The Rainy Pentads of Central America

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(Manuscript received 18 October 1971, in revised form 14 January 1972)

ABSTRACT

A rainy pentad is defined as having 25 mm or more rain in five days. The beginning and end of the rainfall of this amount is shown on maps of Central America.

1. Introduction

Central America is an area of complex rainfall patterns. Since precipitation is the most important meteorological element of this tropical region, investigators have devoted much attention to rainfall studies of the area. The complex topography of Central America has a great influence on its rainfall. High mountains and plateaus extend from western Panama northwestward through Costa Rica, Nicaragua, Honduras, El Salvador and Guatemala. On either side of these highlands are coastal plains which generally are narrow on the Pacific side but extend 100 mi or more inland on the Caribbean side.

The prevailing wind is northeasterly over the entire area during the winter, but during the summer some of the area comes under the influence of the Intertropical Confluence Zone. Locally, the wind is modified by land and sea breezes and in some areas by mountain-valley effects. Easterly waves, tropical storms, hurricanes, thunderstorms, *temporals*, and incursions of polar air each cause precipitation, thus adding to the complexity of the rainfall.

Previous investigations have provided information on the rainfall characteristics of most of the individual countries in the area and on the general rainfall patterns of the whole area. None of these studies presents a comprehensive picture of the entire area, from the standpoint of daily rainfall data. These studies are in the form of technical reports or work within the individual country and generally are not available as publications; thus, specific references are not cited.

Daily rainfall data for 124 stations in Central America were available for study. The number of years of records varied from 2 to 20 years, with the accuracy ranging from poor to excellent. Many of the stations are operated by the meteorological services of the individual countries; others are operated by plantation owners and private individuals.

Almost all of the stations in Central America show two rainfall maxima separated by a shallow minimum. The primary minimum occurs at all stations during the period January through May. This minimum is much more distinct on the Pacific side of the isthmus than on the Caribbean side. The beginning, end, and duration of each season vary considerably throughout the area. The purpose of this investigation is to identify the beginning and end of the heavier rains, using 25 mm of rainfall in 5 days as the identifier.

2. Reduction and testing of the data

The daily data for each station were grouped into 5-day totals. This was done by totaling the rainfall amounts for the first five days of the year, then the second five days, continuing throughout the year. No data for 29 February were used. This procedure was followed for each year. Then, for each pentad the mean was determined. The frequency of occurrence of selected amounts was totaled for each pentad.

In order to identify the rainy pentad, the mean rainfall for each pentad and the frequency of occurrence of 25 and 50 mm of rainfall in each pentad were plotted and analyzed for 61 stations. The pentads with a mean rainfall $\geqslant 25$ mm were identified. Hereafter, this will be called the 25 mm criterion. Also, the pentads in which the frequency of occurrence of 25 mm of rainfall equaled or exceeded 50% were identified. This will be referred to as the 50% criterion. The 25 mm was chosen because that amount represented the rain from one mesoscale rainstorm and is about the lower limit of rain that can be accepted and earth movement construction continue. Also, it happens to be a central value in the array of data.

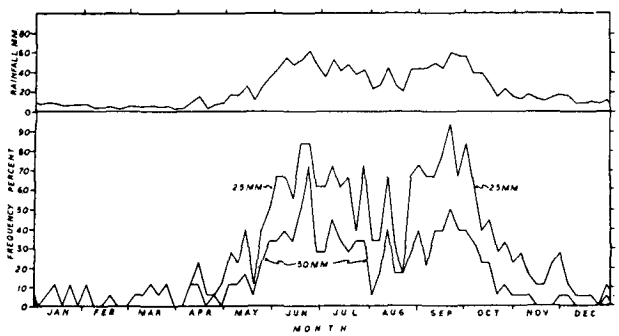

FIG. 1. Mean pentad rainfall (mm) and frequency of occurrence (percent of 25 mm and 50 mm of rainfall) for Santa Rosa de Copan, Honduras.

