

## DAILY WEATHER MAPS AS ILLUSTRATIONS OF WEATHER TYPES

JACK RICHARD VILLMOW

*Department of Geography, The Ohio State University, Columbus 10*

Within the last fifteen years climatologists have grown increasingly aware of the significance of the circulation of the air at middle and high levels to the patterns of surface weather phenomena. The first awareness of the existence of the Jet Stream during the early 1940's opened the door to many discoveries of the relation of upper air phenomena to surface expression.

It is the purpose of this paper to point out a limited number of such relationships which are clearly demonstrable on the United States Government's *Daily Weather Map*. On the *Daily Weather Map* an upper air chart, titled the "500 Millibar Constant Pressure Chart" shows, by means of contour lines, the height in feet of the pressure level surface for 500 mbar of air pressure, determined by radiosonde observations. Air circulation is most active where these contour lines are closest together; hence the Jet Stream is easily identified by noting those areas of contour line concentration.

Jet Stream flow is most significant in concentrating middle and upper air flow; in directing the movement of surface pressure systems; in establishing areas of convergence; and, under favorable conditions, in establishing areas of precipitation.

The succeeding weather map examples will point out the more important relationships between middle and upper air Jet Stream flow and surface weather phenomena.

### *Arctic Outbreak (Figure 1)*

*January 18, 1957.*—The 500 mbar constant pressure chart is dominated by a large trough over the eastern half of the United States. Jet Stream flow is favorable for the rapid movement southward to the Gulf of Mexico of continental Arctic air, produced in northwestern Canada and Alaska. The map of North America in the upper left shows a ridge of high pressure at the surface extending from Alaska south to northeastern Mexico, a distance of 2500 mi. Rapid feeding southward of fresh Arctic air carried the 32° isotherm south of the Rio Grande on the border between Texas and Mexico, to the mouth of the Mississippi (New Orleans had a reading of 28°) and into northern Florida. Zero readings were carried as far south as the Ohio valley, and as far east as southern New England. A new state record low of -55° was established in New York state, and Boston had the second coldest January day in its history.

### *Diverging and Converging Jet Stream Flow (Figure 2)*

*January 29, 1957.*—The 500 mbar constant pressure chart shows a peculiar pattern of upper air flow: a strong upper air jet over northwestern Canada diverges into two distinct jets, one bending over the Pacific Ocean and looping southward over Lower California in a marked trough, then shoots northeastward over the United States. The second jet moves more directly from northwestern Canada south and east to New England where it merges with the Jet from the southwest. The trough over Lower California is associated with rather extensive precipitation over southwestern United States (note the movement of the surface low from the San Francisco area south to Los Angeles). The bifurcation of the jet in northwestern Canada has taken part of the continental Arctic air into northwestern United States (much of eastern Washington and Oregon and all of Idaho lies within the zero isotherm); the larger part of the continental Arctic air, however,

has moved southeastward into the United States; immediately north of Lake Superior a reading of  $-53^{\circ}$  is observed on the map. Convergence of the two jets in eastern United States results in an extremely complex surface weather map: many frontal systems, several low centers, and extensive areas of precipitation bear witness to great activity in the upper air.

#### *Spring (Figure 3)*

*March 14, 1957.*—The 500 mbar constant pressure chart shows a rather simple pattern of a trough over the central and southern Rocky Mountains and a ridge over the eastern half of the United States. The trough insures extensive precipitation over the plains states largely in the form of snow for the air is still very cold. Although most concentrated in the neighborhood of the trough, the upper air jet stream is still effective enough in eastern United States to steer surface lows northeastward drawing warm, moist Gulf air as far north as Chicago where  $70^{\circ}$  was recorded. The presence of the subtropical high of the North Atlantic over a portion of the east coast of the United States resembles the "Heat Wave" situation which occurs several months later. The southern Appalachians receives heavy amounts of orographic precipitation as air moves from the subtropical high to the continental low.

