

## SOME ASPECTS OF COLD FRONTS IN BELIZE

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## ABSTRACT

The meteorological parameters that best indicate frontal passages in Belize were identified as wind, equivalent temperature, and precipitation. The antecedent conditions for a front to pass are: pressure rise; and, fog and drizzle. Both start about 12 hours before passage and a clearing trend starts about 3 hours before passage. It was noted that about twice as many fronts passed Belize as were indicated on the maps of the National Meteorological Center Northern Hemispheric analysis.

## 1. INTRODUCTION

Frontal passages have been observed occasionally in Central America. These systems were not always easy to recognize since strong modification of the cold air typically occurred due to the overwater trajectories. Furthermore, the standard criteria used in the United States for frontal passage identification were not necessarily applicable. Even so, significant local weather changes were observed. Rain often occurred with the passage of the cold front. Consequently, knowledge of a frontal passage can be important from an agricultural standpoint. Frost has occurred infrequently in the interior - more often so in the higher areas. This study examined the meteorological parameters from 3- and 12-hour surface observations taken at Belize over a 9-year period and identified those parameters which were significant.

Figure 1 is a map of Belize showing Belize International Airport and its relation to the rest of the country. The only terrain features of any significance are the 1000m mountains south of Belize City. To the northwest through east of Belize International Airport there are no mountains or other features to impede a front approaching from the Gulf.

Researchers have conducted frontal passage studies in many of the Central American countries. Portig (3) examined frontal passages in San Salvador. Hill (4) examined them for Mexico, Hurd (5) and Parmenter (6) for the Gulf of Tehuantepec, Fermor (7) for Jamaica, McBryde (8) for Guatemala, and DiMego et al (9) in the Gulf and Yucatan. While these studies were able to identify many significant frontal passage characteristics, they were not necessarily suitable for Belize. Portig, Hurd, Parmenter, and McBryde all conducted their studies on the west coast of Central America.



Figure 1. Map of Belize and adjacent area. Stippled area, mountains above 1000m.

## 2. DATA LIMITATIONS AND ANALYSIS

This research made use of the standard observations taken at Belize International Airport, Belize. Data from the years 1969 to 1978 were used for the winter season (November through March). Unfortunately, the data were not always continuous, so a

## NATIONAL WEATHER DIGEST

12-hour time interval was chosen for the first examination. During the years 1975-1978, the observations at Belize were recorded in a more continuous manner and it was possible to select eight cases for detailed examination for which the data was recorded at 3-hour intervals. The parameters considered were: temperature, dew point temperature, surface pressure, rainfall (measured at 6-hour intervals), current weather, wind speed and direction, and cloud cover. These were supplemented by a derived quantity, equivalent temperature. The synoptic situation for each day was examined, using the analysis as shown on the National Meteorological Center's (NMC) northern hemispheric chart. The frontal passages on the NMC maps were compared with the data for Belize to determine if the analysis had frontal passages at the same time that the data indicated passages.

The frontal passages examined in this paper were those of the northern hemisphere winter, which is the dry season in Belize. By using the NMC northern hemisphere maps to determine the frontal passages, it was found that an average of one cold front per month passed Belize International Airport during the months of November through March. Rainfall usually occurred with the frontal passage or soon after the front passed, and can vary in amount from 1 to 40mm.

### 3. TWO CASES OF COLD FRONT PASSAGE

#### a. The Cold Front of 17 March 1978 (Figure 2)

In March 1978 a front passed through Texas and moved southeastward into the Gulf of Mexico. The NMC carried this front on their charts until it reached Cuba and the Yucatan Channel. At this location, the southern part of the front was dropped from the analysis but the Belize data indicates that it passed through Belize.

As the front passed through Belize a distinct shift of wind occurred. The 5kt easterly wind increased speed and changed direction and became a 19kt wind from the north by 0900 GMT (0400 LMT). The pressure, which had been rising, continued to rise steadily. The equivalent temperature dropped 7K

during the 12 hours before the wind shift. The temperature and dew point temperature also lowered during the 6-hour periods before and after the wind shift. The front passed during the early morning and the cooling ahead of the front was attributed to radiational cooling. Finally, sky cover increased after the front passed. It changed from clear to eight-tenths coverage after the wind shift.

At the time of frontal passage, the atmosphere had been undergoing nocturnal cooling. As the day progressed, the usual diurnal heating was reduced by the advection of cool air. However, the radiational heating would account for the rise in temperature and equivalent temperature which had occurred by 1800 GMT (1300 LMT). Therefore, even though the normal pattern (as seen in the previous 48 hours in Figure 2) tried to assert itself, the cooling due to the arrival of the front and the attendant increase in cloud cover overpowered the regular daily modulation of temperature.

