A Macro and Meso Scale Analysis of Sunshine Climates in Central Indiana

T. Stevens[1]
Department of Geography and Geology
Indiana State University, Terre Haute, Indiana 47809

Abstract

The study analyzed variation in the amount of solar radiation received in and near the cities of Indianapolis and Terre Haute, Indiana. Four 7-day recording Pyrheliometers were used to test the hypothesis that a high degree of correlation exists between the sunshine climates of Indianapolis and Terre Haute, Indiana. The area under the ink tracings on the weekly instrument charts was cut and weighed on an analytical balance. The resultant weights for each day's chart were recorded and were correlated with each other. The resultant correlation Matrix showed that for these four locations, during the 90-day test period, there was a high degree of correlation between all of the paired variables.

Introduction

The maximum amount of sunshine that can be recorded at a given location on a given day is determined by the latitude of the site and the date. In mid-latitudes, the actual number of hours of sunshine received and the total amount of radiation received is usually somewhat less than the maximum clear day amount available. In addition, because of various meteorological conditions, several stations situated along the same parallel of latitude can record different amounts of solar radiation on any given day or series of days. These differences are attributable to variations in the amount of cloud cover, water vapor, dust, and other solid and gaseous particulate matter present in the atmosphere (1).

Incoming solar radiation is measured and recorded daily by the National Weather Service at 104 locations throughout the continental United States (3). In Indiana it is recorded only at the Weir Cook International Airport, located southwest of Indianapolis. Indiana scientists needing solar radiation information must either use the data recorded at Indianapolis and assume that it is similar to the sunshine climate at their location or collect data themselves and relate them with the officially recorded data.

This study compared the solar radiation climates of Indianapolis and Terre Haute, Indiana, a city located some 70 miles west by southwest of Weir Cook Airport (the geographic coordinants are 39° 44′N, 86°16′W, and 39°28′N, 86°24′W, respectively).

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[1] Present address: Department of Geography, State University College, Brockport, N.Y. 14420.

Method

It was hypothesized that the solar radiation climates of Indianapolis, Indiana, and Terre Haute, Indiana, are similar. Simple correlation techniques and Students' "t" test were used to test this hypothesis. To this end, 7-day recording pyrheliometers (Belfort Instrument Company) were installed at the following locations:

1) Near the sensor for the integrating Eppley pyranometer, used by the National Weather Service at the Weir Cook Airport, Indianapolis, Indiana;

2) Four miles east of the Indiana State University Science Building, Terre Haute, Indiana;

3) Three miles west of the Indiana State University campus (sites 2 and 3 are 1/10 of the distance separating the two main recorders);

4) Seven miles south of the Weir Cook Airport, in the center of the Greenhouse Tomato Producing District of that city.

All four of the instruments were operated and were calibrated with the National Weather Service instrument before and after the recording period and were found to be accurate to within 0.1 cal/cm^{2}min or 0.1 Langley. All four recorders were located so that the sensors were not shaded at any time from sunrise to sunset. The study encompassed a 12-week period (February 1 through April 30, 1971). The total amount of radiation received at each site was represented by the area under the curve on the recording graph paper.

The weekly charts were projected (enlarged) onto high-quality, 8 1/2″ x 11″ bond paper; and the area under each curve was traced and cut out with a razor blade. Curves for clear days and overcast days were easily traced. Curves for partially cloudy days were almost impossible to trace and were, therefore, excluded from this analysis. Fourteen "cut-outs" representing the total amount of solar radiation received on seven clear days and on seven overcast days were then weighed on a direct-reading analytical balance.

Results

The weight of each day's cut-out for each location is shown in Table 1. The simple correlation coefficients for each pair of variables, for clear days and for overcast days, are shown in Matrix format in Table 2. The Students' "t" test indicates that all coefficients were significant at the 0.05 level on overcast days and at least at the .001 level on clear days.

TABLE 1. *Areal variation in solar radiation receipts during clear and cloudy days.*

Month	Date	Radiation Equivalent (μg) Indianapolis Airport	Indianapolis South	Terre Haute East	Terre Haute West	Radiation[1]	Sky Cover
Feb.	7	23	15	20	20	106	Cloudy
	12	9	6	7	6	41	Cloudy
	20	11	6	7	11	46	Cloudy
	26	18	11	11	12	92	Cloudy
	27	63	64	59	59	417	Clear
	28	67	63	62	67	442	Clear
Mar.	6	12	10	11	11	45	Cloudy
	19	13	9	7	8	48	Cloudy
Apr.	3	87	87	84	86	595	Clear
	5	22	25	33	34	139	Cloudy
	7	87	85	82	83	572	Clear
	8	87	92	88	88	595	Clear
	10	82	81	87	79	592	Clear
	11	91	90	86	84	613	Clear

[1]Radiation totals are in Langleys as measured and recorded by the integrating Eppely pyranometer. These data were obtained from the daily log book maintained by the National Weather Service at the Weir Cook Airport (2).

TABLE 2. *Cloudy and clear day correlation matrix.*

	Indianapolis Airport	Indianapolis South	Terre Haute East	Terre Haute West	Langleys
Airport	1.00000 (1.00000[1])	0.83576 (0.97374)	0.82334 (0.95162)	0.81333 (0.96826)	0.94130 (0.97688)
South		1.00000 (1.00000)	0.98402 (0.95310)	0.97003 (0.96309)	0.92720 (0.95937)
Terre Haute			1.00000 (1.00000)	0.98671 (0.94755)	0.92221 (0.95587)
West Terre Haute				1.00000 (1.00000)	0.91747 (0.95587)
Langleys					1.00000 (1.00000)

[1]Data for clear days is in parenthesis below.

Discussion

There was a high degree of correlation between all paired variables and especially between the weight of the paper representing the amount of radiation recorded at the airport by the mechanical pyrheliometer and the total amount of radiation (in Langleys), as recorded by the National Weather Service's source instrument. There was little variation between any of the recorded values, although the derived correlation coefficients for the clear days were somewhat larger in value than were the derived coefficients for cloudy days. A possible cause for this variation exists in the macro and meso scale areal variation in the amount

of radiation received on any cloudy day due to variable cloud thickness and density at any given time at any two places. On clear days and on overcast days the stated hypothesis is true. On overcast days, however, the amount of variation at the macro scale was sometimes greater than the variation at the meso scale.

Literature Cited

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