THE NORTHERN GULF LOW OF FEBRUARY 14, 1953

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INTRODUCTION

At midnight February 13, a small area of light rain had appeared over Texas from Austin and Junction southward. Within six hours, thunderstorms and rain were spreading eastward into the Gulf States as far as southern Alabama. By nightfall of the 14th, southern Mississippi and Louisiana had experienced flooding and local damage from heavy rains and gusty north winds. Severe turbulence and thunderstorm activity were disrupting air traffic flow from the Florida coast to southern Louisiana.

From the evaluation of weather data and synoptic charts it was apparent that a storm possessing several remarkable characteristics had moved across the northern Gulf of Mexico. It is the purpose of this study to present some of these features and to offer possible explanations for their occurrence.

LOW LEVEL SYNOPTIC FEATURES

In the period from February 11–13 a cold front had moved across the eastern United States and the Gulf of Mexico leaving a vast body of polar air over the area it had traversed. At 1230 GMT on the 13th, the polar front was quasi-stationary and lay across the southern Gulf to the central Mexican coast and northwestward across Mexico into western New Mexico. At this time a small cyclonic circulation was generating on the front near the southern Arizona-New Mexico border in conjunction with a cold Low aloft over southern Arizona. During the next 18 hours, the surface Low traveled southward and its circulation increased as the central pressure dropped to an estimated 1000 mb. By 0630 GMT on the 14th (fig. 1), the Low lay 50 miles north of Torreon, Mexico (station 382) in the Sierra Madre Oriental. The polar front extended eastward crossing the coast 75 miles south of Brownsville, Tex. Meanwhile the polar High center had weakened slightly and shifted from northeastern Texas to southwestern Georgia. At this time a north-south isallobaric discontinuity line appeared 100 miles west of Brownsville suggesting the formation of a new Low on the polar front between Brownsville and Monterrey, Mexico, 170 miles west. By 1230 GMT that day (fig. 2), the new Low had moved across the southernmost tip of Texas to 27° N., 97° W. and had deepened to a central pressure estimated at 1002 mb. Twelve hours later (fig. 4), the Low was centered 70 miles south of Pensacola, Fla., and was moving east-northeastward at approximately 50 knots. Its central pressure had decreased to 1000 mb. or less. New Orleans District Forecasters estimate that the pressure gradient, computed from time-space considerations of the passage of isobars at New Orleans, would indicate a central pressure near 996 mb. Accelerated deepening took place as the Low turned inland across Georgia and moved up the Atlantic coast.

The six-hourly surface analyses in figures 1 through 4 show the passage of the storm across the Gulf and give some idea of the attendant weather distribution. The increase of thunderstorm intensity in extreme western

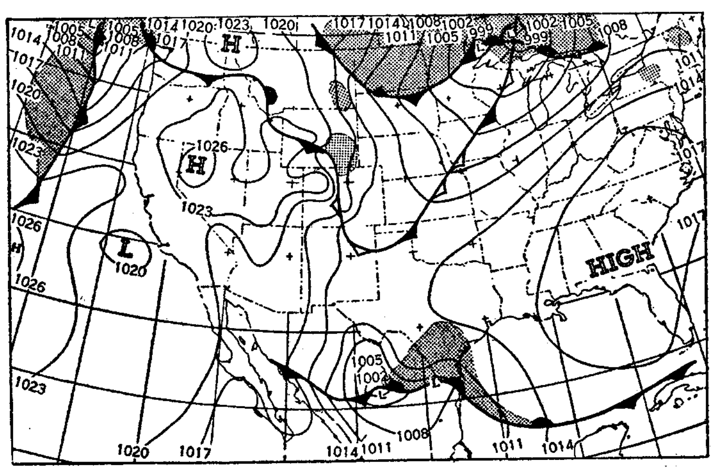

FIGURE 1.—Surface weather chart for 0630 GMT, February 14, 1953, showing the development of the Low along the polar front across Mexico with the precipitation north of it.