#### *Ridge—Trough Pattern (Figure 4)*

*June 2, 1956.*—A well-marked ridge in western United States, and an equally well-marked trough east of the Mississippi River introduce a marked contrast across the breadth of the country. Associated with the ridge at high levels in the west is dominantly fair weather with 90-degree readings extending northward to the Canadian border (Havre, Montana had  $92^{\circ}$ ). Rather concentrated jet flow due south from the James Bay area to the Gulf of Mexico is in a position to dominate the weather of the Mississippi valley; readings in the 40's and 50's are common in the Great Lakes and Ohio River areas. The east side of the trough with a strong southerly flow from the Gulf of Mexico carries cloud and rain along the entire eastern seaboard.

#### *Summer Heat Wave (Figure 5)*

*July 27, 1955.*—Essentially a very simple pattern, the 500 mbar constant pressure chart shows most of the eastern half of the country is dominated by a massive ridge whose center lies over the southern Appalachians. A minor trough lies over the Pacific northwest, and the jet stream moves quickly around the southern edge of this trough and on into southern Canada leaving the continent north of Newfoundland. Heavy precipitation is concentrated in Washington and Oregon as a result of the trough aloft as well as the surface and upper level convergence features. Most of the remainder of the country is dominated by the subsiding air of the extensive high; winds aloft and at the surface are from a southerly direction, and Tropical maritime air is nearly everywhere. Ninety-degree readings cover two-thirds of the country, from California east and north to Montana and thence eastward to New England. Over 100-degrees was recorded as far north as Minneapolis and as far east as Milwaukee.

#### *Early Fall (Figure 6)*

*August 19, 1956.*—Fresh Polar continental air masses from north central Canada can easily invade the United States when the upper air pattern on the 500 mbar constant pressure chart shown here is dominant. Concentrated flow southward from northern Canada, and then eastward over northern United States brings daytime readings in the cool 70's southward to the Ohio valley, and nighttime readings in the low 40's to the Lake Superior area. Dominance of the high aloft over southeastern United States produces readings in the low 100's from the Rio Grande to the southern Appalachians; this area and the desert country in the far west remain the only areas to escape the cooling effect of the Canadian air.