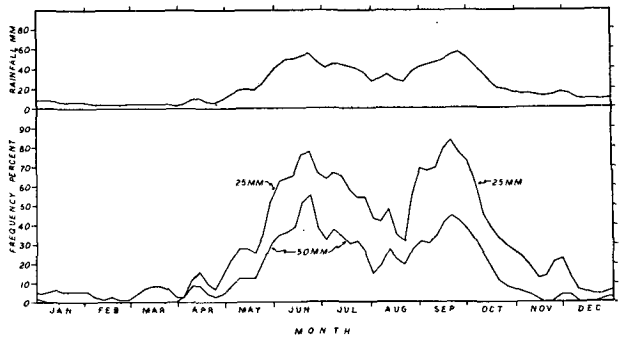

FIG. 2. Smoothed mean pentad rainfall (mm) and frequency of occurrence (percent of 25 mm and 50 mm rainfall) for Santa Rosa de Copan, Honduras.

The detection of the rainy pentad at each station was accomplished using the 25 mm and 50% criteria. The first pentad for which the mean rainfall was 25 mm was identified as the beginning of the rainy pentads, and the last pentad with a mean of 25 mm deemed the end of the rainy pentads. The 50% criterion was used in the same manner.

3. Results of the analysis

The rainfall mean for each pentad and the frequency of occurrence of 25 mm and greater and 50 mm and greater were computed and plotted. An example is shown in Fig. 1. One evident feature of these graphs is the erratic sawtooth pattern of the lines. This pattern was very evident for stations with short periods of record but could also be seen for stations with long periods of record. The station (Santa Rosa de Copan, Honduras) shown in Fig. 1 has 18 years of data. Running averages of the means and the frequency of occurrence of selected amounts were computed. This was accomplished by adding the values of the pentads on either

