Forecasting

A TECHNIQUE FOR FORECASTING HEAVY PRECIPITATION IN THE SOUTHEASTERN UNITED STATES

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ABSTRACT

Flooding has become the nation's leading weather problem. Therefore, in an effort to provide better precipitation input for flood events, a method of forecasting rainfall using facsimile products to identify the synoptic situations producing heavy precipitation has been developed. The 1000-500 mb thickness is the key parameter for forecasting heavy precipitation in the southeastern United States. Twelve hour forecasting guides are presented. These forecasting guides were verified with subsequent occurrences and found to improve the MOS and QPF guidance.

1. INTRODUCTION

Every year floods cause millions of dollars of property damage and hundreds of deaths in the United States. Floods are common to all sections of the country and no area escapes the devastation they may bring. The need for more accurate forecasts of heavy precipitation was stressed in a report by the American Meteorological Society (1) on flash floods. In addition, Fawcett (2) states that precipitation is one of the difficult of the meteorological parameters to forecast. Even with the increased number of numerical models the skill of the precipitation forecast has not improved over the last 10 years. Further research into the present forecast methods or development of new ones is warranted.

2. WINTER RAINFALL AND FRONTS

Since heavy rainfall often accompanies fronts a count was made of the frequency of fronts in the southeastern United States (which for the purpose of this study includes eastern Texas, Mississippi, Alabama, Louisiana, Georgia, and Florida) for the winter seasons (November through March) of 1973-1977. The fronts were counted from the surface analyses of the National Meteorological Center (NMC). The results of this count are shown in Table 1. A total of 155 fronts entered the southeastern United States during these five winter seasons. The average duration of a front in the area was 3.1 days. The precipitation associated with these fronts was identified and the fraction of the winter rainfall determined (Table 2). This study shows that for all states and years at least 60 percent of the total winter season precipitation was associated with fronts.

Some investigations have been performed in an attempt to find the synoptic patterns accompanying frontal passages associated with significant precipitation. Garcia, et al. (3) found heavy frontal-associated precipitation in the Dominican Republic occurring with strong surface east winds in conjunction with strong upper level westerlies and lower tropospheric ridging behind the front. Maddox, et al. (4) found that of 151 flooding events occurring in the United States between 1973-1977 roughly 25 percent were associated with fronts. Maddox and his associates went one step further and calculated mean atmospheric conditions accompanying these frontal-type flooding events. Other research in this direction has been performed by Kreitzberg and Brown (5), Smith and Younkin (6), Bosart (7), Estogue (8), and Jensen(9).

3. ANALYSIS

3.1 Data

The precipitation data used in this study were taken from the National Climatic Center (NCC) daily precipitation records for the individual states. Data for the synoptic analyses are taken from the NMC facsimile maps. In addition, Service A and C teletype data were available. NMC analyses were used so that the parameters utilized to develop a heavy precipitation forecasting technique would be available to all forecasters, and to eliminate bias and increase objectivity on our part. We believe that some fronts were removed from the analyses prematurely, which would have increased the numbers in Tables 1 and 2. However, in this study the NMC analysis was used.

3.2 Selection of Cases

The first step was to compute daily

Table 1. Frontal occurrences in the southeastern United States during the period of study. Top numbers represent the number of fronts per month, bottom numbers are the total days per month front(s) were analyzed in the study area.

Year	Nov	Dec	Jan	Feb	Mar	Total
1973	5 15	6 20	5 28	6 13	7 30	29 106
1974	6 16	7 24	5 26	6 19	5 17	29 102
1975	5 12	7 18	5 18	7 23	8 23	32 94
1976	3 11	6 15	7 15	5 10	6 18	27 69
1977	6 21	8 24	8 20	8 18	8 21	38 104
						155 475

Table 2. Percentage of wintertime precipitation associated with fronts for the southeastern United States during the period of study.