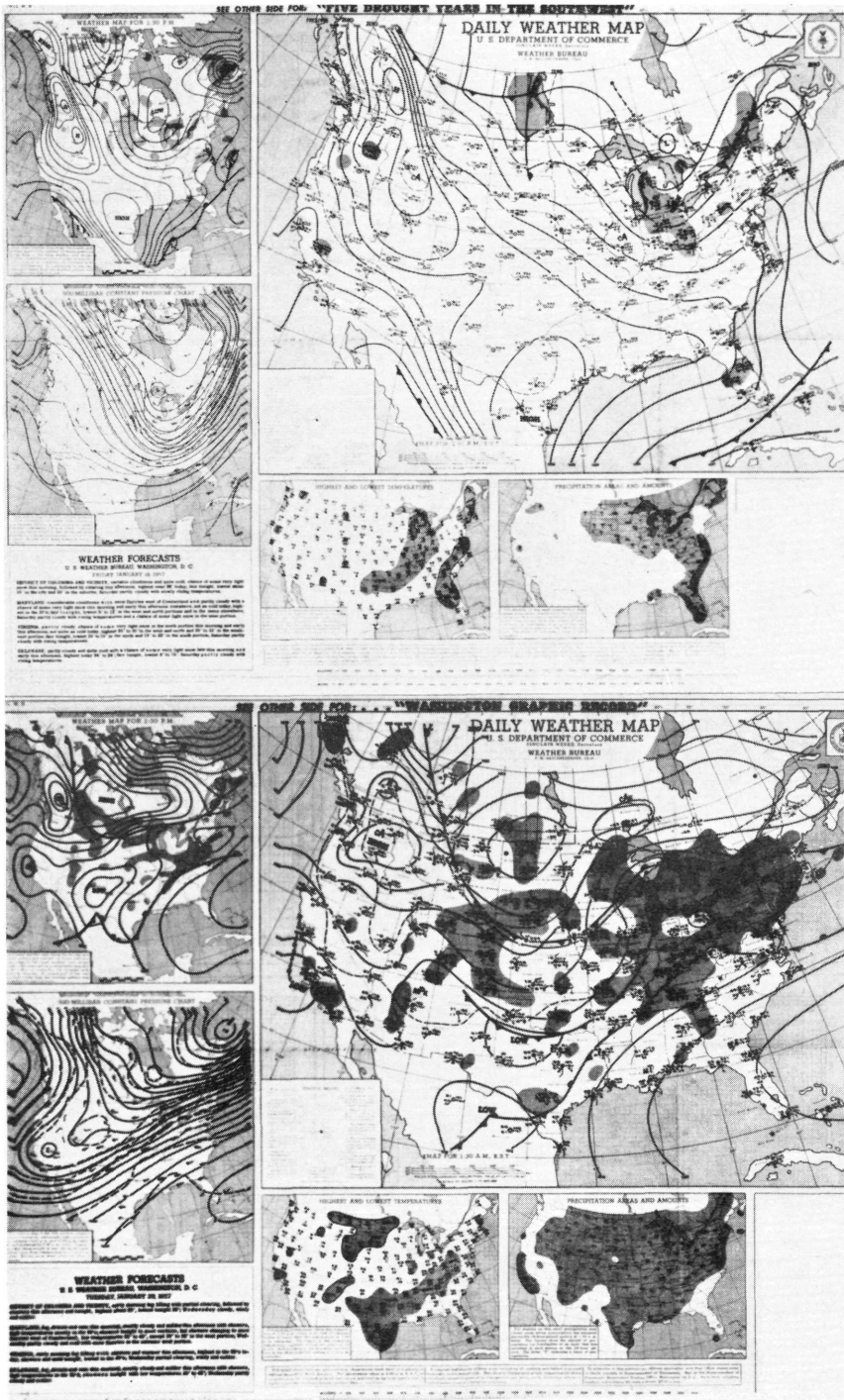


FIGURE 1 (top). FIGURE 2 (bottom).