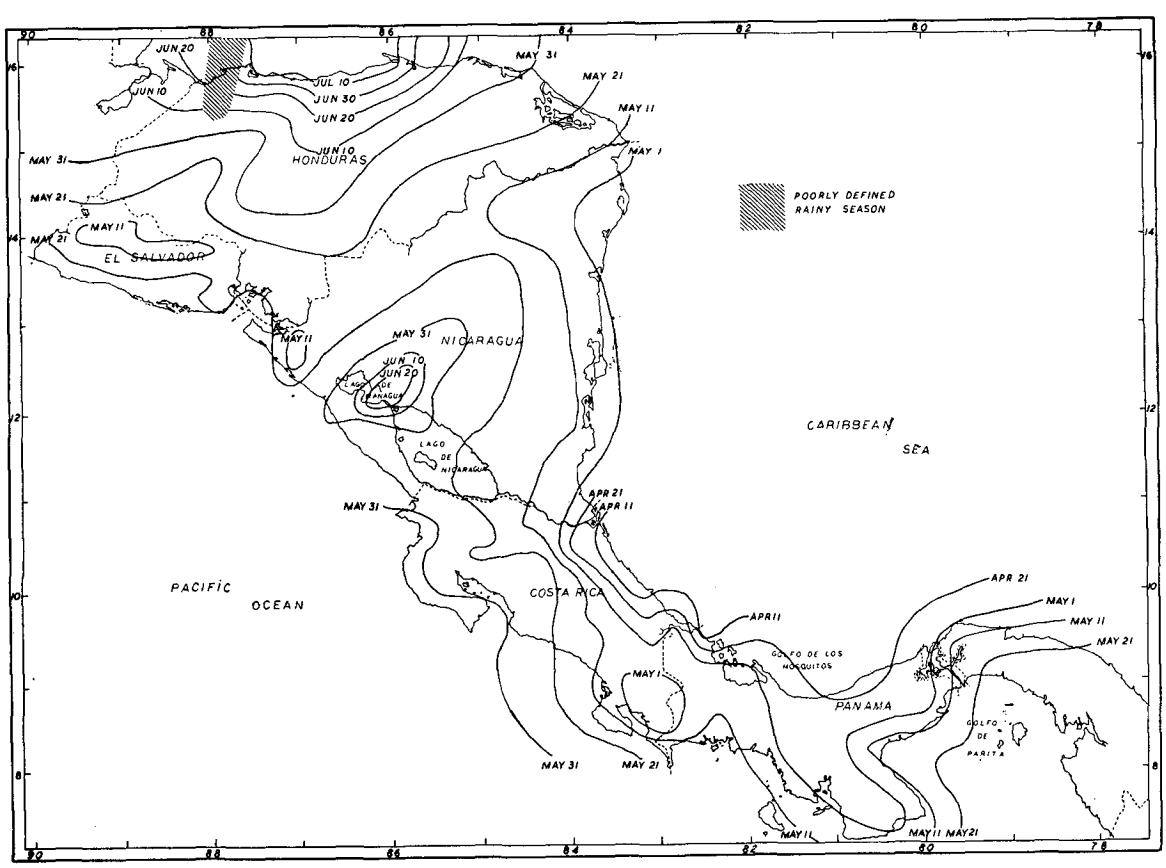

FIG. 3. Mean date of beginning of the rainy pentads.

side of a pentad to twice the value of the center pentad and dividing by four.

Fig. 1 shows that 21 May is the first day in which the mean rainfall exceeds and stays above the 25-mm criterion and that the mean value drops below 25 mm only from 30 July to 3 August, and from 19 to 23 August. The end of the rainy pentads occurs on 17 October. After that day the mean 5-day rainfall total remains less than 25 mm. One can also see in Fig. 1 that the 50% criterion is exceeded from 26 May to 29 July. A diminution and increased fluctuation of the frequency occurs from 20 July to 23 August, after which the frequency becomes greater than 50% on 24 August and remains so through 7 October. This station demonstrates very well that there are two groups of rainy pentads, a condition which exists over much of Central America.

Fig. 2 shows the running averages for Santa Rosa de Copan. While these are much smoother curves than those of Fig. 1, the averaging technique did not eliminate all of the fluctuations. From the 25-mm criterion, the rainy pentad begins on 21 May and ends on 17 October. The period of diminished rains during August is not definable using the 25 mm criterion because the rainfall is not less than 25 mm. With the 50% criterion, the rains begin on 26 May and last through 29 July.

TABLE 1. Dates for the beginning and end of the rainy pentads as determined by all criteria (Santa Rosa de Copan, Honduras).

	Criteria			
	25 mm	25 mm (av)	50%	50% (av)
Beginning	21 May	21 May	26 May	26 May
First end	3 Aug	*	29 Jul	29 Jul
Second start	24 Aug	*	24 Aug	24 Aug
Final end	17 Oct	17 Oct	7 Oct	7 Oct

* Not apparent by this method.

The relatively dry period extends from 30 July to 23 August, and the rainy pentads begin again on 24 August, finally ending on 12 October.

4. Beginning and end of the rainy pentads

All of the analyses yielded results which defined the beginning and end of the rainy pentads. In Central America the beginning and end of the rainy pentad is the beginning and end of the rainy season. This is not true in the drier tropics where the five-day totals will not average 25 mm. Figs. 1 and 2 show the rapid transition. The mean total rain of the preceding 30 days is usually less than 270 mm, while the next 30 days usually exceeds 250 mm. A summary of the beginning