#### b. The Cold Front of 8 December 1976 (Figure 3)

On 7 December, a cold front entered the Gulf of Mexico and moved southeastward. The NMC carried this front on their charts through the Yucatan peninsula on 8 December, dropped it on 9 December, and picked it up again on 10 December in Guatemala and Honduras.

At Belize International Airport the wind was calm for several hours before the front passed. After frontal passage, the wind became 5kt from the northwest and increased in speed later. Pressure, which had a rising trend for 12 hours, dropped just before the wind shift, and then rose and continued to rise for the next 6 hours. This front passed just before sunrise, thus the equivalent temperature had lowered prior to the wind shift. During a 24-hour period centered on the time of the wind shift, the equivalent temperature was reduced by 15K. Dew point temperature lowered 5C during the same time period. Rainfall was initiated 6 hours after the wind shift, but was minimal. The next day over 40mm of



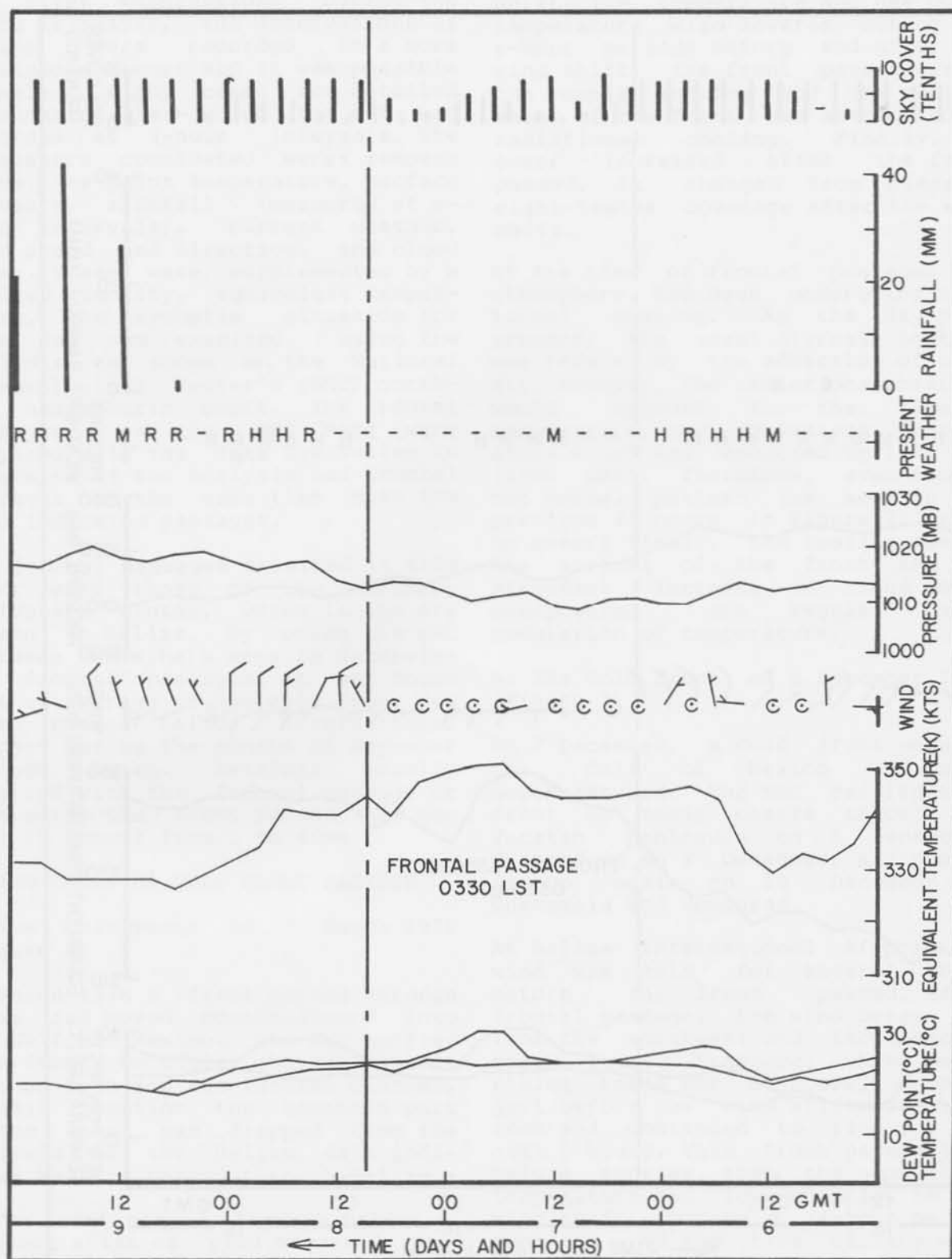


Figure 3. Variation of the weather parameters with the cold front of 8 December 1976 (- means zero value).

rain fell. Finally, sky cover increased about the time of wind shift and became less variable during the next 6 hours.

