AN EXAMINATION OF SOME INDICATORS OF FRONTAL PASSAGE IN COASTAL HONDURAS

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ABSTRACT

An examination of the fluctuations in various meteorological parameters during frontal passage in coastal Honduras is presented. A composite analysis based on mean values of the parameters from five frontal episodes for four stations was prepared. The composite is presented by graphical means in an attempt to best isolate the parameters most indicative of frontal passage. The results of one frontal episode taken as representative of the five cases studied are presented in detail. The best indicators of the frontal activity are changes in low clouds and rainfall; and to a lesser extent, wind speed, temperature, and dew point.

1. INTRODUCTION

Frontal systems that enter the Gulf of Mexico and the Caribbean Sea during the winter months frequently maintain their identity long enough to affect the countries of Central America. Although in a much weakened state and sufficiently modified from below by the relatively warm Gulf and Caribbean waters, these systems still are capable of producing significant changes in the weather as they move across Central America. Because of the extensive modification it often is difficult to locate these fronts. The purpose of this study is to examine meteorological parameters from hourly surface observations in an attempt to isolate possible indicators of frontal passage in coastal Honduras. This in turn should lead to better analysis and better forecasts of precipitation during the otherwise dry season.

Portig (1) conducted a comprehensive study of air mass properties in Central America. He stated that the main indicators of air mass changes are visibility, dew point temperature, clouds, and precipitation. However, his results were for San Salvador, located on the Pacific side of Central America. Consequently, as pointed out by Portig, these results probably are not representative of conditions on the Atlantic side.

Other researchers have performed studies on conditions associated with frontal passages in various countries. Hill (2) examined conditions for Mexico, Hurd (3) and Parmenter (4) for the Gulf of Tehuantepec, Fermor (5) for Jamaica, and McBryde (6) for Guatemala. These studies comment on the occurrence of heavy rains, strong gusty winds, and considerable temperature variations associated with the frontal passages.

DiMego et al (7) examined the frequency and mean conditions associated with frontal systems as they traversed the Gulf of Mexico and the Caribbean Sea. In general, they report a veering of the winds with height, an increase of relative humidity, and a temperature increase in the 1000-700mb layer prior to frontal passage with an abrupt reversal of these characteristics after frontal passage. Not all areas had radiosonde data so surface observations were paramount in this study.

2. DATA AND LIMITATIONS

The data for this study consisted of surface observations for four stations in Honduras: Guanaja (78701), La Ceiba (78705), Tela (78706), and San Pedro Sula (78708). Only data for the winter months (November, December, January, February) for the years 1975-1976 were available on a continuous basis. Therefore, four of the five case studies were from this period of time. The data availability for San Pedro Sula was limited to the winter months of 1976. However, San Pedro

Sula was the only station of the four that reported every hour of the day. The other stations reported on a 12 to 18-hour basis. This limitation proved to be rather critical in a couple of the case studies.

In addition to the Honduras surface observations, rainfall data were available on a regular basis for the years 1972-1977. The data were recorded daily at 6-hour intervals. A few of the stations frequently were missing the 0600 GMT observation.

National Climatic Center Northern Hemisphere Data Tabulations (NCC-NHDT) were used to extract surface data for the synoptic analysis of the study area. The data were for the 0000 GMT and 1200 GMT. The study area is shown in Figure 1.

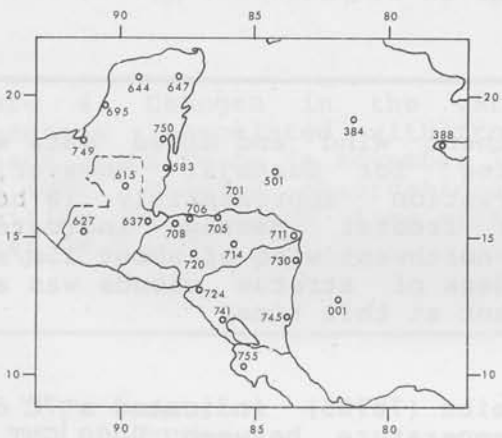

Figure 1. The distribution of surface stations in Honduras and vicinity.

3. METHOD OF ANALYSIS

Surface data were plotted for each case study at 12-hour intervals and then analyzed to determine frontal positions and characteristics of the general pressure pattern. After the data were plotted and hand-analyzed, charts depicting 12- and 24-hour changes in certain parameters at each station were prepared. Special attention was given to notable pressure variations, wind shifts, and/or temperature and dew point fluctuations. The use of these change charts eased the task of locating frontal positions in certain areas. The resulting frontal positions were compared with the National Meteorological Center's (NMC) analyses, and they were similar. Graphical analyses showing hourly variations in temperature, dew point (when available), wind, pressure (when available), rainfall, and low and middle clouds were performed for the four Honduras stations.