State	1973	1974	1975	1976	1977
Louisiana	83	86	75	68	89
Mississippi	90	90	86	87	94
Florida	86	91	74	60	84
Georgia	89	93	81	73	93
Alabama	93	86	86	78	91
East Texas	75	75	76	62	81

precipitation averages for each of the NCC subsections within the six states involved in this study. This was done for every day of the winter months of 1973 through 1977. These daily precipitation averages were then plotted on sectional maps and isoplethed at 10 mm intervals. Next, using NMC surface analyses, a record was made of each frontal episode that occurred over the southeastern United States. An episode was comprised of the time before a front entered the study area to the time the front exited. This was accomplished by recording the 0000 GMT position of the front for each day of the frontal episode on a map. The 0000 GMT frontal position was selected because it occurs approximately in the middle of the observe 24 hour total precipitation used to calculate the daily precipitation averages. Therefore it was representative of the mean position of the front during the 24 hour period. In order to check for frontal associated precipitation, the 0000 GMT frontal position for a given 24 hour period was superimposed over the daily precipitation averages for the same period. All precipitation within 100 km of the front was considered to be produced by the front. The heavy precipitation events (the precipitation deemed most likely to cause flooding) were identified. A heavy precipitation event was identified to be an area of at least 1.5 x 10^5 km^2 enclosed by the 25 mm isohyet. Each frontal episode was checked for these criteria. About 10 percent of the fronts caused heavy precipitation. No heavy precipitation was found that was not associated with a front. Five cases were selected from 15 frontal episodes which met these criteria. These cases included fronts with east-west and north-south orientations. In addition, four cases of frontal passage with little or no precipitation were chosen as a control. Table 3 is a list and brief description of each case.

3.3 Synoptic Analysis

The synoptic situation was examined for each of the nine cases. Upper air maps from 850 to 200 mb inclusive were examined for height, temperature, wind speed and direction, and where appropriate dewpoint depressions were tabulated. Also included in the analyses were stability indices, freezing levels, mean surface-500 mb relative humidity, 1000-500 mb thickness, vertical velocities, and vorticity patterns. Surface maps were examined for frontal positions in relation to many of the above parameters. Other surface parameters such as wind, temperature, etc. were examined but did not relate to the rainfall as well as the upper air parameters, thus the study of the surface was discontinued. When the individual synoptic analyses were compiled they were then compared to each other. Noting the similarities and differences in these analyses lead to the technique to forecast heavy precipitation events associated with fronts.

4. RESULTS

From the synoptic comparisons described in the previous section the most representative synoptic parameters were selected and models were developed for heavy and light precipitation associated with north to south and east to west oriented fronts. Since all maps for a given time (either 0000 or 1200 GMT) were readily available, these models show conditions for approximately 12 hours prior to the occurrence of precipitation (precipitation will begin after 1200 or 0000 GMT depending on whether the initial mapset was from 0000 or 1200 GMT), so that a 12 hour forecast may be made, and also for following 12 hour periods, of the continuation of the heavy precipitation including the location and movement of the heavy precipitation area. In actuality, though, since there is a delay in receiving the facsimile products, the 12 hour forecast periods will be somewhat displaced. In all likelihood, the initial mapset used will be complete at 0400 or 1600 GMT. Therefore, the initial forecast period will be approximately 8 hours, with the assumption that the forecast will be valid until the next mapset is available (either 1600 or 0400 GMT). The above reasoning will follow throughout the continuation of the precipitation. Therefore in reality, the forecast periods will be from either 0400 to 1600 or 1600 to 0400 GMT.

4.1 Heavy Precipitation Associated with Cold Fronts Oriented North to South

The 1000-500 mb thickness was the most important parameter which indicated that heavy precipitation would occur. When a thickness ridge starts to increase as the front approaches, the forecaster should consider forecasting heavy precipitation to begin within the next 12 hours. The area which will receive the heavy precipitation is located between the thickness ridge line and the downstream inflection point. In addition, the following conditions should exist in the area for a forecast of heavy precipitation. Some of these conditions are shown schematically in Figure 1.

1. Mean surface- 500 mb relative humidity > 70 %.

2. Vertical motions > 1 $\mu b\ s^{-1}$.

3. K-indices > 15, with representative values about 20.

4. A pressure ridge moving over the area at the standard levels 700-200 mb inclusive. The rain area will be located between the ridge line and upstream inflection point.

Table 3. List of cases selected for study.