This frontal passage occurred at the same time of day as the previous case. Again, nocturnal cooling occurred prior to the arrival of the front. However, this time the air mass behind the front was not as cold as in the 17 March case and therefore, the diurnal heating effect was more prevalent the next day. This can be seen in the equivalent temperature values from 0900-1800 GMT (0400-1300 LMT). The cloud cover and cold air advection continued and the result was the depressed temperature, dew point temperature, and equivalent temperature values the following night.

#### 4. COMPOSITE ANALYSIS

Frontal criteria charts were compiled from all cases using both the 12-hour and 3-hour data and are shown in Tables 1 and 2, and Figure 4. The composite graph (Figure 4) is for a 48-hour period, centered on frontal passage time and using data points for every 3 hours. These data were taken from the eight cases that were examined. Of the eight frontal passages, 6 occurred approximately at sunrise so the cooling prior to the front is nocturnal. All the data were summed and averaged; the resulting mean values were used to construct the composite. The height of cloud bases were examined; a specific pattern was not determined because of their great variability. Generally, the cloud bases are approximately

1. Wind shift to a northerly direction and increases speed.
2. Pressure rise 4 mb in 12 h.
3.  $T_e$  drop 5 K in 12 h  
10 K in 24 h  
10 K in 36 h

Table 1. Time changes of weather elements occurring with the frontal passage at Belize using 12h data.

1. Wind shifts to a northerly direction and increases speed.					
Time changes for other parameters:					
		3 h before to 3 h after	6 h before to 6 h after	9 h before to 9 h after	12 h before to 12 h after
2. Pressure rise mb		2	4	5	6
3. $T_e$ drop K		10	10	12	12
4. Precipitation	before after	none prob. rain	prob. drizzle prob. rain	prob. drizzle none	none none
5. $T_d$ drop °C		2	4	4	4
6. Sky cover amount	before after	scattered broken	broken broken	broken broken	scattered broken

Table 2. Time changes of weather elements occurring with the frontal passage at Belize using 3h data.



900m, and then lowered somewhat (0-300m) during the 6-hour period following frontal passage. Both temperature and dew point temperature were reduced after the front passed. Equivalent temperature decreased also, but in a more distinct manner, especially at the time of frontal passage. The pressure rose steadily from a weak minimum 21 hours before frontal passage. Rainfall started just before the front arrived, but its maximum value was just after the front passed. The wind shift was the most obvious change. It changed from calm (1kt winds were considered calm) to a speed 5-10kt from a northerly direction.

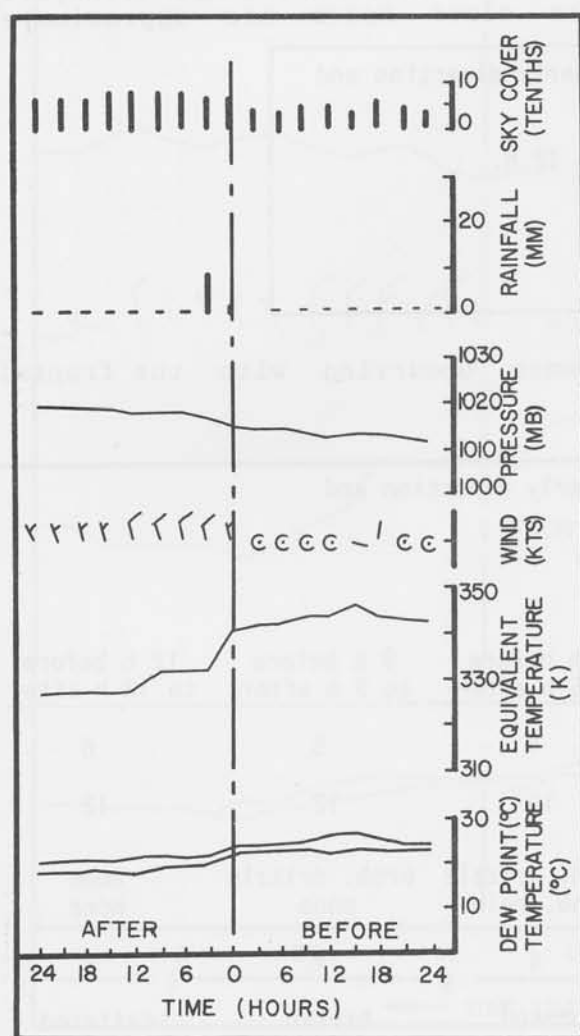


Figure 4. The graph of mean parameters, before and after a frontal passage in Belize (- means zero value).