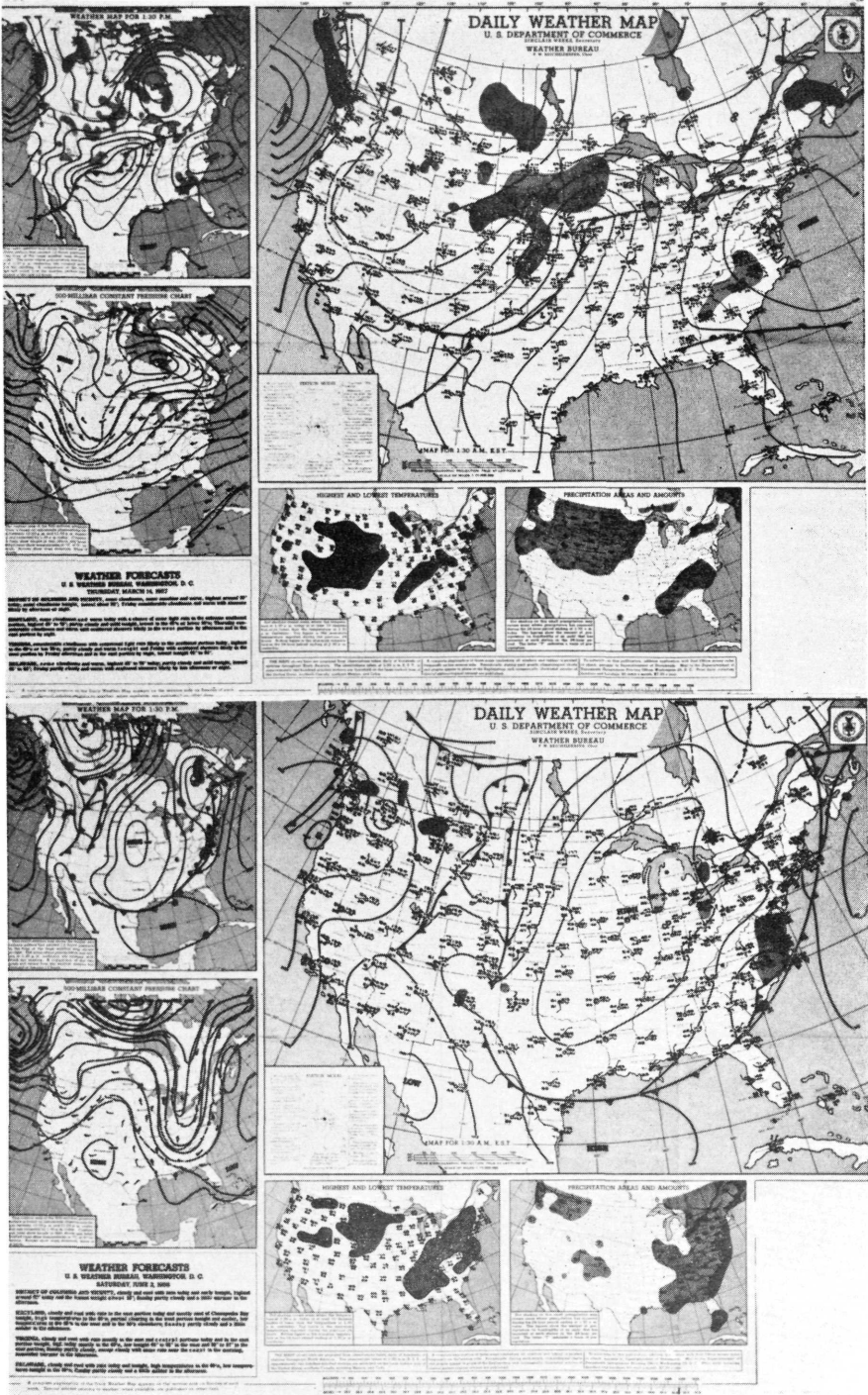


FIGURE 3 (top). FIGURE 4 (bottom).

