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THE FIELD PERFORMANCE OF TEN BELLANI RADIATION INTEGRATORS

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by

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THE FIELD PERFORMANCE OF TEN BELLANI RADIATION INTEGRATORS[1/]

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ABSTRACT

The field performance of ten Bellani radiation integrators (pyranometers) was determined during 47 days in the spring and summer of 1962. The model tested was the Davos Observatory Model which has a spherical, metal-coated glass radiation receiver, a distillation system with ~~high~~ VERY LOW residual air pressure, and uses alcohol as a liquid. Since the instrument is not mass-produced, the alcohol content varies slightly from one instrument to another. So, each is individually calibrated by the manufacturer. One of the ten instruments compared was used as a standard. It was found that, after one year of use, the daily response of all ten pyranometers to changing meteorological conditions was essentially the same.

INTRODUCTION

The Bellani-type radiation integrator is considered by some workers (Shaw and McComb 1959, Vézina 1961, MacHattie 1961) as a useful and reliable instrument in forest research for measuring total solar radiation. As pointed out by MacHattie (1961), the Bellani pyranometer has many advantages. It is simple, easy to operate, and easily transported. It is relatively inexpensive, and independent of electric power. Moreover, it has no appreciable radiation threshold. However, it is highly dependent on wind and ambient temperature. Consequently, careful installation is essential, and corrections of readings for ambient temperature are needed. Since the radiation receiver is a sphere, the instrument, when used in the forest, measures not only the downward flux of short wave radiation but also the upward flux reflected from the forest floor

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and low vegetation. So the location of instruments in the field must be made carefully in order to obtain radiation values representative of the conditions encountered.

The instrument is not altogether new. It was first described in 1836 and early models have been in use mainly in France and Italy since that time. Some of the first scientific reports appeared in the late 1920's in La Météorologie and Revue des Eaux et Forêts. In the forestry studies reported by the latter journal, however, integrators were located according to the best judgment of the forester. It was this feature of these studies that brought them under criticism in later years. Moreover, the accuracy of the early models was not sufficient and their performance and calibration had been questioned by many scientists. In the recent years, however, a number of improved models of radiation integrators have been developed and manufactured. One of these, the Davos Observatory Model, has been used in forest research by the writer since 1957. Reports on this model were given by Courvoisier and Wierzejewski (1954), Vézina (1961), and MacHattie (1961). Considerable improvement both in design and in manufacturing have resulted in a greater accuracy and a better sensitivity of the Bellani pyranometer. Courvoisier and Wierzejewski (1954), in their description of the instrument, stated that the sensitivity of the Davos Observatory Model may be taken as unchanged for 20 years. This is, however, more a tentative indication based on the results of artificial ageing of some instruments by means of an intensive ultraviolet light source (quartz lamp) than an actual finding. In fact, according to Dr. Mörikofer[3/], no experience has yet been gained with the durability of this new model of Bellani, because it has been in use only for ten years. A break in the glass of the receiver may cause at any time a decrease in the vacuum between the spheres, or the metal-glass contact of the receiver may deteriorate (Pereira 1959) after some years of field use.

[3/] Personal communication, August 22, 1962.

The object of the test reported here was to learn how ten Bellani radiation integrators which had been in use for one year under different forest conditions would compare with each other when exposed under identical conditions.

MATERIALS AND METHODS

The daily total solar radiation measured by ten Bellani pyranometers was compared during 47 days in the spring and summer of 1962. The pyranometers used in the test had been manufactured and calibrated as shown in Table 1. All the instruments were mounted roughly 5.5 feet above the ground in an open field at the Valcartier Forest Experiment Station near Quebec City (Figure 1). The amount of alcohol distilled was normally read daily at 8:00 a.m., and the instruments were then reset. Occasionally, on very clear days, another reading and reset were done at or close to noon. After correcting for ambient temperature, the daily amounts of distilled liquid, in cubic centimeters, were then converted, by means of the individual calibration curves, into gram calories per square centimeter (langleys).