On the criteria charts, items are listed in order of importance, the most significant factors first. These criteria were selected after examining all frontal passages in the 9-year period of study. Table 1 consists of mean values from all 9 years, while Table 2 displays the mean values for all eight cases that the 3-hour data were used. The decreases of the equivalent temperature of the magnitude listed in Table 1 would be expected with about 60 percent of the fronts.

## 5. FRONTAL PRECURSORS

When a front has moved into the Gulf and possibly could continue on to Belize, the forecaster needs to decide if it will pass and if so, predict the time of frontal passage. The weather communications networks in Central America are not dependable. Thus, it often is necessary to make a forecast using only the data from Belize International Airport. Therefore, the data were studied to find any precursors of frontal passage. It was found that during the 15-hour time period before frontal passage fog, drizzle, haze, rain, or rain showers occurred. Furthermore, an initial pressure drop was followed by a rising trend which starts 6-18 hours before the frontal passage. This pressure rise invariably accelerated following frontal passage. Most of the fronts passed at about 0900 GMT (0400 LMT) which was during a diurnal pressure minimum so the rise during this time was from moving pressure systems. These parameters are shown in Table 3, in order of importance. Of course, from one station, the timing of the passage of an approaching cold front is rather poor, but these are the apparent indicators that a front is approaching. Data for November and December 1978 had been withheld from the original analysis as a control and were used to forecast frontal passages. The data were for 12-hour intervals, so the 12-hour decision chart was used. No maps were used that showed a front had entered the Gulf or would be expected to pass.

1. Pressure drop and then slow rise 6-24 h before frontal passage
2. Fog, drizzle, haze, rain or showers often occur in the period 3-15 h before frontal passage.

Table 3. Surface indicators at Belize that a cold front is approaching.

From this data two frontal passages and maybe a third were forecast. The continuing data verified that all three fronts passed and the "maybe" was the weakest of the three. Therefore, even with the limit of 12-hour data, fronts can be forecast. Better results should be obtained using 3-hour data.

#### 6. NATIONAL METEOROLOGICAL CENTER ANALYSIS

The frontal passages through Belize analyzed in the same manner as the two previous cases, were compared with frontal passages analyzed by the NMC. The composite analysis and criteria charts of this study were used to determine whether or not a front passed. Some fronts that were not on the NMC analysis were detected. Maybe the reasons that NMC had not analyzed these fronts are that the region is an area of secondary importance to forecasters in the United States; and, frontal criteria of the NMC (10,11) were not met. (The 1000-500mb thickness gradient was not strong enough to meet the NMC definition of a front.)

At this point, the question of defining a front may be raised. There are several definitions. However, when a front has been analyzed as entering the Gulf of Mexico and has been followed to Belize (or farther), and a weather system passed which caused precipitation, lowering of the temperature, and reducing the visibility and ceiling, why not continue to call it a front? To debate if the system is a front or a rainband is

beside the point, which is that the system can be analyzed and predicted, and it does cause weather.

These results of comparing the fronts from the NMC analysis and from the data from Belize are tabulated in Table 4. On the average, the NMC missed about 50 percent of the fronts (weather system from the north) that push through Belize. Often the NMC will locate the front in Mexico and the Gulf of Mexico. However, when it reaches the country of Belize, it will be frontolyzed with the cold front extending from the northeast usually terminated somewhere between Cuba and the Central American coast.

#### 7. ACKNOWLEDGEMENTS

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Years	No. of Fronts Belize Data	No. of Fronts Analyzed by NMC	No. of Fronts Missed by NMC	Percent of Fronts Missed by NMC
69-70	12	5	7	58
70-71	10	7	3	30
71-72	8	3	5	63
72-73	9	8	1	11
73-74	6	5	1	17
74-75	6	3	3	50
75-76	11	2	9	82
76-77	11	5	6	55
77-78	17	6	11	65
Total	90	44	46	51

Table 4. Number of fronts indicated by NMC and those indicated by the data of Belize from 1 November through 31 March.

the United States Air Force until retiring from the Air Force.

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