the McGill University climatology programme in Barbados

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Abstract

The McGill University climate program in Barbados began in 1968 within the framework of land-use studies. From 1958 to 1966, emphasis was placed on maintaining a standard observation station to provide a base for work in agrometeorology. Since 1966 the program has been re-organized to develop energy balance studies at four sites on the island with a view to contributing fundamental knowledge of the role of the surface in the microclimates of the Caribbean region.

Introduction

McGill University's systematic program of scientific work in Barbados can be said to have started in 1954 when the Bellairs Research Institute for Marine Biology (Fig. 1) was founded following the donation of a house and ten acres of land to the University under the will of Commander C. W. Bellairs, R.N. Since then the Institute has expanded somewhat beyond its original conception to become a center for numerous aspects of the environmental sciences, while activities such as the High Altitude Research Project (HARP) and work on wind and solar energy through the Brace Engineering Research Institute have further extended the scientific studies on the island directly connected with McGill University. The Department of Geography at McGill has been actively associated with this work. Through the energy and initiative of Prof. T. L. Hills in particular, a number of studies into land use and agriculture were made and it was within the framework of these that the climatological program was started. It began in 1958 using an experimental site on five acres of land leased for 50 years from the Barbados Government at a peppercorn rent. This site is at Waterford, on the north-east outskirts of Bridgetown as shown on Fig. 2.

The climate station at Waterford is by no means the first or only observing site on the island. It is, indeed, situated on land of the Codrington Agricultural Station within a mile of the climate post attached to that station, where records of temperature, humidity, rainfall, and sunshine are made, and which has been operated by the Barbados Ministry of Agriculture, Lands, and Fisheries since the beginning of the present century.

Fig. 1. Bellairs Research Institute.

Another relatively long-term station providing standard meteorological records is that at Seawell International Airport. This has been operated by the Barbados Meteorological Service since the end of the Second World War. There are, in addition, some 80 to 100 rainfall stations scattered over the 160 sq mi of the island. These stations are located mainly on sugar plantations, some of them with records dating to the middle of the nineteenth century. In recent years more rainfall, and some climatological, stations have been added through various governmental and other agencies.

The particular contribution of McGill University to a knowledge of Barbados climate may be conveniently considered in two parts: the activities from 1958 to the beginning of 1966, and the work from the latter date onwards.

Activity from 1958 to 1966

The Waterford climatological station was conceived within the framework of studies in agricultural geography. As a result, its instrumentation included not only the standard facilities for measuring temperature, humidity, wind, and rainfall, but also a certain amount of special equipment for measuring evaporation, such as a Class A pan, Thornthwaite-type lysimeters and Bellani black porous plate atmometers. In addition, soil thermometers were installed in both grass-covered and bare-soil plots at 2 inch, 4 inch and 8 inch depths.

Fig. 2. Observing sites and topography on Barbados. Inset map shows relative location of Barbados to South America and the Caribbean.

These parameters were all recorded regularly during this initial period of the site's development and a major contribution of the first seven years of the station's existence has been the collection of these data, including also autographic records of rainfall and temperature. These daily data were published at 4-monthly intervals by the Department of Geography in a series of Climatic Observations from March 1959 to December 1965, and they have recently been used as the basis of a short study of the climate of Barbados (Tout, 1968).¹

Specialized research during this period of the climatological program was mainly devoted to aspects of agricultural climatology. Dr. Ivan Smith who was in

¹ A more detailed presentation within an *Atlas of Barbados* is currently in preparation.

charge of the station from 1958 to 1962, used the facilities as background for a doctoral dissertation entitled "The Climatic Control and Distribution and Cultivation of Sugar Cane" (Smith, 1963). Other studies relating climate and agriculture on the island included one on rainfall variability and its influence on sugar cane yields (Oguntoyinbo, 1964) and two studies in Barbadian climatology dealing with aspects of the island's moisture balance, evapotranspiration, and energy relationships (Rouse and Watts, 1966).

The climatological facilities available during this period also inspired some work on radiation. The most extensive survey of this kind was that made between 1963 and 1965 by D. G. Tout who was in charge of the Waterford Station during these two years. Tout main-

tained a total of eight stations using silicon cells to measure daily totals of global radiation on a horizontal surface and at the same time made use of the facilities of the Brace Engineering Research Institute for more sophisticated measurements with an Eppley pyrlieliometer (Tout, 1967). Another valuable study of these two years was of the albedo of various characteristic surfaces on the island. This survey was made by L. S. Chia, who used both surface and aeroplane measuring techniques for his work (Chia, 1967).

The climatological program since 1966

Early in 1966 it was decided to re-organize the climatological program in Barbados so as to integrate it more closely with the overall climatology program within the Department of Geography at McGill University itself. The latter program is concentrating particularly on microclimatological work, using the three field stations maintained by the Department a) in Barbados, b) at Mont St. Hilaire (25 miles east of Montreal), and c) at Schefferville, Labrador. The essence of the program is to use these sites as laboratories for measuring the interconnections between physical parameters like slope, aspect, soil properties, and vegetation on the one hand, and energy fluxes and prevailing atmospheric circumstances on the other, in an effort to understand not only the pattern of microclimatological characteristics themselves, but also the role of the surface in the total energy and moisture balances under differing atmospheric states in different climatic regions.