Case Number	Date	Description
1	12-19 March 1975	A north to south cold front which moved through the study area and then returned as an east to west warm front. The front was associated with heavy precipitation as a cold and as a warm front.
2	23-29 Dec. 1973	A north to south oriented cold front with heavy precipitation.
3	4-7 Dec. 1973	A north to south cold front with heavy precipitation.
4	26-31 March 1973	A east to west oriented cold front which moved into the Gulf of Mexico and became stationary off the Gulf coast. This front had heavy precipitation associated with it.
5	4-6 Nov. 1973	A east to west oriented cold front which moved into the Gulf of Mexico and became stationary. This front had heavy precipitation associated with it.
6	8-10 Dec. 1973	North to south cold front with light precipitation associated with it.
7	15-17 Jan. 1976	North to south cold front with light precipitation associated with it.
8	15-17 March 1977	A east to west oriented cold front which became stationary as it entered the Gulf of Mexico. This front had light precipitation associated with it.
9	1-3 March 1975	A east to west oriented cold front which moved through the study area and had light precipitation associated with it.

Table 4. Verification of forecast model for fronts oriented north to south prior to the front's entrance into the study area. Any rain should be forecast to begin in approximately 8h. Legend: Y=yes, condition met; N=no, condition not met; M=condition met marginally.

Date	Thickness ridge	Mean surface-500 mb relative humidity > 73%	Vertical motions > 1½ bar s^{-1}	Ridge 700-200 mb	Winds WSW-SSW at all levels, speeds 40-50 kt at 850 mb	Diffluence at 300 mb	Dewpoint depressions ≤ 6° C at 850 and 500 mb	Thermal ridge 850-700 mb	K-index > 15	Heavy rain area determined from model.	Actual heavy rain area.	Heavy rain area from NWS forecast.	Actual heavy rain area.
0000 GMT, 17 March, 1980	Y	Y	Y	M	M	Y	Y	M[6]	Y	Eastern Louisiana Mississippi, and Alabama.	As forecast.[5]	QPF over eastern Louisiana, Mississippi, and Alabama; POP > 55%.	As forecast.
1200 GMT, 23 January, 1979	Y	Y	Y	Y	Y	M	Y	M[6]	Y	Southern Louisiana.	As forecast.	None forecast.	Southern Louisiana.
1200 GMT, 20 February, 1978	N	N	N	N	Y	N	N	M[1]	N	None.	None.	None forecast on QPF; POP <35% over southeastern United States.	None.
0000 GMT, 3 December, 1978	Y	M[2]	Y	Y	Y	M	M[3]	M[4]	Y	Louisiana, Mississippi, western Alabama.	As forecast.	QPF over Louisiana, Mississippi, and western Alabama; PoP not available.	As forecast.

[1] No at 850 and 500 mb, yes at 700 mb.
[2] RH between 65-70%.
[3] Yes at 850 mb, no at 500 mb.
[4] No at 700 mb.
[5] Severe flooding occurred in Louisiana during this passage.
[6] Yes at 850 and 700 mb, no at 500 mb.

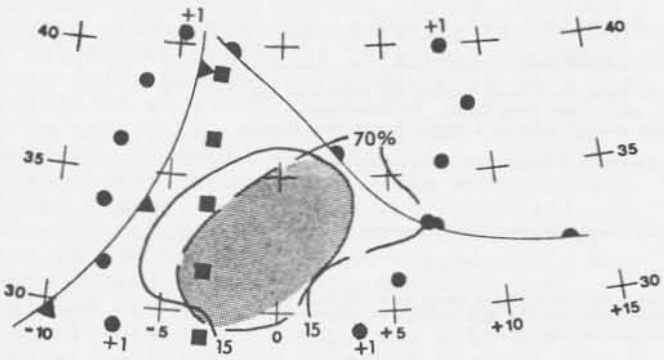

Fig. 1. Synoptic situation accompanying fronts oriented north to south 8 h prior to the occurrence of heavy precipitation. In this and all following figures the longitude identifiers have been changed to avoid the concept that the rains are in a geographic area. For these schematic composites the rain area was located and the parameters were placed in relation to the rain area. To locate the heavy rain area the opposite procedure should be followed. Legend: ▩ Rain area; ——— K-index; —— ——Mean surface-500 mb relative humidity (%); ■ ■ ■ Thickness and 850 mb thermal ridge line; ● ● ●Vertical motion (μb s^{-1}).

cribed above if the heavy precipitation is to persist. Figure 2 is a schematic of the synoptic patterns.

1. Mean surface-500 mb relative humidity > 60 %.

2. Vertical motions > 1 μb s^{-1}.

3. K-indices > 15, with values of 30 being common.

4. The pressure ridge aloft will have moved eastward so that the precipitation area is under the influence of a trough-ridge system (with the inflection point located over the heavy precipitation area).