4. RESULTS

During the period 13-17 November 1975 a relatively significant frontal system crossed the Gulf of Mexico and Caribbean Sea and moved through the Central American country of Honduras. This system was approaching an already existing pressure trough over the Yucatan Peninsula at 0000 GMT on 13 November. By 0000 GMT on 14 November a strong high pressure center northwest of the surface frontal boundary had pushed the front to the western edge of Honduras. The frontal system crossed Honduras in the next 24 hours and then was indicated as stationary and frontolyzed to a point approximately 330km east of Nicaragua by 0000 GMT on 15 November. Figures 2a and 2b show the location of the front at 0000 GMT and 1200 GMT on 14 November 1975, respectively.

The best indicator of the arrival of the front at Guanaja (78701) was a 5C drop in temperature over a 12-hour span. However, it was unfortunate that the front passed the station just prior to a period of missing surface observations. Therefore, fluctuations in temperature, as well as in wind and low cloud base heights, could not be examined for about 12 hours after frontal passage. Nevertheless, for quite some time after this period of missing data, temperature remained rather low, compared to the temperature profile ahead of the front. (See Figure 3.)

Six-hour rainfall totals showed a marked increase after frontal passage. Rainfall was not particularly heavy for any 6-hour period, but was quite persistent for some 36-48 hours after the front passed. The maximum 6-hour rainfall (2.04mm) occurred prior to 1200 GMT on 15 November. Figure 3 illustrates the characteristics of the rainfall activity.

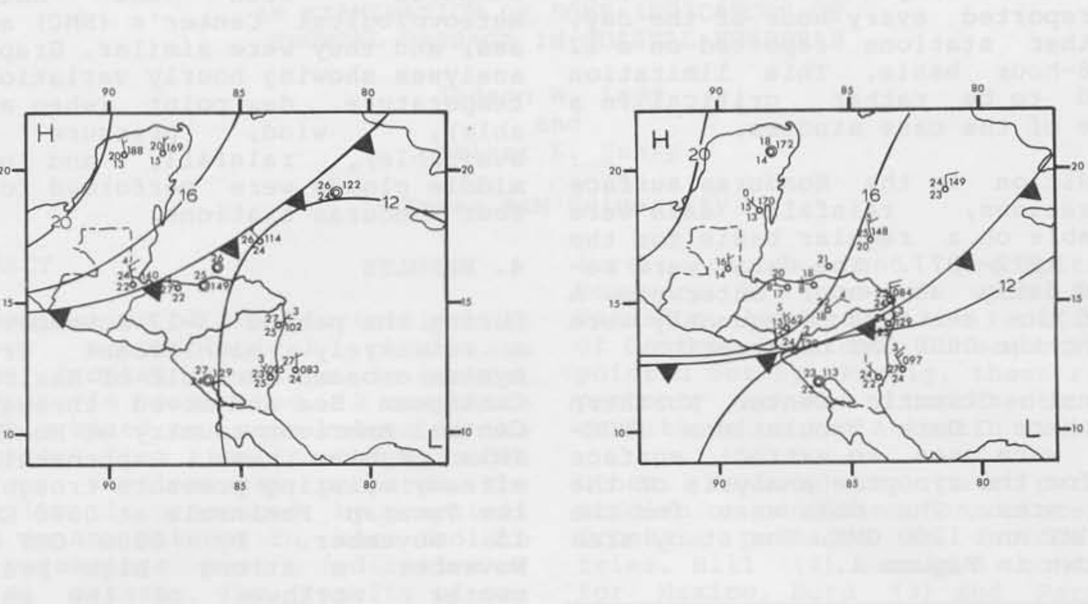

Figure 2. Frontal positions of (a) 0000 GMT on 14 November 1975 (b) 1200 GMT on 14 November 1975.

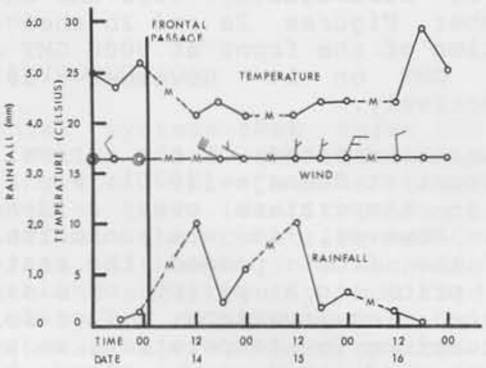

Figure 3. Changes in the various parameters associated with frontal passage at Guanaja in November 1975. Time (GMT). Missing observations are signified by a broken line with the letter "M."

Pertinent wind and cloud data were missing for Guanaja. However, an observation approximately 18 hours after frontal passage indicated a west-northwest wind of about 15m/s. A low deck of stratus clouds was also evident at this time.