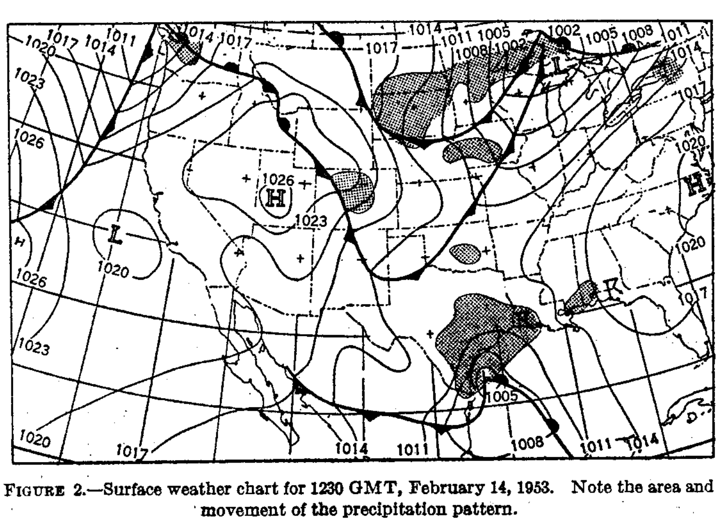

FIGURE 2.—Surface weather chart for 1230 GMT, February 14, 1953. Note the area and movement of the precipitation pattern.

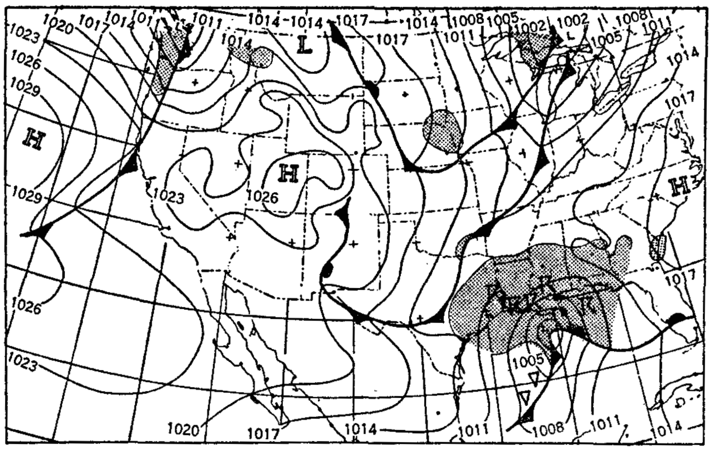

Figure 3.—Surface weather chart for 1830 GMT, February 14, 1953. Concentration of the thunderstorm activity is along the coast.

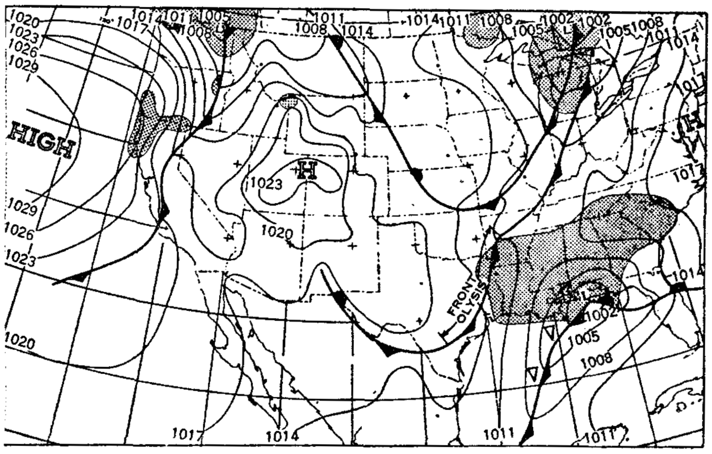

Figure 4.—Surface weather chart for 0030 GMT, February 15, 1953. About 3 hours later the surface center moved inland near Panama City, Fla.

Florida with the approach of the storm crest was associated with heavy rains. Pensacola reported a rainfall total of 3.10 inches during the six hours ending at 0030 GMT on the 15th.