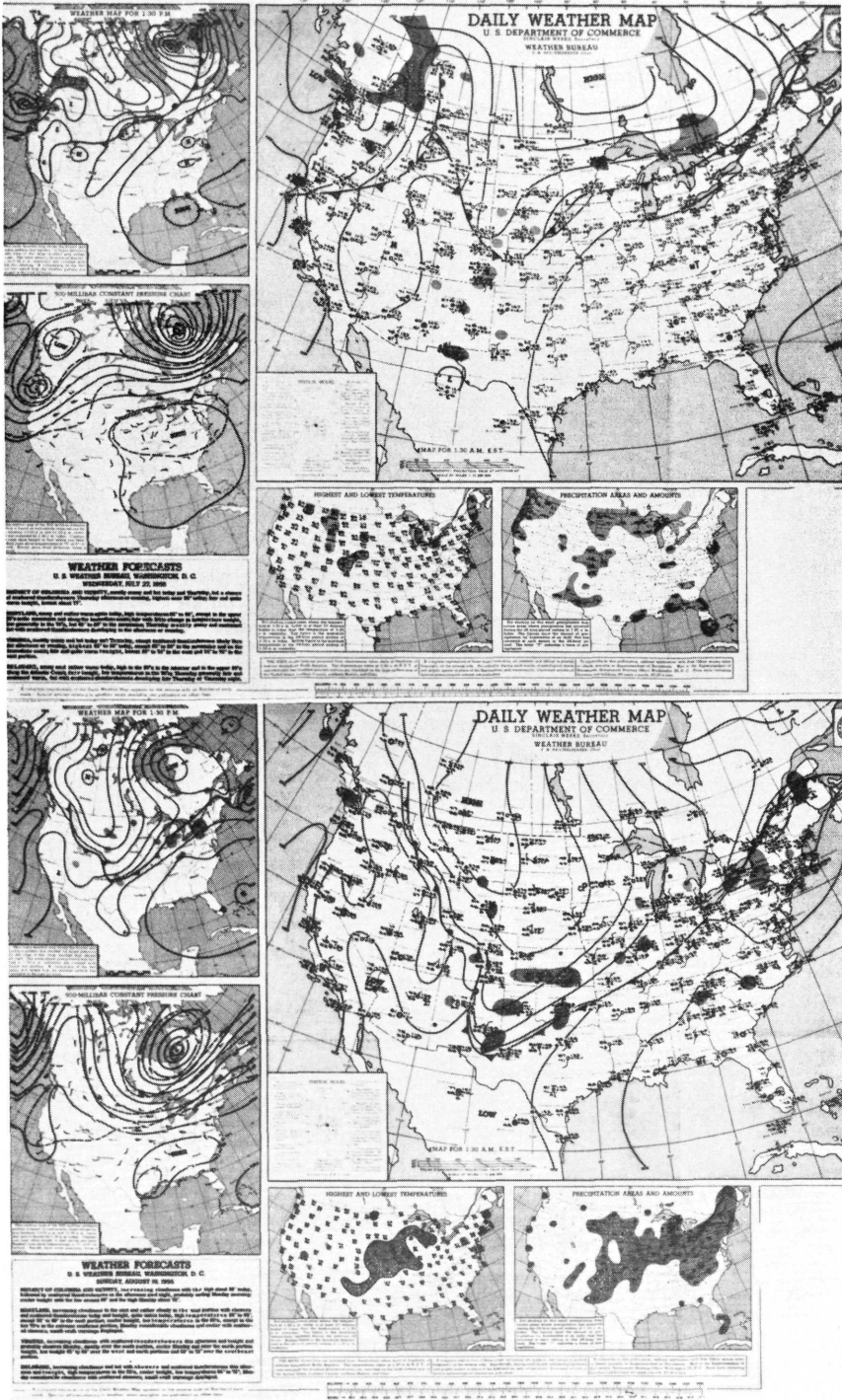


FIGURE 5 (top). FIGURE 6 (bottom).