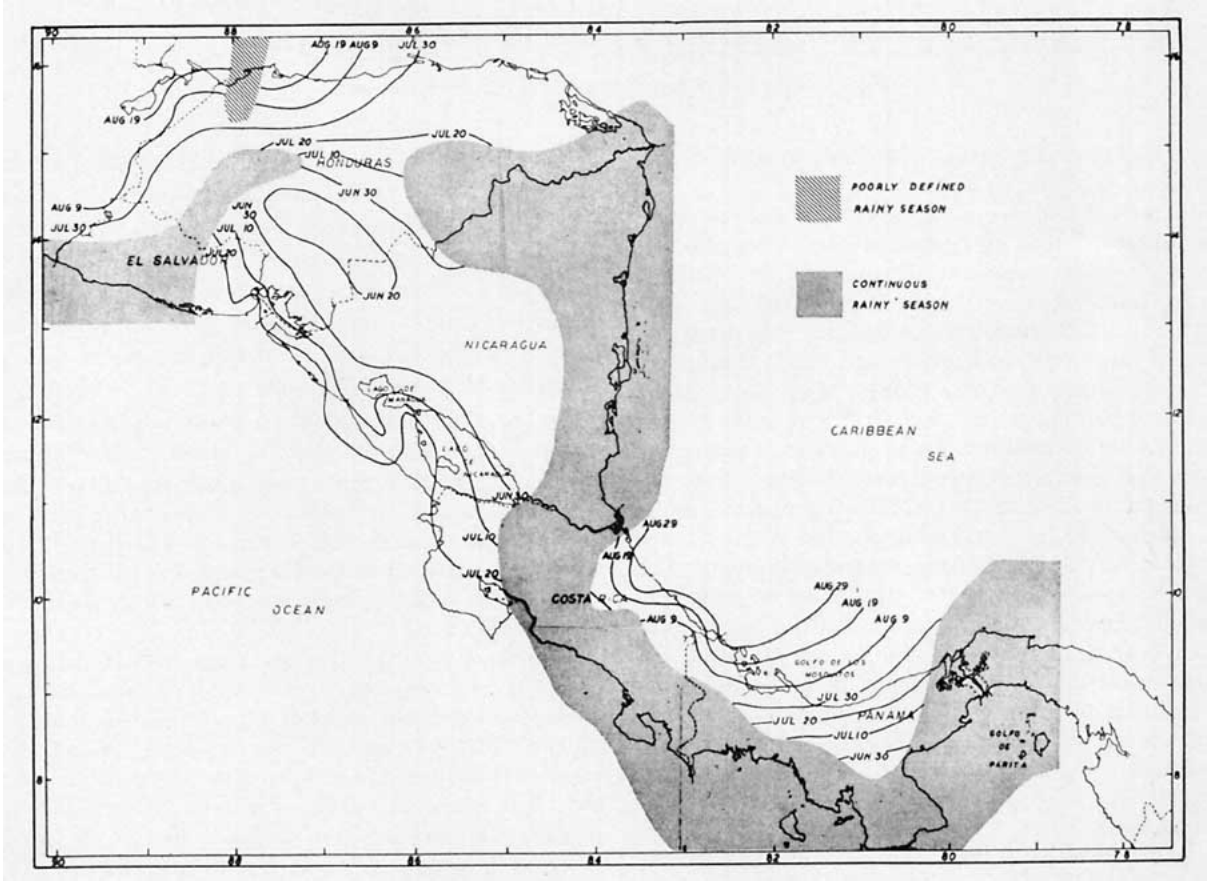

FIG. 4. Mean date of beginning of the break in the rainy pentads.