The 850-mb. chart of 0300 GMT on the 15th (fig. 5) illustrates the unusual strength of the cold front. Although at this level the cold front joins the warm front in a single crest, the Miami District Center has pointed out the strong likelihood of several smaller cyclonic perturbations along the surface polar front. The Low center whose passage across the Gulf has been described was apparently the one associated with the crest aloft and might logically be assumed to be associated with the most intense weather.

The absence of thunderstorms in weather reports from ships in the mid-Gulf area, in contrast to the many reported along the Gulf Coast, suggests that convective activity was at a maximum north of the frontal system. From pilot reports and coastal radar reports, as well as station reports of thunderstorm intensity, it appears likely that airmass turbulence increased toward the wave crest. The constant pressure charts at low levels indicate the

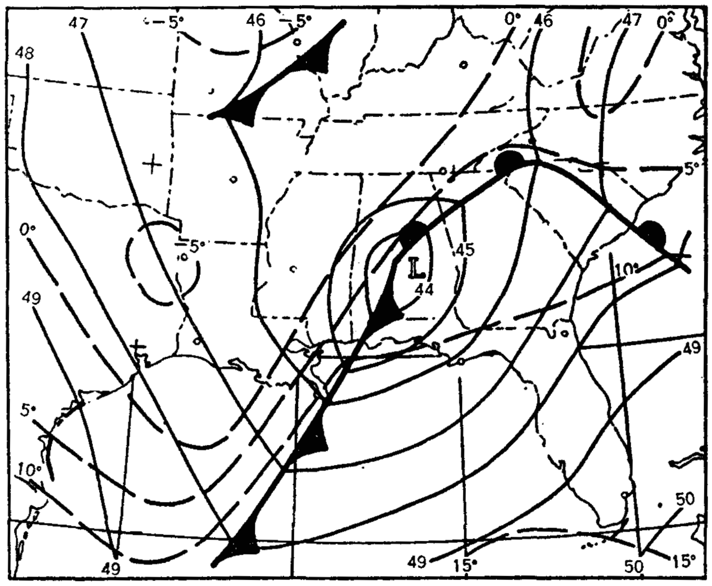

Figure 5.—850-mb. chart for 0300 GMT, February 15, 1953, showing the intensity of isotherm packing associated with the cold front.