La Ceiba (78705) indicated a 7C drop in temperature between 0000 GMT and 1200 GMT on 14 November. Part of this temperature decrease probably was due to diurnal effects. Frontal passage occurred at roughly 0300 GMT on 14 November. While this was the only major fluctuation in the temperature profile, readings remained low for the next 48 hours. The temperature profile for La Ceiba is shown in Figure 4.

The most noticeable feature of frontal passage at La Ceiba was a 9mb rise in pressure from 1200 GMT on 13 November to 1200 GMT on 14 November. However, missing data between 0000 GMT and 1200 GMT on 14 November prevented an hourly examination of the pressure profile. Pressure is depicted in Figure 4.

Rainfall, also shown in Figure 4, illustrates the maximum 6-hour total of 5.6mm that occurred at 1200 GMT on 14 November. Rainfall activity at La Ceiba for this system was localized, occurring mostly over a 12-hour span between 0600 GMT and 1800 GMT on 14 November.

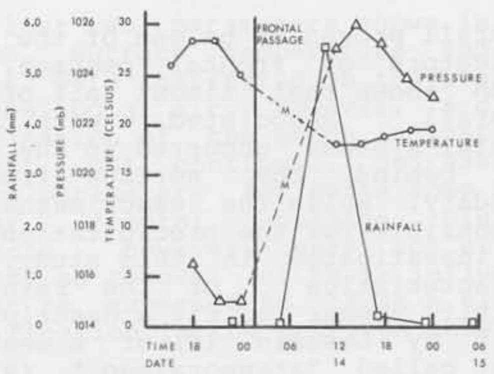

Figure 4. Changes in the various parameters associated with frontal passage at La Ceiba in November 1975. Time (GMT). Missing observations are signified by a broken line with the letter "M."

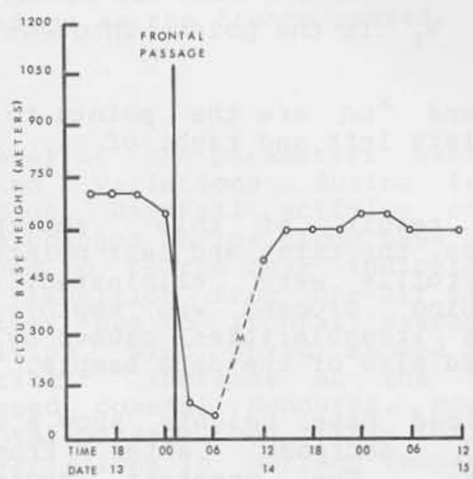

Figure 5. Changes in cloud base height associated with frontal passage at Tela in November 1975. Time (GMT). Missing observations are signified by a broken line with the letter "M."

Tela (78706) showed some interesting changes in the meteorological parameters. Foremost among these changes was an abrupt drop in low cloud base heights. This is seen in Figure 5. This decrease amounted to about 450m in only one hour. In addition, this drop in cloud base was accompanied by a cloud structure change from cumulus to stratus.

Temperature and dew point exhibited noticeable drops as the front moved through Tela. The most marked temperature drop occurred over a 12-hour span centered on the time of frontal passage. (See Figure 6.) The dew point did not react quite as much but did maintain a slow but continual decrease for about 24-36 hours. As shown in the graph, the lowest temperature values occurred during the period of maximum rainfall activity.

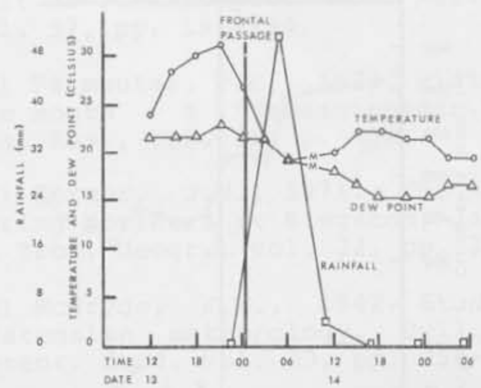

Figure 6. Changes in the various parameters associated with frontal passage at Tela in November 1975. Time (GMT). Missing observations are signified by a broken line with the letter "M."

Soundings for 1200 GMT on 13 November and 14 November at Swan Island (78501) helped verify some of the features mentioned above. The pre-frontal sounding for 1200 GMT on 13 November indicated light winds at all levels. The temperature profile showed a conditionally unstable layer from the surface to 850mb. Above, the temperature profile virtually followed the moist adiabat. No temperature inversions were observed in this sounding.

The post-frontal sounding 1200 GMT for 14 November at Swan Island showed some very distinct changes. Although the surface temperature remained about the same as for the previous 1200 GMT sounding, an average cooling of about 3C was evident from about 950mb to 550mb. Winds shifted around to the north or northeast in the 1000-700mb layer and had a marked increase in speed.