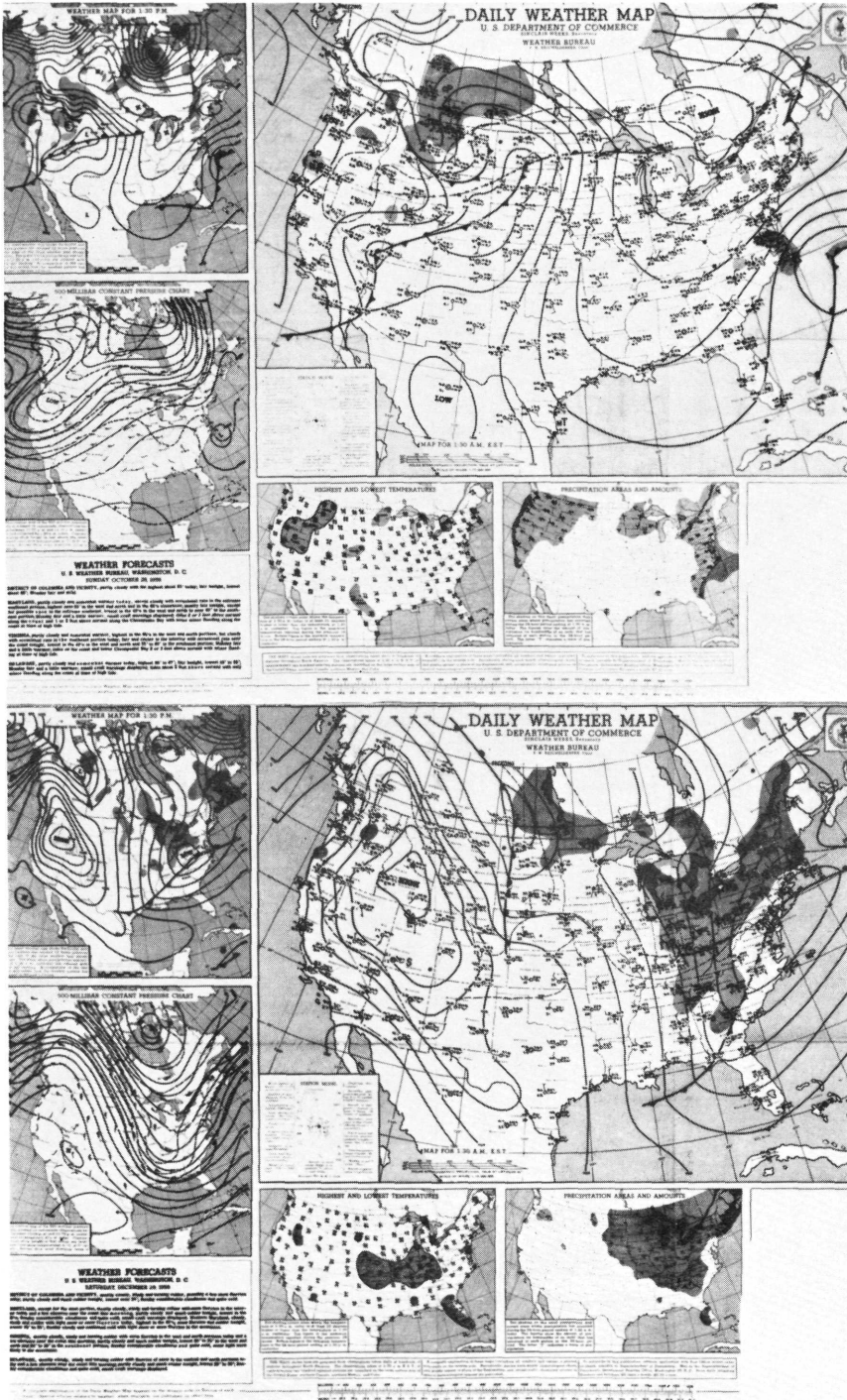


FIGURE 7 (top). FIGURE 8 (bottom).