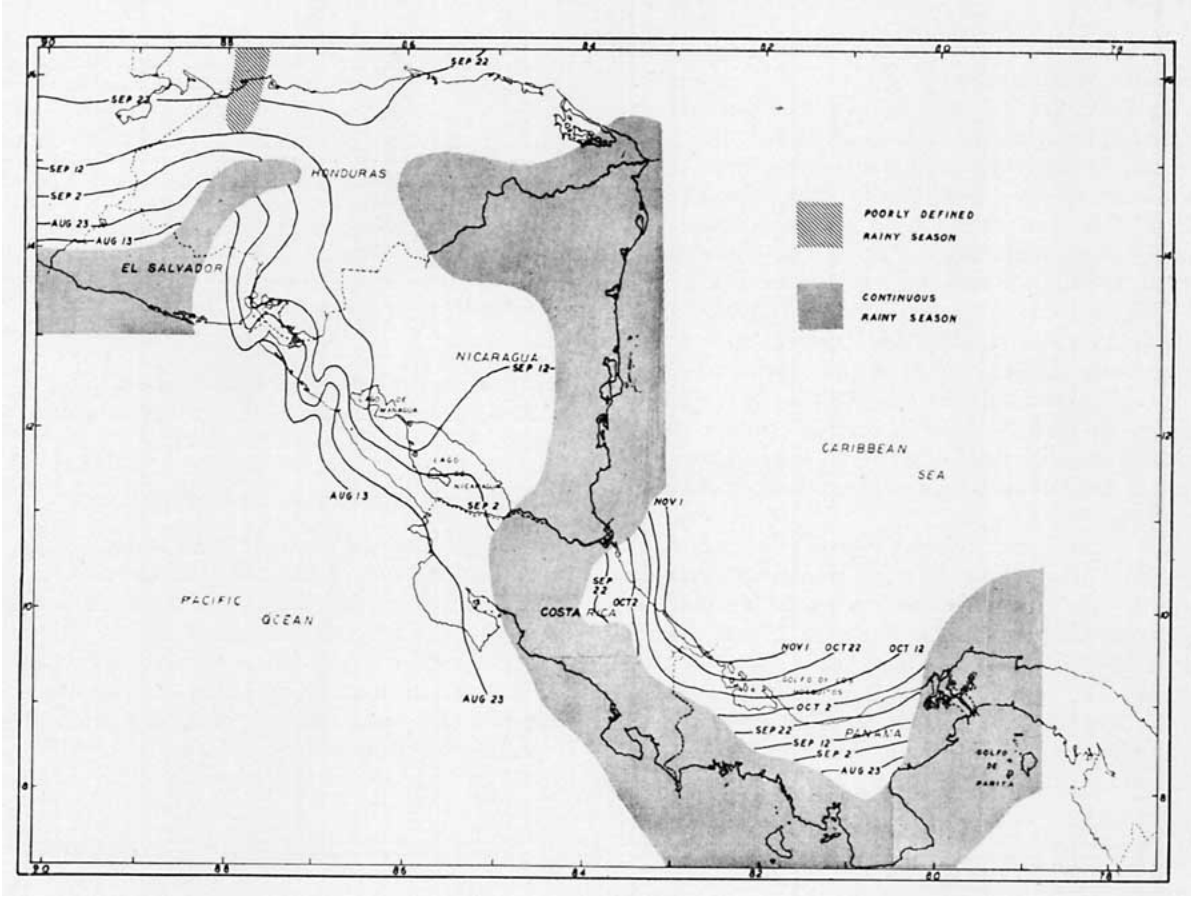

FIG. 5. Mean date of end of the break in the rainy pentads.

and end of the rainy pentads for Santa Rosa de Copan, Honduras, is shown in Table 1.

Similar results were obtained for all stations which were analyzed. The differences of dates result because the median and mean are not the same, indicating a skewed distribution of the data. The actual date, when there was a difference, was selected by considering the slope of the curves, which indicated that a change was occurring. Based on these results, mean dates of the beginning and end of the major rainy pentads at each station were determined. These dates were plotted on maps, and isochrones were drawn. Because there is a significant diminution of the rains over much of the area during late July and lasting through August, it was decided that this also could be portrayed on maps. This was accomplished by plotting the dates on which the rains first end on one map and by plotting the dates on which they again begin on another set of maps. Isochrones were then drawn to depict these events.