5. Wind directions SSW-WSW.

6. Strong diffluence at 300 mb.

7. A thermal ridge located over the precipitation area at the 850-500 mb levels.

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5. Wind directions WSW-SSW at all levels with wind speeds 40-50 kt at 850 mb.

6. Slight diffluence at 300 mb.

7. Dewpoint depressions $\leq$6 C at 850 and 500 mb.

8. A thermal ridge at all levels located over the potential rain area. The 850 mb thermal ridge line will usually coincide with the 1000-500 mb thickness ridge line.

After the precipitation starts the synoptic criteria for continuation of the rain were slightly different. Once again, the 1000-500 mb thickness was the key parameter. In relation to the surface front and 1000-500 mb thickness ridge the rain area will be located between the thickness ridge line and the surface front. As the distance between the thickness ridge line and surface front decreases the rains will become heavier; the precipitation either ceases or becomes light when the surface front overtakes the thickness ridge line. In addition, the following conditions should exist in the area des-

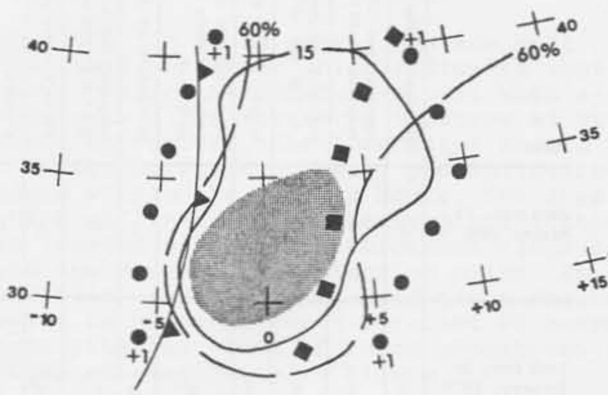

Fig. 2. Synoptic situation accompanying fronts oriented north to south during the occurrence of heavy precipitation. Legend: ▩ Rain area; ——— K-index; —— ——Mean surface-500 mb relative humidity (%); ■ ■ ■ Thickness ridge line; ● ● ● Vertical motion (μb s^{-1}).

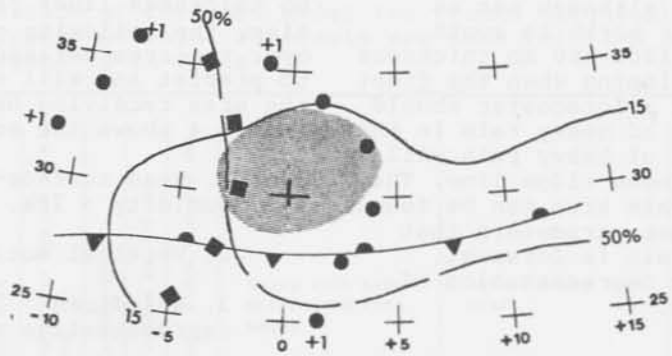

Fig. 3. Synoptic situation accompanying fronts oriented east to west 8 h prior to the occurrence of heavy precipitation. Legend: Rain area; ———K-index; — —Mean surface-500 mb relative humidity (%); ■ ■ ■ Thickness ridge line; ● ● ● Vertical motion (μb s^{-1}).

4.2 Light Precipitation Associated with Fronts Oriented North to South

Prior to and during the occurrence of light precipitation the synoptic situation was very different from the conditions occurring with heavy precipitation. If the following conditions exist as the front moves toward and through the study area heavy precipitation should not be forecast.

1. A 1000-500 mb thickness trough intensifying and moving through the area.

2. Mean surface-500 mb relative humidities < 60 %.

3. K-indices < 15.

4. A pressure trough at all levels moving into and across the area.

5. Winds WSW-NW at all levels (an exception to this was at 850 mb prior to the occurrence of light rain, the winds were NE-NW at 5-25 kt).

6. Dewpoint depressions > 12 C at 850 and 500 mb.

7. No diffluence at 300 mb.

8. Vertical motions < 1 μb s^{-1}.

4.3 Heavy Precipitation Associated with Fronts Oriented East to West

The synoptic situation for east to west oriented fronts was not defined as well as it was for north to south oriented fronts. Again, the 1000-500 mb thickness was the best parameter for identifying the heavy precipitation forecast (although not as definitive as it was for north to south oriented fronts). If a 1000-500 mb thickness ridge should begin developing when the front is along the Gulf coast a forecaster should consider the occurrence of heavy rain in the next 12 hours. The area of heavy rain will occur east of the thickness ridge line. The eastern border of the rain area can be found with the aid of the other parameters that should exist if heavy rain is forecast. Figure 3 is a schematic representation of the synoptic conditions.