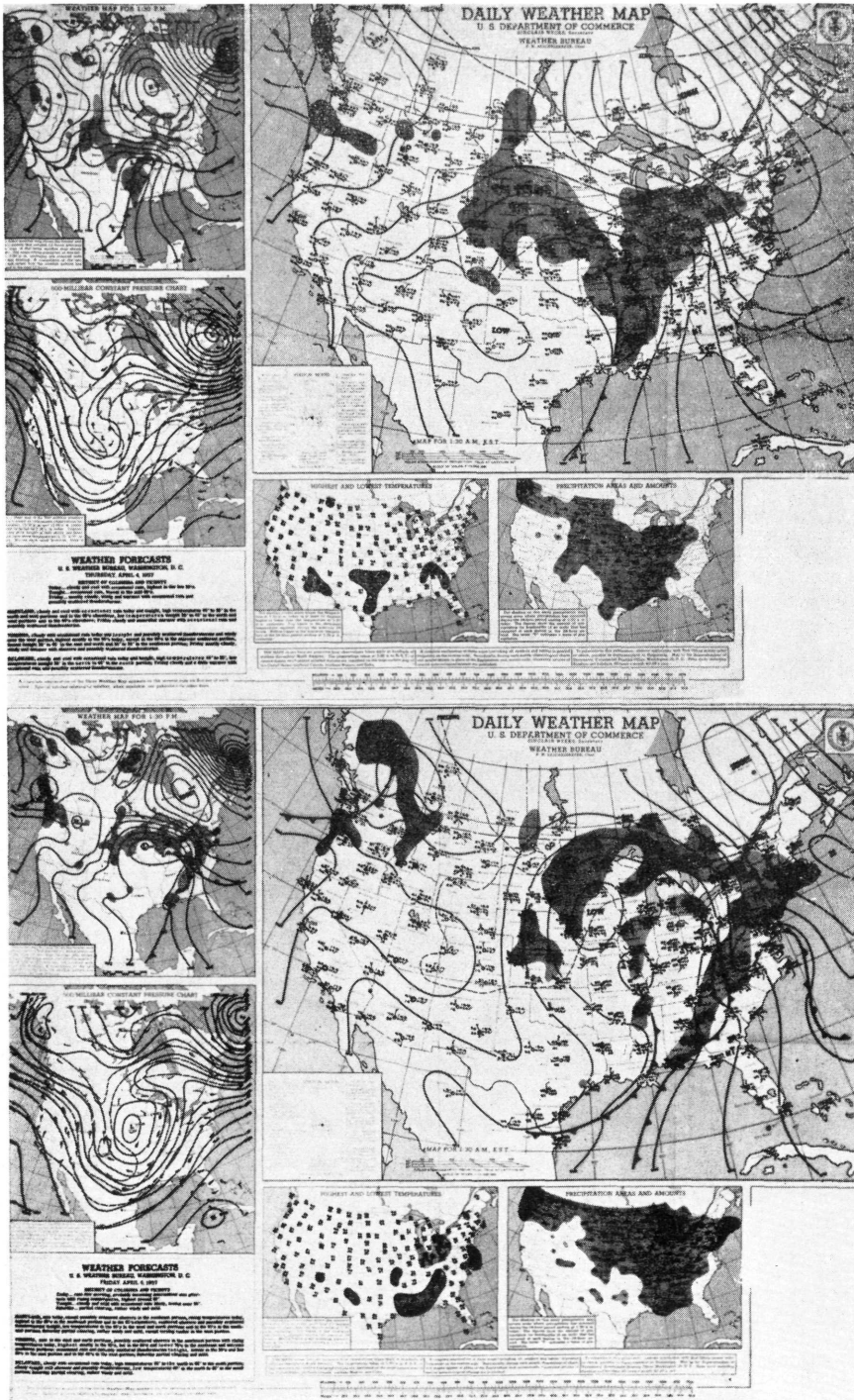


FIGURE 9 (top). FIGURE 10 (bottom).

*Indian Summer (Figure 7)*

October 28, 1956.—A well-defined trough in the western part of the United States and a ridge over the east succeeded by another trough off the Atlantic coast is the three-fold pattern on this map. The trough in the west is associated on the surface with extensive areas of precipitation from Washington west to eastern Montana and southward to southern California. Over most of the remainder of the United States high pressure at the surface and aloft and a weak low moving northeastward through the high plains resulted in mid-sixty degree readings from South Dakota eastward through Wisconsin and on to the Middle Atlantic states. Clear warm days and cool nights are the rule in most of the eastern half of the country. Off the east coast a late season tropical storm moves northward causing widespread cloud over the Atlantic and cloud and rain over the eastern portions of the Atlantic coastal states.

*Chinook (Figure 8)*

December 29, 1956.—A pronounced ridge pattern at the 500 mbar constant pressure level and a very strong surface anticyclone combine to produce the phenomenon called "chinook." The presence of the concentrated jet flow to the east of the Rocky Mountains steers cyclonic centers south and east of the highland barrier inducing a strong surface flow from the Great Basin country. Subsidence and divergence along the eastern margin of the Rockies produces temperatures in the low 60's from Colorado to northern Montana, but eastward temperatures remain in the mid-thirties to the Atlantic coast. The trough aloft over eastern United States combined with rapidly moving surface cyclones produce widespread cloud and precipitation in the form of rain and snow from the Great Lakes to the Atlantic and south to the Gulf of Mexico.

*Flood Pattern (Figures 9 and 10)*

April 4, 1957.—The 500 mbar constant pressure chart shows a concentrated flow of air entering the northwestern part of the United States and then looping southward in a huge continental sized trough which dominates the circulation pattern of the entire continent. As a result the nation is dominated by Polar maritime and Tropical maritime air; two-thirds of the country received precipitation during this regime. A well-developed cyclone moves northward along the eastern side of the trough drawing warm, humid air from the Gulf. Precipitation totals along the eastern side of the upper air trough exceeded one inch in 24 hrs from Columbus, Ohio to the lower Mississippi; amounts in excess of three in. were common in the Arkansas-Tennessee area.

April 5, 1957.—Stagnation of a distinct pattern is here illustrated; the trough evident in the preceding map is even more intensified the following day; the axis of the trough aloft has shifted slightly eastward, coinciding now with the Great Plains rather than the Rocky Mountains. The moisture-bringing effect to eastern United States is not much altered however. Forty-eight hr totals for representative stations include: Cincinnati 2.48 in.; Louisville 2.90 in.; Memphis 3.06 in.; and New Orleans 3.60 in. The combination of *two* factors is most significant in explaining the flood danger aspect here illustrated: (1) the distinctive atmospheric circulation pattern providing maximum potentiality for heavy precipitation in the eastern half of the country; and (2) the stagnation of that pattern over sufficiently long period of time to provide near disaster conditions on the earth's surface.

Although these maps have been selected to illustrate *familiar* case studies, it is important to note that each day's map allows a similar interpretation. Upper air phenomena and surface expression are irrevocably interdependent. To ignore one is to give only half the story; and, more particularly, to ignore the upper air phenomena is to ignore well more than half the story.