It can be seen in Fig. 3 that the first rainy pentad occurred along the southern part of the area on the Caribbean coast of Panama and Costa Rica. The date when the first rainy pentad occurs progresses across the isthmus in these two countries and moves inland from the east coast of Nicaragua. The mountains of northern El Salvador experience their first rain at about the same time as the rain starts in eastern Nicaragua. Apparently orographic uplift causes the rain to start in northern El Salvador before the rain-producing phenomena arrive by direct movement. The movement both north and south from an axis orientated east-west and located about 14N is interesting. The rainy pentad arrives latest along the northern coast of Honduras and in a small area near Managua, Nicaragua.

Fig. 4 reveals that the ending of this first rainy pentad group occurs earliest in southern Honduras and central Nicaragua. The last rainy pentad occurs at a later date along the coasts on both sides of the isthmus. This period of diminished rains begins much later along the Caribbean coast of Costa Rica and a small section of the coast of northern Honduras than it does for any of the other sections.

The shaded portions of the maps indicate areas in which the rainy pentads continue. The rains decrease in these areas, but enough rain occurs so that the amount is above the 25 mm or 50% criteria. No significant dry period occurs, and the areas remain quite wet. It is interesting to note that the area where rains continue shifts from the Caribbean coast to the south coast of Panama, effectively changing sides of the mountains.

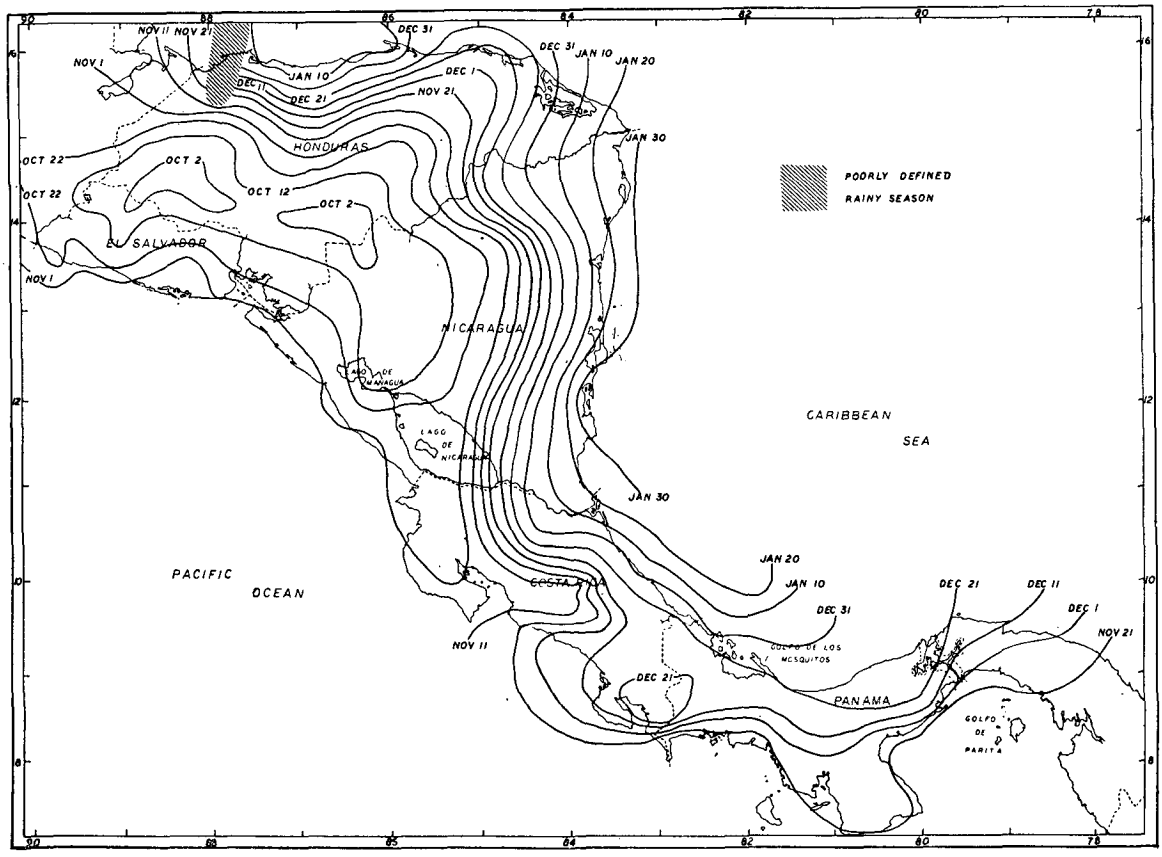

FIG. 6. Mean date of end of the rainy pentads.