1. Mean surface-500 mb relative humidity > 50%.

2. Vertical motions > 1 $\mu b\ s^{-1}$.

3. K-indices > 15 with representative values being 20 to 30.

4. A trough-ridge system located over the study area at 850, 300, and 200 mb with the system having a high amplitude at 850 mb and the rain occurring under the southwesterly winds.

5. A thermal ridge located over the area at 850 and 500 mbs.

6. Dewpoint depressions < 6 C at 500 mb.

Once the precipitation starts, as with north to south oriented fronts, the synoptic conditions for the continuation of the rainfall are somewhat different. The 1000-500 mb thickness was once again the key parameter in this situation. The thickness ridge line will be located over the western portion of the rain area and the area will be bounded on the north and south by the 5610 and 5690 mb thickness lines respectively. In addition, the following conditions should exist over the area defined above if the rain is to presist and will serve further to define the area receiving heavy precipitation. Figure 4 shows the schematic relationship.

1. Mean surface-500 mb relative humidity > 70%.

2. Vertical motions > 2 $\mu b\ s^{-1}$.

3. K-indices > 15, with representative values about 30.

4. A trough-ridge system over the study area at 850, 300, and 200 mb with the system at 850 mb having a high amplitude and the rain area located between the trough line and inflection point under north to south oriented contours.

5. A thermal ridge located over the precipitation area at 850 and 500 mb.

6. Wind directions SW at 850, 300, and 200 mb.

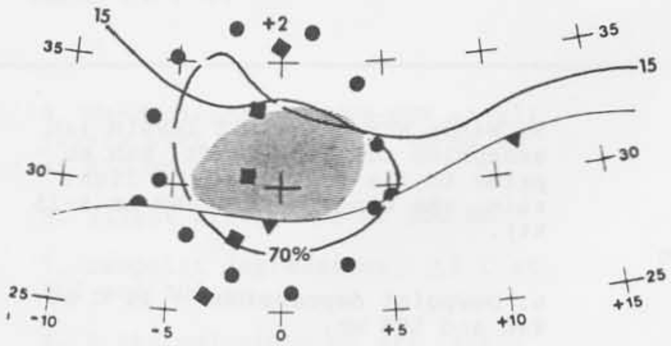

Fig. 4. Synoptic situation accompanying fronts oriented east to west during the occurrence of heavy precipitation.. Legend: [shading] Rain area; ——— K-index; — — Mean surface-500 mb relative humidity (%); ■ ■ ■ Thickness ridge line; ● ● ● Vertical motion ($\mu b\ s^{-1}$).

4.4 Light Precipitation Associated with Fronts Oriented East to West

Prior to and during the occurrence of light precipitation the synoptic situation was completely different than that occurring with heavy precipitation. If the following conditions exist as the front moves toward and through the area heavy precipitation should not be forecast.

1. A 1000-500 mb thickness trough located over the study area.

2. Mean surface-500 mb relative humidities < 50%.

Table 5. Verification of forecast model for fronts oriented north to south during the occurrence of rain. Forecasts are made for 12-h periods using initial data. Legend as in Table 4.

Date	Thickness ridge	Mean surface-500 mb relative humidity > 60%	Vertical motions > 1 μ bar s^{-1}	K-index > 15	Trough-ridge system at all levels	Winds WSW-SSW	Diffluence at 300 mb	Thermal ridge 850-700 mb	Heavy rain area determined from model.	Actual heavy rain area.	Heavy rain area from NWS forecast.	Actual heavy rain area.
1200 GMT, 17 -0000 GMT, 18 March, 1980	Y	Y	Y	Y	Y	Y	Y	Y	Louisiana, Mississippi, and western Alabama.	As forecast.	QPF over Louisiana Mississippi, western Alabama; POP > 65%.	As forecast.
and												
0000 GMT-1200 GMT, 18 March, 1980	Y	Y	Y	Y	Y	Y	M	Y	Georgia, Alabama, and southeastern Mississippi.	As forecast.	QPF over Georgia, Alabama, and eastern Mississippi; POP > 65%.	As forecast.
0000 GMT-1200 GMT, 25 January, 1979	Y	Y	Y	Y	Y[1]	Y	Y	Y	Eastern Mississippi Alabama, and western and southern Georgia.	Many stations in forecast area > 25 mm, but most < 25.	QPF over southeastern Mississipp Alabama, and Georgia; > POP 55%.	Many stations in forecast area>25 mm.
0000 GMT-1200 GMT, 21 February,	N	N[2]	N	N	N	Y	N	M	None.	None.	None from QPF; POP over southeastern United States < 25%.	None.
and												
1200 GMT, 21-0000 GMT, 22 February,	N	N[3]	N	M	N	M	N	M.	None.	None.	None from QPF; POP over southeastern United States < 25%.	None.