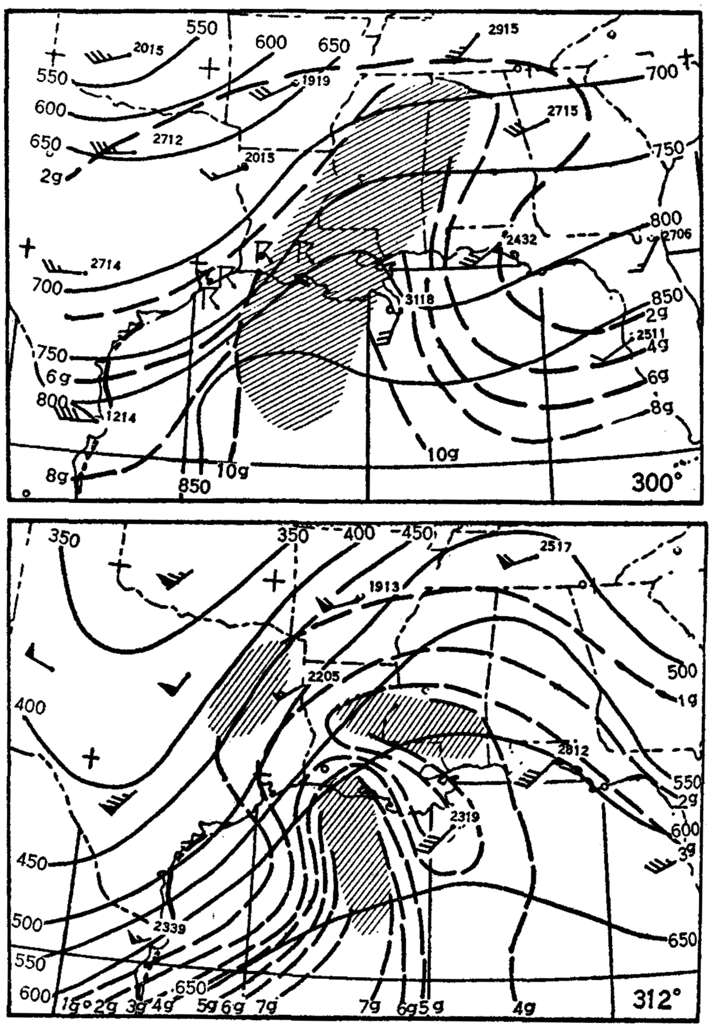

Figure 6.—300° A. and 312° A. isentropic surfaces for 1500 GMT, February 14, 1953. Pressure (solid lines) in millibars. Moisture (dashed lines) in grams per kilogram. Hatched area indicates saturation. Numbers indicate the thermal winds (ddff), direction in tens of degrees and force in knots.