The hatched area in northern Honduras indicates an area in which the rainy pentads are not well defined. Most of this area has uniform rainfall from late May through January. The rainfall exceeds a mean of 25 mm in a pentad only on three or four occasions throughout the year. A 50% frequency of occurrence of 25 mm of rain in a pentad was a rare event.

In Fig. 5, it can be seen that the date of beginning of the second rainy pentad group occurs earliest on the Pacific side of the isthmus. The Caribbean coast of Costa Rica experiences the latest beginning of this season.

A comparison of Figs. 4 and 5 shows that the interior portions of southern Honduras and western Nicaragua have the longest period of diminished rains. At Tegucigalpa, Honduras, this period lasted for 80 days. Since this area has less rain than most of the rest of Central America, the long dry period is not surprising.

Fig. 6 reveals that the final end to the rainy pentads occurs earliest in the mountains of El Salvador, Honduras, and Nicaragua. This area is almost the same as the starting axis at 14N, but curves off to the south. The Pacific coast experiences a much earlier end to the rainy pentads than the Caribbean coast. The rainy pentads have this final ending along the northern coast of Honduras and the eastern coast of Nicaragua.

5. Causes of the rainfall

The consistency of the advance and ending of the rainy pentad(s) is rather remarkable when all the possible causes of rainfall listed earlier are considered. It would seem that some rainfall-associated factor ought to be identified which would account for the variations shown. The concept of the "zenithal" rain following the sun would not fit the orientation nor the dates of the rainfall. It would seem difficult for the ITCZ to arrive first on the east coast of Costa Rica having bypassed all of Panama; the dates, moreover, do not fit with the established mean position of the ITCZ. The start of the rains certainly does not coincide with the hurricane-tropical storm season. Finally, the northeast trades could be considered as a source of warm moist air over the area, and the orographic uplift along the east coast could account for the advance in Costa Rica. How then, the sudden jump across the mountains to the lee side, i.e., southern Costa Rica and western Nicaragua? And besides, the trades have been blowing all throughout the dry season.

Having eliminated the assumed, direct causes of the rains, it becomes apparent that a complex problem remains. The causes of the rains are not as identifiable as the patterns of their beginning and ending. This problem will not be answered before much more

synoptic surface and upper air data become available. Portig (1965, 1969) describes the rainfall beginning as an explosion in all directions and the cause as undetermined. The movements presented are more orderly than an explosion, but the causes are not determined at this time. Lessman (1963) also points out the problems. Because of the two distinct rainy periods it could be assumed that two separate rain-causing phenomena occur in the area.

6. Conclusions

The analysis of daily rainfall data by 5-day totals is a satisfactory technique to identify the beginning, end, and duration of the rainy pentad groups in Central America. The two-peaked nature of the rainy season is evident over the entire area with the exception of the stations along the Caribbean coast of Honduras. The duration of the period of diminished rains between the two peak periods is found to be longest in the interior of southern Honduras and in eastern Nicaragua. This period of diminished rains is most dramatic in eastern El Salvador and extreme western Nicaragua.

The results and conclusions presented in this study are limited by the data available. There are several areas in which the beginning and end of the rainy pentads were extrapolated from the results in adjacent areas. A more precise definition would result if these gaps could be filled by acquisition of additional data.

Acknowledgments. Work on this paper was supported, in part, by the U. S. Electronics Command under Contract DAAB07-69-C0203. The paper for the most part is condensed from an M.S. thesis by Major Gramzow.

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