RESULTS AND DISCUSSION

The daily totals of radiation integrated by all ten pyranometers were very similar (Tables 2, 3, 4). The data in Table 2 show that the differences between instruments, under various cloudiness conditions and for all days as well, were slight. Moreover, there was no differential response to varying meteorological conditions for the various instruments. No significant differences have been found between the correlation coefficients presented in Table 3. Table 4, comparing the daily solar radiation integrated by the various pyranometers over a 47-day period substantiates this fact. The data show that the differences between the responses of the "standard" and any other Bellani never reach the level of significance.

Throughout the test instruments No. 60 594 and 60 595 integrated 2.1 per cent more radiation than the standard ones (Table 2). This greater

response is observed for every cloudiness condition. Despite the fact that a slightly greater response was given consistently by the two instruments, as compared to the standard, their daily response to changing weather conditions is very close (Table 3). As stated above, Table 4, besides, shows no significant difference between the response of any of these instruments and that of the standard.

CONCLUSION AND SUMMARY

The daily response of ten Bellani radiation integrators was compared over a period of 47 days during the spring and summer of 1962. The relative solar radiation registered by all ten instruments under different weather conditions was very similar. Correlation of any instrument with a "standard" one was highly significant, $r > .992$ (P. 01 = .372). It is therefore concluded that the daily response of all ten instruments tested to changing meteorological conditions is essentially the same.

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Figure 1.- Bellani radiation integrators under comparison.

TABLE 1. Instrument number, and dates of manufacturing and calibration of the ten Bellani spherical pyranometers under test.

Instrument Number	Dates of Manufacturing	Dates of Calibration 1/
60 592	March 1960	June 1960
60 593	" "	" "
60 594	" "	" "
60 595	" "	" "
61 596	April 1960	July 1960
61 597	May 1960	" "
61 598	" "	August 1960
61 599	" "	July 1960
61 600	" "	August 1960
61 601		" "

1/ All these calibrations were made at the Davos Observatory by means of a standard spherical pyranometer which had been calibrated itself in absolute units.

TABLE 2. Relative solar radiation from various integrators under different weather conditions.

Radiation Integrator Number	All Days (47) 2/	Sunny Days 3/ (10)	Partly Cloudy Days (18)	Overcast Days (19)
61 600 4/	100.0	100.0	100.0	100.0
61 601	101.1	101.2	101.1	101.0
60 592	100.6	101.0	100.2	100.5
60 593	100.7	100.4	101.2	100.7
60 594	102.1	102.3	101.7	102.2
60 595	102.1	102.0	102.3	102.1
61 596	100.5	100.5	100.2	100.6
61 597	101.5	101.4	101.6	101.6
61 598	100.2	99.9	100.4	100.2
61 599	101.2	101.4	101.8	100.8

2/ Number of days compared.

3/ Sunny, partly cloudy, and overcast days with 0-2/10, 3-7/10, and 8-10/10 cloudiness, respectively. Cloudiness averaged 5 tenths for the partly cloudy days.

4/ The "Standard".

TABLE 3. Correlation coefficients between daily solar radiation from various Bellani pyranometers

Instruments correlated	Correlation coefficient[5]
61 600 - 61 601	0.999
61 600 - 60 592	0.992
61 600 - 60 593	0.994
61 600 - 60 594	0.993
61 600 - 60 595	0.994
61 600 - 61 596	0.992
61 600 - 61 597	0.994
61 600 - 61 598	0.997
61 600 - 61 599	0.993

[5] Number of days n = 47; 1% sig. = 0.372

TABLE 4. Comparison of daily solar radiation measured by various pyranometers over a 47-day period, between April 25 and July 4, 1962[6]

Instruments compared	Value of "t"[7]
61 600 - 61 601	0.109
61 600 - 60 592	0.057
61 600 - 60 593	0.066
61 600 - 60 594	0.210
61 600 - 60 595	0.206
61 600 - 61 596	0.010
61 600 - 61 597	0.152
61 600 - 61 598	0.017
61 600 - 61 599	0.116

[6] With an interruption from June 4 to 19. Saturdays and Sundays and statutory holidays excluded.

[7] P.05 = 1.99; P.01 = 2.64.