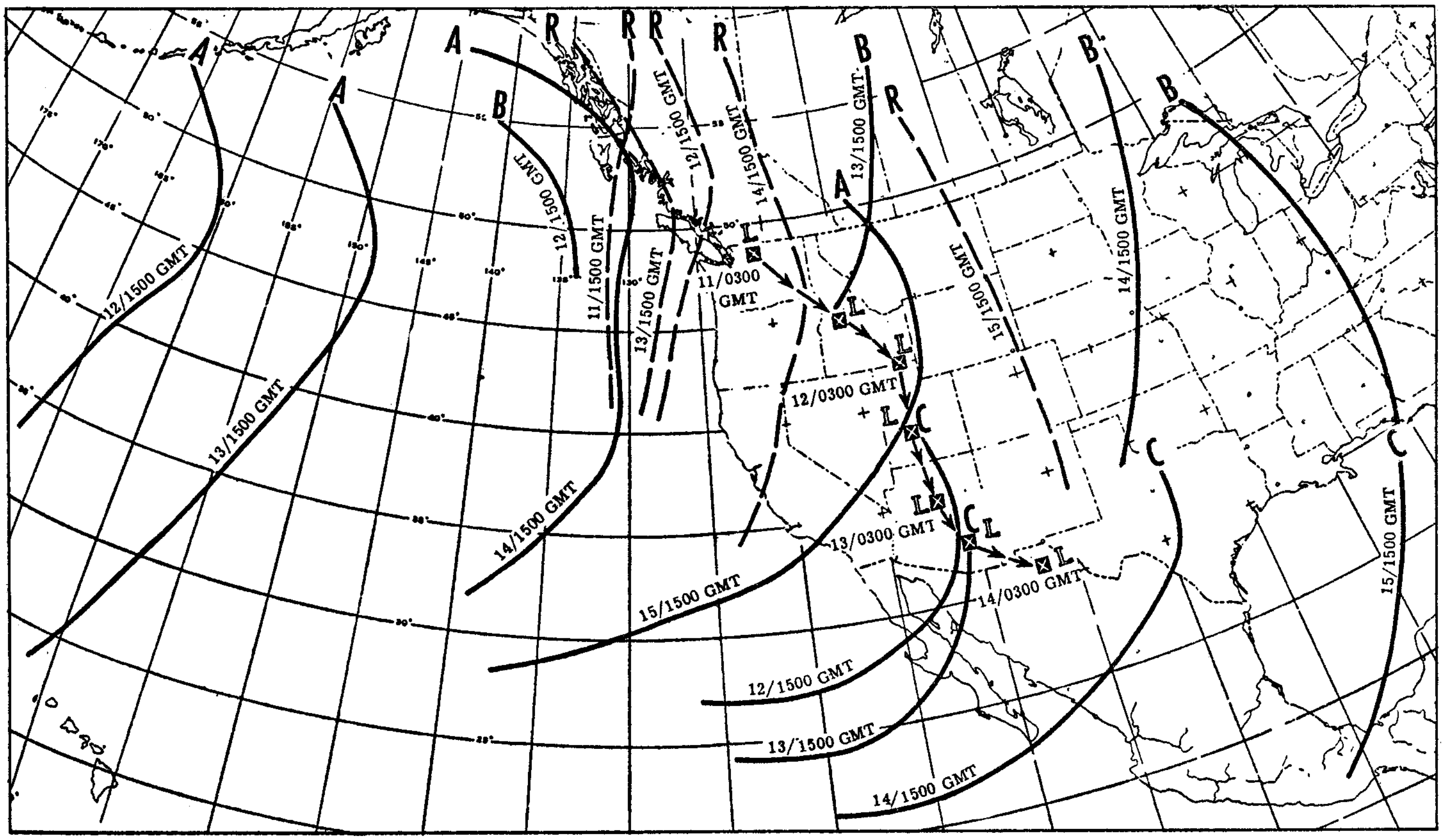

FIGURE 7.—500-mb trough-ridge analysis. Solid lines indicate troughs at 24-hour intervals, dashed lines indicate the ridge (R) at 24-hour intervals, and the arrow indicates the track of the Low (L) at 12-hour intervals. (A) indicates the Pacific trough, (B) the Canadian trough, and (C) the Southwest trough.

pronounced thrust of cold air against the moist air in advance of it. The vertical action is further clarified by the isentropic analyses for 1500 GMT on the 14th shown in figure 6. From an examination of the soundings, the 300° A. and 312° A. potential temperature surfaces were chosen in order to portray the interaction of dry and moist tongues taking place between low and intermediate levels. The drive eastward of the dry tongue at 312° produced sufficient convective instability over southernmost Louisiana to result in a break-through of moisture from the lower levels into this dry air. Soundings 12 hours later revealed pronounced vertical diffusion of moisture with the trend toward stabilization in the moist air as thunderstorms disappeared and steady rainfall developed.

The turbulence of the atmosphere north of the wave was quite evident in the chaotic pressure traces delineated by barograms at stations from southern Louisiana through southern Alabama and westernmost Florida. These barograms have been studied by the members of the Weather Bureau Pressure Jump Project who identified two predominate features of tendency behavior. One consisted of a line of sharp pressure drops whose magnitude was of the order of 0.140 inch in ten minutes, the other a line of pressure jumps of the order of 0.100 inch in ten minutes. The isochrones of pressure drop showed an average speed of 63 m. p. h. northeastward in a direction normal to the isochrones. The pressure jump isochrones averaged 32 m. p. h. east-southeastward, intersecting the drop isochrones along a line from a point just west of New Orleans at 2200 GMT on the 14th to a point 40 miles south of Mobile near 0000 GMT on the 15th and to just south of Marianna, Fla., by 0230 GMT. To the north of the intersection line the jump preceded the drop, to the south the drop preceded the jump. The interpretation given to these pressure variations is that they reflect marked local fluctuation of the frontal surface. Consequently adjacent to the line of intersection the almost simultaneous reversal of pressure change of the magnitude involved would produce extremely chaotic air motions.

500-MB. FEATURES

In the following discussion, frequent reference will be made to the 500-mb. trough-ridge analysis in figure 7. In the first two weeks of February, high level circulation patterns had maintained a regime of relatively large amplitude waves slowly retrograding westward over North America. By the tenth of the month the 500-mb. ridge lay along the west coast between two main troughs. The first of these extended from the Dakotas southwestward; the second trailed southward from a Low at 45° N., 175° W. A cold tongue was moving across the top of the west coast ridge into western Canada, forming a closed Low (L) over northern Washington by 0300 GMT on the 11th