Date	Thickness ridge	Mean surface-500 mb relative humidity > 60%	Vertical motions > 1 μ bar s^{-1}	K-index > 15	Trough-ridge system at all levels	Winds WSW-SSW	Diffluence at 300 mb	Thermal ridge 850-700 mb	Heavy rain area determined from model.	Actual heavy rain area.	Heavy rain area from NWS forecast.	Actual heavy rain area.
1200 GMT, 3-0000 GMT, 4 December,	Y	Y[4]	Y	Y[4]	Y	Y	Y	Y	Louisiana, Mississippi, and northwest Alabama.	As forecast.	QPF over Louisiana Mississippi, and northwest Alabama; POP > 45%.	As forecast.
and												
0000 GMT-1200 GMT, 4 December,	Y	Y	Y	M	Y	Y	Y	Y	Louisiana, Mississippi, and western Alabama.	As forecast.	QPF over Louisiana Mississippi, and western Alabama; POP > 75%.	As forecast.
and												
1200 GMT, 4-0000 GMT, 5 December,	Y		Y	Y	Y	Y	N	Y	Georgia, southeastern Alabama.	As forecast.	QPF over Georgia, southeastern Alabama; POP > 85%	As forecast.

[1] Inflection point on fringe of area 500-200 mb.
[2] Relative humidity 60% only over extreme northern Louisiana and Mississippi.
[3] Relative humidity 60% only over extreme northern portion of the study area.
[4] All but central Mississippi.

Table 6. Verification of forecast model for fronts oriented east to west prior to the occurrence of rain. Using initial maps, any heavy rain should be forecast to begin in approximately 8h. Legend as in Table 4.

Date	Thickness ridge	Mean surface-500 mb relative humidity > 50%	Vertical motions > 1μbar s⁻¹	K-index > 15	Trough-ridge system 850, 300, and 200 mb	Thermal ridge 850 and 500 mb	S winds	Dewpoint depressions < 6°C at 500 mb	Heavy rain area determined from model.	Actual heavy rain area.	Heavy rain area from NWS forecast.	Actual heavy rain area.
0000 GMT-1200 GMT, 20 March, 1980	M	Y	M	Y	N	M[3]	N	Y	None.	Light rain over Louisiana, Mississippi, and Alabama, only one small section > 25 mm.	None on QPF; POP > 45% over Louisiana, Mississippi, and Alabama.	Light rain over POP forecast area; one small section > 25 mm.
1200 GMT, 14-0000 GMT, 15 December, 1978	N	N	N	N	N	N	N	N[2]	None.	None.	None on QPF; POP over southeastern United States < 25%.	None.
0000 GMT-1200 GMT, 21 January, 1980	M[1]	Y	M	Y	N	M[3]	N	Y	No widespread heavy rain, perhaps a few scattered showers over East Texas, Louisiana, and Mississippi.[4]	Light rain over majority of area defined on left, two small sections > 25 mm.	QPF shows 50 mm rainfall over East Texas, Louisiana, and Mississippi; POP over area > 65%.	Light rain over majority of forecast area; two small sections > 25 mm.

[1] Small, flat ridge.
[2] Very small section, over extreme western portion of the study area.
[3] No at 850 mb, yes at 500 mb.
[4] Since thickness ridge marginal a few scattered heavy showers may occur.

Table 7. Verification of forecast model for fronts oriented east to west during the occurrence of rain. Forecasts are made for 12-h periods. Legend as in Table 4, with the addition of: N/A=data not available.