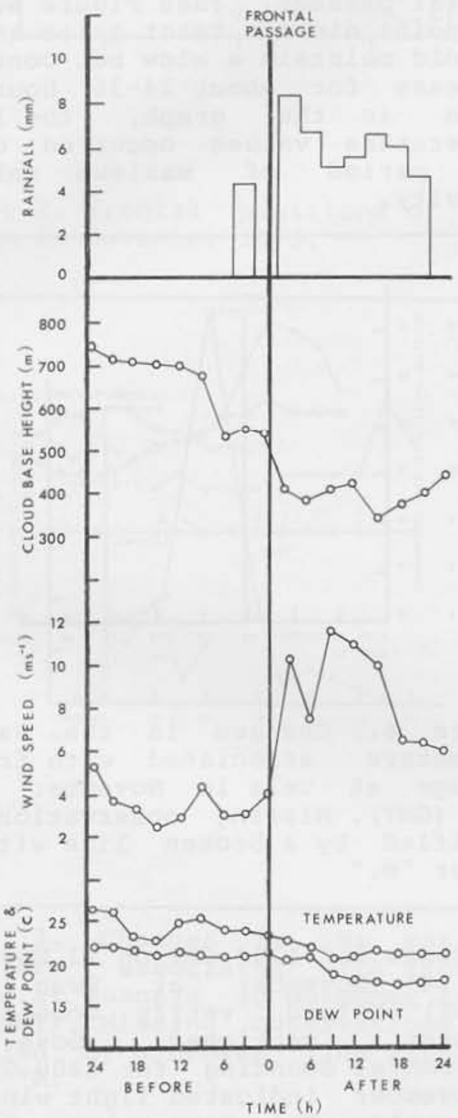

Figure 7. Composite analysis of mean changes in the various parameters at the four stations in Honduras in November 1975.

5. COMPOSITE ANALYSIS

The graphical presentation in Figure 7 represents a composite of mean values of the parameters based on data from all four coastal stations for the five frontal episodes studied. Therefore, the graph represents a model of variations in the parameters accompanying frontal passage in coastal Honduras.

Rainfall proved to be one of the best indicators of frontal passage. The graph shows that almost all of the rainfall associated with these frontal systems occurred in the cold air behind the surface frontal boundary. While the exact mechanism responsible for the precipitation was not investigated in this study, the characteristics of the rainfall activity appear to fit a description given by Lessman (8) of a weather event called "atemporalado." (9) In addition, some of the rainfall may be induced by orographic lifting by the mountains in Honduras. It should be mentioned that the rainfall profile shown in Figure 7 is the result of a simple smoothing process based on the following equation:

$$y = \frac{x_{i-1} + 2x_i + x_{i+1}}{4}$$

where x_i is the point in question, and

x_{i-1} and x_{i+1} are the points to the immediate left and right of x_i.

As a result of this smoothing process, the first and last points of the profile were eliminated. The smoothing process was employed to remove irregularities caused by the limited size of the data sample.

Low cloud base heights show a very marked decrease after frontal passage. The greatest decrease occurred within 3 hours after the intrusion of polar air. This decrease in cloud base height was accompanied by a cloud structure change from cumulus to stratocumulus or stratus. This, too, is characteristic of a variation of the "atemporalado" mentioned previously.

While wind direction showed little or no systematic variation during the frontal episodes, changes in wind speed were very noticeable. As exemplified in the diagram, wind speed increased very rapidly after frontal passage and maintained high values for approximately 12 hours. Wind speeds as high as 15m/s were observed in a few frontal episodes.

The last two parameters shown in the graph, surface temperature and dew point, were unaffected on the average by the polar air. However, a close examination of the graph indicates a slight, but continual, decrease in these parameters for quite some time after frontal passage. Diurnal effects, however, were not eliminated, so removal of their influence might be expected to cause a slight modification in the profiles shown.

6. CONCLUSION

The variation in certain meteorological parameters for five frontal episodes in the winter months of 1974-1976 were examined at each of the four coastal stations in Honduras. A graphical analysis depicting these fluctuations was prepared in an attempt to determine which of the parameters indicated the change in air mass experienced at the stations as the fronts passed.

Several of the parameters exhibited marked variations during frontal passage. Rainfall activity coupled with changes in low cloud base height proved to be the best indicators of the transition from one air mass to another due to frontal passage. In addition, wind speed showed a very distinct increase as the fronts crossed coastal Honduras. However, frontal passage had little influence on variations in surface temperature and dew point.

The results of this study were based only on a few frontal episodes and many more could be examined. However, the trend of the conditions described along with previous reports lead to the conclusions that these are close to the true indicators.

7. ACKNOWLEDGEMENTS

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(9) Atemporalado is a term used in Central America to describe a rain event occurring during the early winter. A light rain falls from stratus clouds and may have a duration of 12-15 hours. The activity is caused by a cold front.