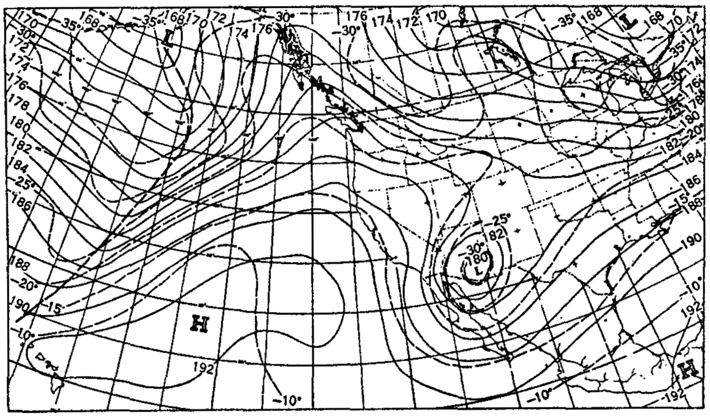

FIGURE 8.—500-mb. chart for 1500 GMT, February 13, 1953. Contours (solid lines) are labeled in hundreds of geopotential feet. Isotherms (dashed lines) are in °C. This is the chart from which the Fjørtoft prognosis was constructed.

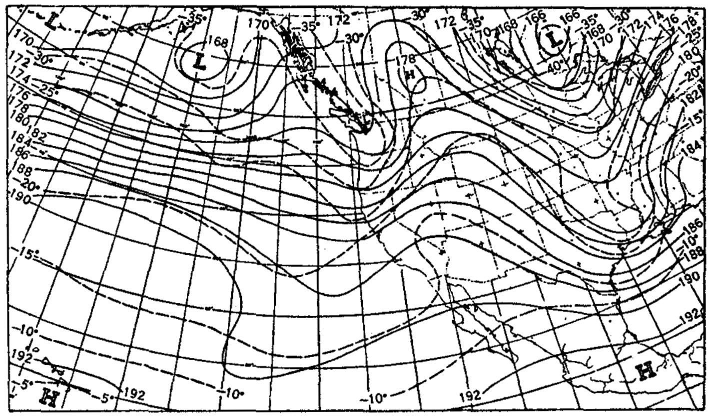

FIGURE 10.—500-mb. chart for 0300 GMT, February 15, 1953. Note the movement of the Southwest trough and the alignment of this trough and the Canadian through.

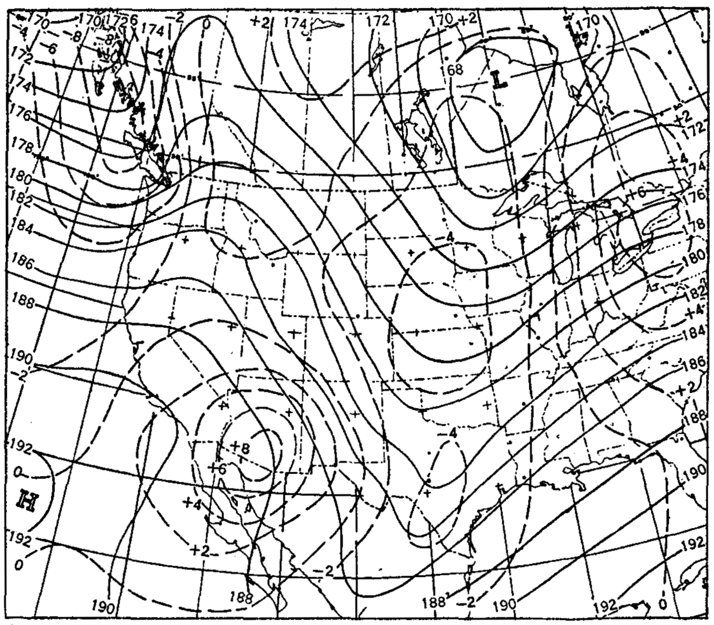

FIGURE 9.—500-mb. chart for 1500 GMT, February 14, 1953. 24-hour height changes (dashed lines) are drawn for 200-foot intervals.

