Java. The studies of the character of the monthly variations have led to the conclusion that, whilst in Europe the amount of water vapour exerts the predominating influence upon the annual course of the solar radiation intensity, on the contrary in the equatorial region it is the transparency of the earth's atmosphere as modified by the dry and rainy seasons that has the controlling influence.

The greatest intensity of the solar radiation, in the equatorial regions, which occurs during the rainy season, is generally less than during the summer in Europe.

We do not undertake to refer to all the scientific results of the Polish Expedition, but we would remark that up to the present time only the question of the decrease of the intensity in the red part of the solar spectrum, observed through the earth's atmosphere, has been briefly discussed in a short "Report" in the Polish language, published in the "Bulletin No. 9/10, 1923 of the Meteorological Institute at Warsaw, and also in Paris in "Comptes Rendus de l'Académie des Sciences" (October, 1923). Returning to the above mentioned Table 1, we call special attention to the fact that between Europe and the equator there exists a gradual decrease in the intensity of red rays in relation to the total intensity of the solar radiation. This decrease, which depends in the first place upon the amount of water vapour in the earth's atmosphere, is to be explained partially also by the increase of the zenith distances of the sun with latitude. Here the analogy may be found in the "reddening" of the sunlight as the sun approaches the horizon.

Remembering that in the warmer part of the year the intensity of the total solar radiation is usually stronger in Europe (or generally in the middle latitudes) than at the equator, we easily arrive at the conclusion that an explanation of the different actions and effects of sunlight in the temperate and hot zones ought to be sought not in the total intensity, but rather in a different kind of

distribution of the solar energy in the different parts of the spectrum when observed at the earth's surface.

This deficit of "reddening" (united with a certain surplus of violet) in the inter-tropical zone can of itself explain many facts concerning the acclimatization of human bodies, of animal and vegetable life, and likewise many facts concerning the insufficiently studied question of the sensible temperatures, and the comfort of the races in connection with the climate.

Although the discovery of the fact of the decrease towards the equator of the solar radiation intensity in the red and infra-red part of the spectrum does not admit of any doubt, we cannot consider further researches in this direction as unnecessary. On the contrary further investigations of this question, so important from the scientific and practical standpoint, are not only advisable but should not be delayed. The study of these conditions over a single narrow belt on our globe is insufficient, and all the most characteristic regions of the earth should be investigated. In the first instance expeditions are necessary to desert regions (Sahara mountains and some hills in proximity to the Suez-Canal), to equatorial mountains (especially South-India and Java), to the South American mountains, to small islands in mid-ocean, and finally to suitable places in the circumpolar regions.

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