A first step in such a program is to examine surface geometry and to measure the radiation and energy balances at selected locations. The latter data may then be related to the former so as to map the topographic variations of these important energy conditions. The program in Barbados will, therefore, concentrate on this work during the immediate future. Surface terrain analyses are already being made, instrumentation at Waterford has been improved for the necessary energy balance measurements, and three new stations are being added for use during a period of intensive observations from July 1968 to October 1969. The three new sites have been chosen so that, in conjunction with the Waterford observations, it will be possible to sample the contrasts between the regions of windward (east) and leeward (west) exposure, and between the coast and the interior. Each site, including Waterford, will consist of level grassed plots so that the albedo of the observation points will be similar, thus providing uniform conditions for comparing radiation and energy budget studies between sites of differing location, aspect, and elevation.

The observation program will be organized so as to provide short periods of intensive observation at selected times to sample the different climatic seasons against a background of continuing routine observations. The detailed measurements and routine observations will be correlated with a view to establishing relationships from which to estimate the energy budget in a tropical island environment from the data of standard climatological

stations and a knowledge of weather systems and terrain conditions.

The various parameters of the heat budget will be measured in standard ways. a) *Net radiation* will be measured by means of battery operated net radiometers. b) *Heat transfer* into the ground will be recorded at Waterford continuously by a battery operated heat flux recording system. A similar instrument will be used for limited periods during special observation periods in succession at the other three sites. At all sites additional soil heat flow plates will be installed and read at hourly intervals during special observation periods by means of a mini-mite potentiometer. c) *Ground temperature* will be recorded by means of distance thermographs using mercury in steel sensors inserted 1 cm below the ground surface. Temperature checks will also be maintained at hourly intervals during special observation periods using soil cell thermistor units read by a soil temperature and moisture meter. d) *Temperature and humidity* profiles will be measured by shielded wet and dry thermistors using battery operated recorders.

In addition to the foregoing special equipment, each station will be equipped with the standard instruments normally used at climatological stations for measuring temperature, humidity, rainfall, wind speed, and evaporation, and each station will have a bi-metallic actinograph. The data from these routine instruments will enable the estimates of the energy budget, which can be made by means of standard formulae and using regularly-recorded meteorological observations, to be tested and modified against the results of the special observation periods.

Value of the current program

Although the specific observation program for 1968-69 described in this article is limited in scope, the results from it are likely to have wide applicability. The preliminary studies already made of Barbados over the past 15 years by scientists working in diverse fields, indicate that a concerted attack on the interface characteristics of this small island of varied slopes, surfaces, and aspects within the moist trade wind air stream, is likely to yield large scientific dividends. The next 18 to 20 months is particularly auspicious for such an attack in view of the Barbados Experiment of Florida State University in 1968 followed by BOMEX in the summer of 1969. The McGill University program of energy budget measurements and terrain analysis during this time will be a contribution not only towards the particular evaluation of the microclimatological pattern on the island, but also towards a better understanding of the interrelationships between physical parameters and different weather conditions. Thus, it will contribute to ways in which the interconnections between the land and the air under different atmospheric states can be generalized so as to understand better the response of different parts of Barbados to the large-scale steady-state attack of trade wind conditions, or to the influx of mesoscale synoptic disturbances, or to contrasting solar energy situations.

At the same time it will be possible to make quantitative assessments of possible contributions by the island's differing surfaces to the promotion, development, or modification of turbulent, cloud, and precipitation effects.

Such results will be widely applicable elsewhere than in Barbados. They will, for example, enable conclusions to be drawn from which to generalize in respect of heated island effects within the tropical trade wind zones the world over. Barbados is not "just an island" in the trade wind zone. It is an island remarkably well placed in relation to one of the world's major oceanic air streams. Possessing sufficient topographic variety to show how contrasting internal conditions in a trade-wind context may interrelate with large-scale and small-scale atmospheric systems, its relief is nevertheless neither so intense nor so variegated as to produce a degree of microclimatological diversity which defies analysis. On the contrary, the island's small size, simple yet strong physiography, and structural orientation across the prevailing wind system combine to provide a unique opportunity for establishing results which may be used widely as a basis for improving knowledge of tropical island/atmosphere relationships, not only elsewhere in the Caribbean, but also in comparable parts of the Pacific and Indian oceans.

Applicability of results in such large-scale terms is matched by their usefulness at a smaller scale. By developing quantitative relationships based on surface character and prevailing atmospheric conditions, the microclimatology of other tropical islands can be estimated without carrying out costly basic research. Such knowledge can be derived by applying the results of the Barbados experiment to other islands in the Caribbean region, and the tropical oceanic environment.

By working with existing topographic maps and air photographs, with weather and climate data sources, and with synoptic charts and satellite photograph coverages, the correlations established for Barbados can be put to work to evaluate conditions in other tropical realms.

In short, the current McGill University climatology program in Barbados seems capable of producing results which could eventually be applied globally. Moreover, and as an added dividend, it will contribute materially to a better understanding of aspects of tropical island climatology important to the economic development of many parts of the underdeveloped world.

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