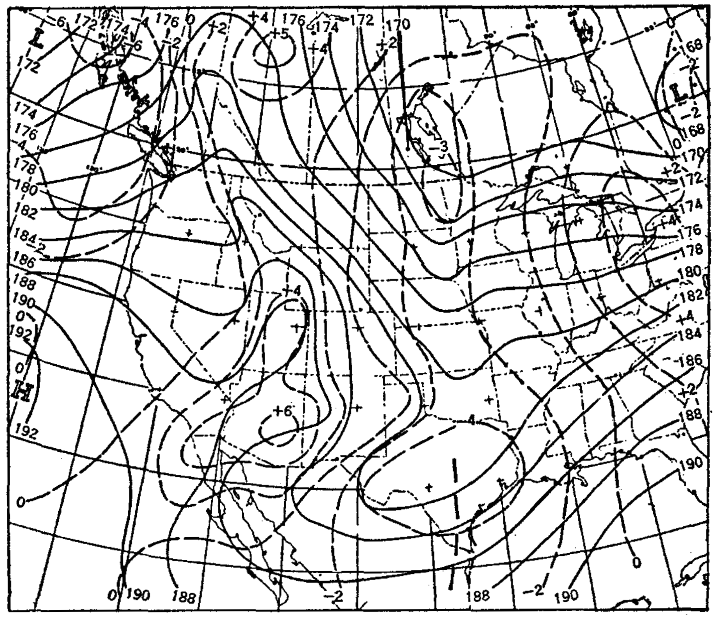

FIGURE 11.—500-mb. 24-hour prognostic chart verifying at 1500 GMT, February 14, 1953, with 24-hour prognosticated height changes (dashed lines) using Fjørtoft integration method. Compare the location of the centers of height changes with the actual 24-hour changes of figure 9.

(fig. 7). The Low (L) then moved southward, reaching southern Arizona by 1500 GMT on the 13th. Meanwhile another cold tongue (B) had made its way from the southern Gulf of Alaska into Alberta and Montana. Pacific trough (A) had accelerated eastward, reaching 155° W. at this time.

By 1500 GMT on the 14th, Pacific trough (A) was entering the west coast, displacing ridge (R) ahead of it, and forcing the Arizona Low (now trough C) eastward to join trough (B) over eastern Texas. The eastward push of cold air in trough (C) produced a steep thermal gradient of 9° C. between Brownsville and San Antonio at 500 mb. In turn the southwest wind belt from southern Texas to Georgia suddenly strengthened to form a jet whose maximum velocity was at least 80 knots. Simultaneously the surface Low beneath it assumed its rapid movement across the Gulf.

Although trough B-C was moving eastward at an average speed of 30 knots, the centers of 12-hour height fall and surface pressure fall were moving to the east at 40–45 knots and maintaining a separation of about 450 miles. This suggests that the strong winds over the path of the Low were related rather directly to the rapid movement of the Low. The movement of trough B-C is not to be ignored, but the possibility is suggested that the impulse associated with its motion traveled eastward with a speed exceeding that of the trough.

The 500-mb. charts (figs. 8 and 10) at 1500 GMT on the 13th and 0300 GMT on the 15th portray conditions preceding and following the Gulf storm. As has been summarized above, the integration of several important actions took place in producing the marked difference in circulation patterns shown by these charts. The 500-mb. chart for 1500 GMT on the 14th (fig. 9) shows the pattern at the time when complete integration took place, coinciding with the development and movement of the surface storm. It is probable that the low level action would have been weaker or even absent if these several actions had not combined simultaneously as shown. In particular, the cold tongue at 500 mb. moved from Montana southeastward in time to reinforce the cold air moving out of Arizona. This junction in the east Texas region was at a critical time and place to have the maximum effect upon the surface Low starting out over the northwestern Gulf. This in turn could not have occurred if the oncoming Pacific trough had not displaced the west coast ridge, with resultant shift of the Arizona Low and trough.

500-MB. PROGNOSIS

From the preceding summary it is clear that a prognostic 500-mb. chart constructed to verify at 1500 GMT on the 14th should include the following features to be accurate:

1. The Pacific trough and zonal flow over the Pacific region.
2. The major trough in the middle of the country, composed of the developing trough from Montana and the cold trough from Arizona.
3. The eastward movement of height falls imbedded in a strong southwest wind current over the northern Gulf.