Date	Thickness ridge	Mean surface-500 mb relative humidity > 70%	Vertical motions > 3μbar s⁻¹	Trough-ridge system at 850, 300, and 200 mb	SW winds	Thermal ridge at 850 and 500 mb	K-index > 15	Heavy rain area determined from model.	Actual heavy rain area.	Heavy rain area from NWS forecast.	Actual heavy rain area.
1200 GMT, 20-0000 GMT, 21 March, 1980	M	N/A	M	M[4]	M[4]	N	N/A	No widespread hea rain, perhaps a few scattered showers over area.[5]	None.	None on QPF; POP > 55% over Alabama.	None.
0000 GMT-1200 GMT, 15 December, 1978	N	N	N	N	N	M	N	None.	None.	None on QPF; POP over southeastern United States < 25%.	None.
and											
1200 GMT, 15-0000 GMT, 16 December, 1978	N	M[2]	N	N	N	M[1]	M[2]	None.	None.	None on QPF; POP < 25%.	None.
and											
0000 GMT-1200 GMT, 16 December, 1978	N	N	N	M[4]	M[4]	M[3]	Y	None.	None.	None on QPF; POP < 25%.	None.
1200 GMT, 21-0000 GMT, 22 January, 1980	N	Y	N	N	M[4]	M[1]	Y	None.	Scattered heavy showers over Texas.	QPF shows > 25 mm over East Texas and Louisiana; POP 15-55%.	Scattered heavy showers over Texas.
and											
0000 GMT-1200 GMT, 22 January, 1980	N	Y	M	N	N	Y	Y	None	Scattered heavy showers over Texas.	QPF shows > 25 mm over East Texas and Louisiana; POP 25-55%.	Scattered heavy showers over Texas.

[1] Yes at 850 mb, no at 500 mb.
[2] Almost entire study area > 15 only southern third Louisiana 15-30. This area also has RH 70%.
[3] Weak ridge at 850 mb.
[4] Yes at 850 mb, no at 200 and 300 mb
[5] Since thickness ridge marginal forecast a few heavy showers.

3. K-indices < 15.

4. Vertical motions < 1 $\mu b\ s^{-1}$.

5. A thermal trough located over the study area at 850 and 500 mb.

6. Dewpoint depressions $\geq$12 C at 500 mb as the front becomes stationary.

7. Wind directions of W-NW at 850, 300, and 200 mb.

5. VERIFICATION

Frontal passage situations that occurred after March 1977 were used to verify the effectiveness of the proposed forecasting models. These will serve as an example of application. These verifications are shown in Tables 4-7. Each forecast parameter for the test cases was examined to see if it met the model criteria and entered into a table by the use of yes (Y), no (N), or marginal (M). After this was done, the heavy rain area (if any) as forecast by these models was compared to the Quantitative Precipitation Forecast and Probability of Precipitation rainfall areas forecast by the National Weather Service, and to the actual precipitation areas. As the tables show, for north to south oriented fronts, the developed forecast models compared favorably with the National Weather Service guidance. On a positive note, the proposed models verified one heavy rainfall event that the National Weather Service missed. For east to west oriented fronts the developed models also performed reasonably well. In most cases when the models and National Weather Service forecast no widespread heavy precipitation none occurred (although there a few areas of localized heavy precipitation, this probably would not lead to extensive severe flooding). Again, in one case when the Quantitative Precipitation Forecast forecast a widespread area of heavy precipitation, and the new model did not, the new model was a slight improvement (some small sections of the area in question did have 25mm of precipitation).

Although not formally presented, the synoptic conditions accompanying all the fronts for the winter season of 1979-1980 were observed. No cases were observed that met the conditions of the model that heavy rainfall did not occur and no heavy rain occurred when not forecast. It is realized that one year is not a large sample and that the model could forecast heavy rain and the rain not occur.

6. SUMMARY AND CONCLUSION

The meteorological parameters causing heavy or light rains associated with wintertime fronts in the southeastern United States have been identified. It was found that certain synoptic characteristics distinguish the heavy from light precipitation cases. The key parameter for both north to south and east to west oriented fronts was the 1000-500 mb thickness. A thickness ridge will be present in the heavy rain cases, while the light rain cases will have a thickness trough. In addition several other parameters are noted as being unique to the heavy rain cases. To test the use of the above information as a forecasting tool a verification was performed. This verification showed the technique worked well at forecasting and pinpointing areas of heavy precipitation.

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