In the preparation of such a prognostic chart by subjective methods the following facts up to and including the charts of 1500 GMT on the 13th were noted:

1. The Pacific trough was moving eastward, the 500-mb. level at ship station "Q" west of the trough showing persistent warming with strengthening west wind.
2. Isotherms in the cold air over western Canada were moving southeastward at a regular rate, with the speed of the wind normal to them.
3. The axis of the 12-hour height tendency field around the Arizona Low was rotating from north-south to northwest-southeast by 1500 GMT on the 13th.
4. The thermal and contour gradients in the soutly east quadrant of the Arizona Low were slowh-tightening.

From the above considerations the general trend of events might have been determined subjectively 24 hours in advance. The specific trend was more difficult to assess, unless an objective approach could be found. In an attempt to meet this requirement, the construction of a 24-hour prognostic 500-mb. chart was made from 1500 GMT on the 13th, utilizing the vorticity integration technique presented by Fjørtoft [1]. Although the technique is tedious and lengthy, it has the advantage of objectivity. Essentially what is done is to determine the upper flow pattern and height changes 24 hours in the future, assuming that the absolute vorticity is conserved and moves with the direction and strength of the computed mean flow pattern. The method was followed exactly, except that 80 percent of the geostrophic wind was used in advecting the vorticity field, as recommended by Cressman [2]. The prognostic chart and the actual verification at 1500 GMT, February 14, are shown in figures 11 and 9. The merging of troughs in the center of the country, the change to zonal flow off the west coast, and the development of strong winds over the Gulf region are indicated quite well. The 24-hour height change patterns also show good agreement with respect to location and orientation. The eastward shift of height falls from southern Arizona to Texas is perhaps the most significant single feature. The forecasted trough through the western States is approximately 18 hours too fast. This error is due to marked change in mean flow pattern over the Pacific and perhaps in part to possible error of original analysis over the ocean. The forecasted "hang-back trough" over northern Mexico is an error possibly due to original analysis error over areas where data are lacking, and to location on the fringe area of computation.

COMPARISON WITH OTHER GULF CYCLONES

It was also of interest to compare this case with the rather extensive study of Gulf cyclones by Saucier [3] in 1949. Despite the unusual speed and depth of this particular cyclone the preceding conditions for formation which he describes apply here. In accordance with his findings, evidence of westward retrogression of high level mean trough patterns was present, and polar air had invaded the eastern United States prior to the development. Some difference enters during the period that the Low traveled across the Gulf. The polar outbreak accompanying movement of the storm was stronger than the outbreak preceding storm formation. The second principal difference was the complete breakdown of low index to the west of the storm's longitude. Nevertheless these variations should not be construed to contradict in any way the findings of Saucier since the storm itself is by no means a classic example of the usual northern Gulf cyclone.

CONCLUSIONS

The review of this storm situation brought forth an appreciation of the influence of rapid air motion in both distorting and intensifying the interaction of airmasses. The remarkable integration of a variety of motions in the higher atmosphere is not often so clearly defined as it was in this case. The ability of the Fjørtoft technique to anticipate this integration implies that in this particular case the translation of a vorticity field already set up 24 hours in advance played a major part in the outcome.

ACKNOWLEDGMENTS

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1. R. Fjørtoft, "On a Numerical Method of Integrating the Barotropic Vorticity Equation", *Tellus*, vol. 4, No. 3, August 1952, pp. 179–194.
2. G. P. Cressman, "An Application of Absolute-Vorticity Charts", *Journal of Meteorology*, vol. 10, No. 1, February 1953, pp. 17–24.
3. W. J. Saucier, "Texas-West Gulf Cyclones", *Monthly Weather Review*, vol. 77, No. 8, August 1949, pp. 219–231.

CORRECTION

MONTHLY WEATHER REVIEW, vol. 80, No. 11, November 1952, p. 204: In footnote 3, ratio for making frequencies taken by 10° squares at 30° N. comparable to those taken at 40° N. should be cos 40°/cos 30°, *not* sin 30°/sin 40°.

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