

Tiros Reveals Cloud Formations

Tiros I, the experimental weather satellite, in the first month of its operation, orbited the earth about 450 times and took about 9000 pictures of various cloud formations (1). The observing equipment has been described elsewhere (2). The pictures have revealed a large degree of organization in cloud systems over much of the earth's surface. The most striking patterns are spiral cloud bands associated with large storms, some about 1000 miles in diameter, observed over the United States, the North Atlantic Ocean, the North and South Pacific Oceans, and the Indian Ocean (3). Seven of these cloud vortices are shown in the accompanying figures.

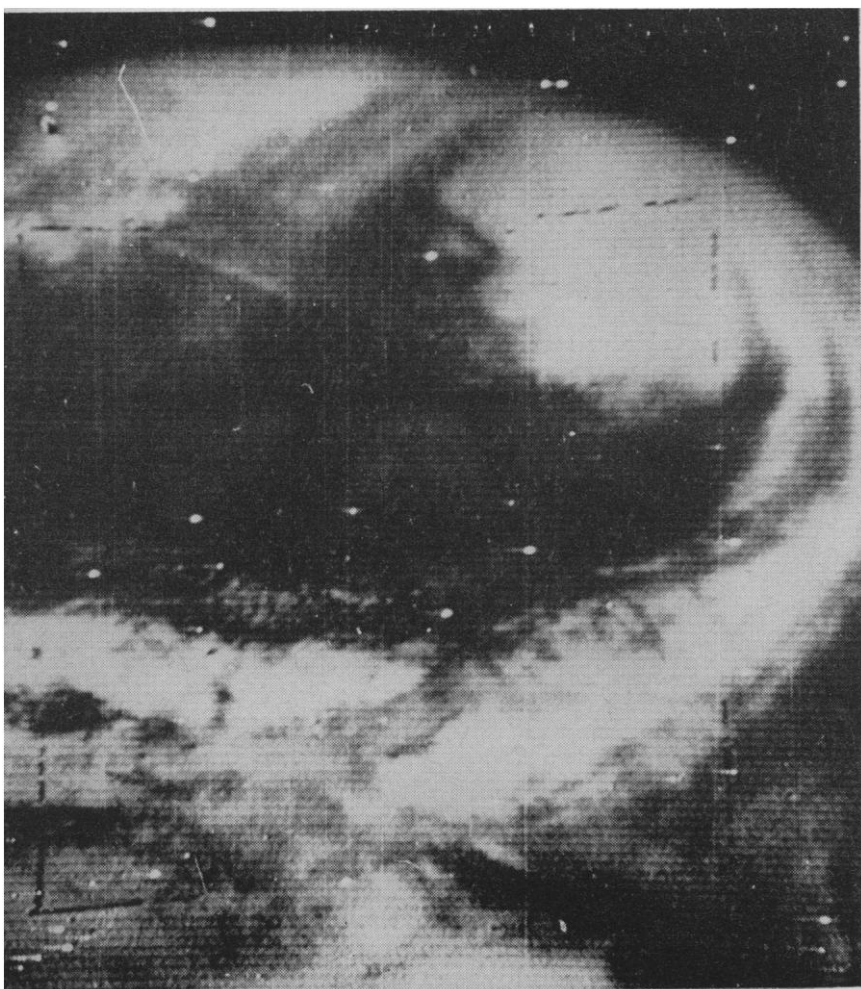
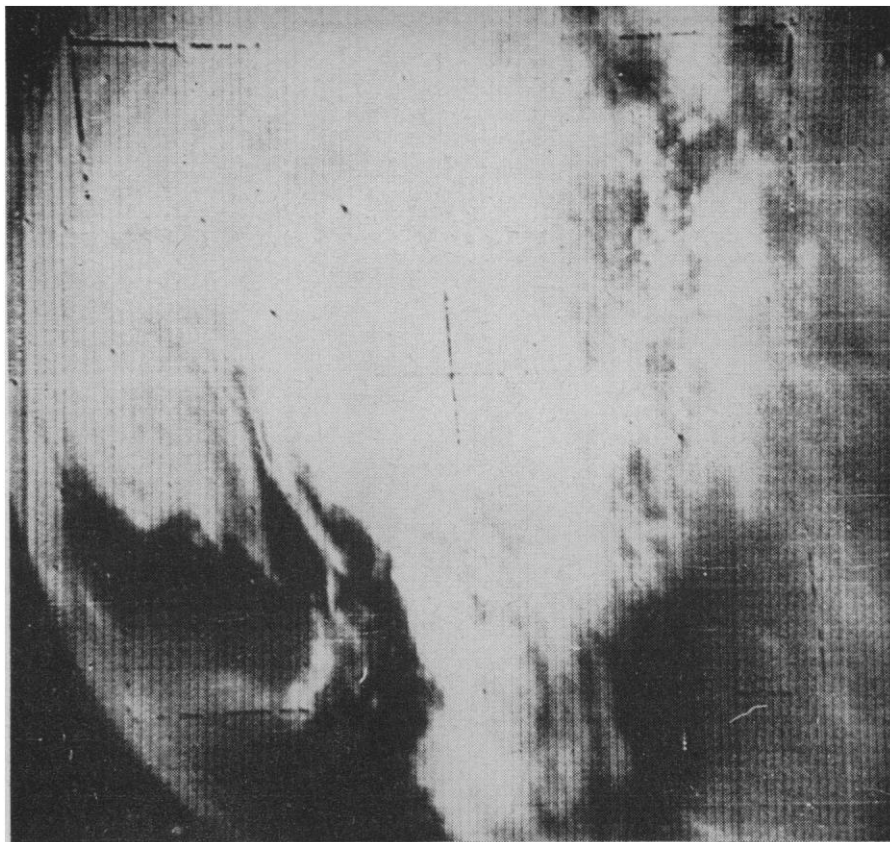
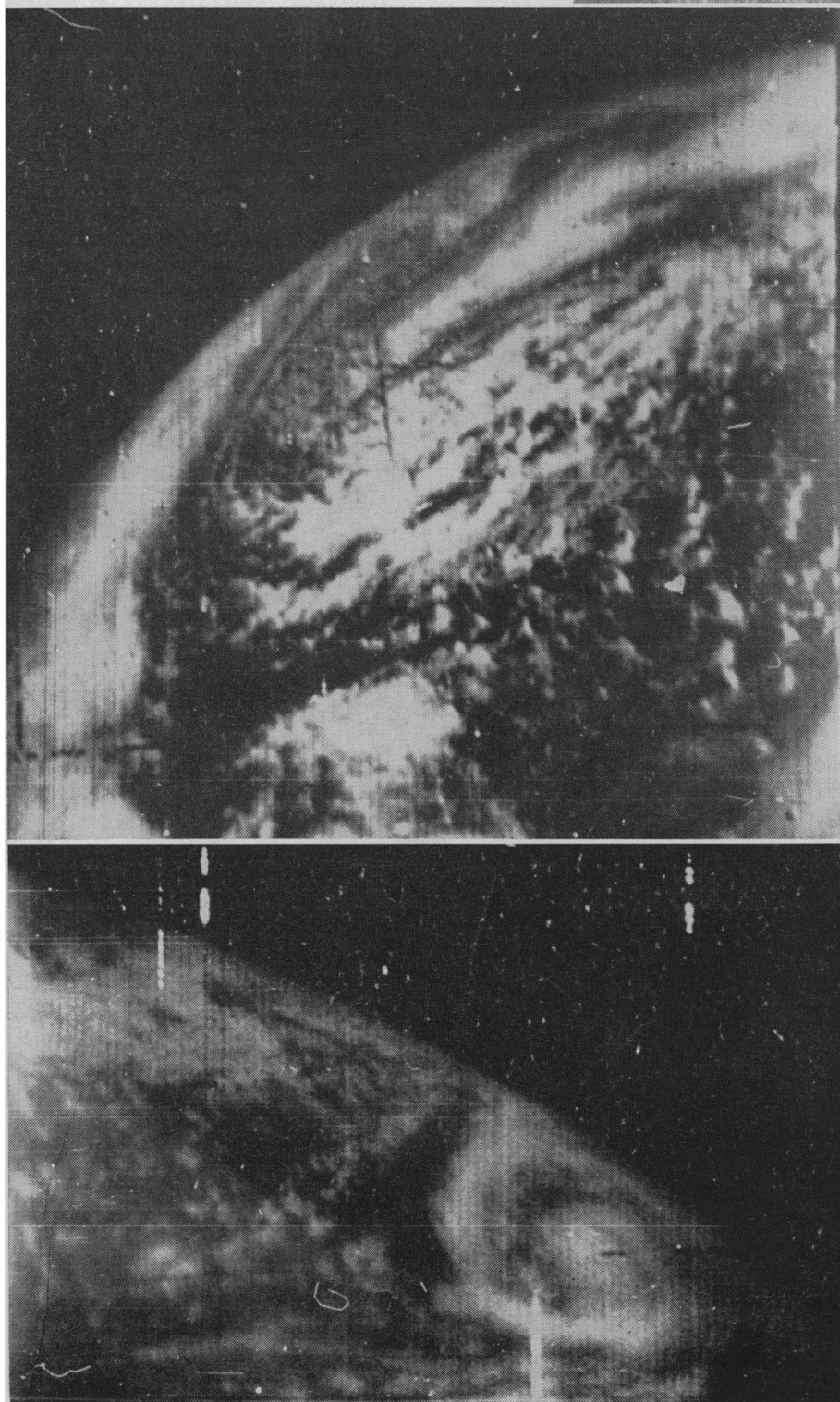
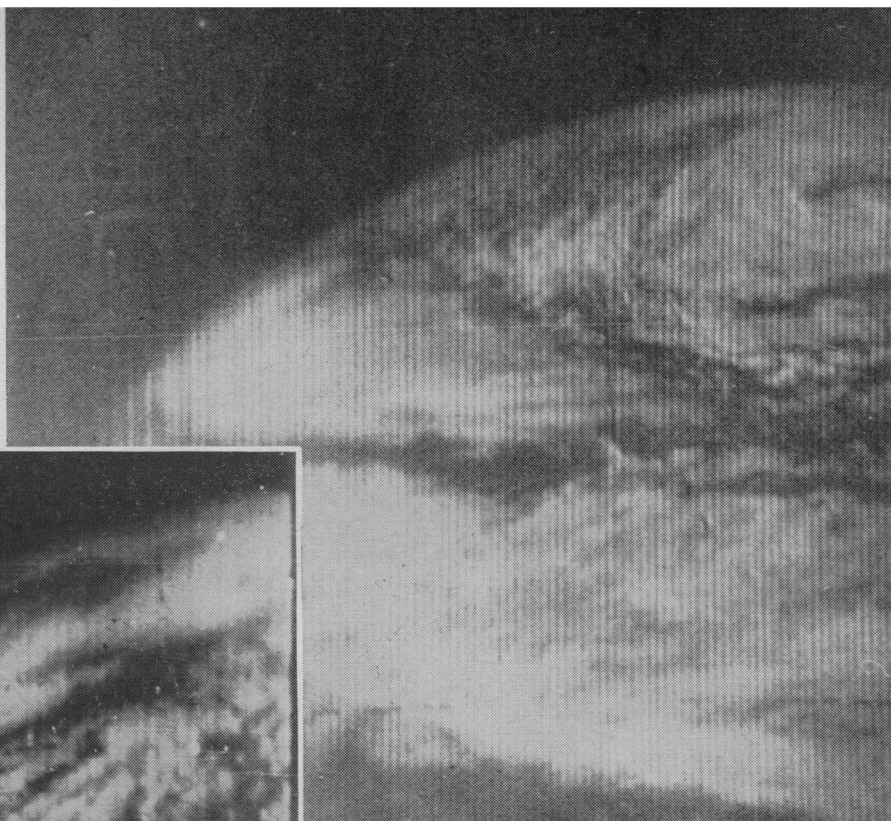


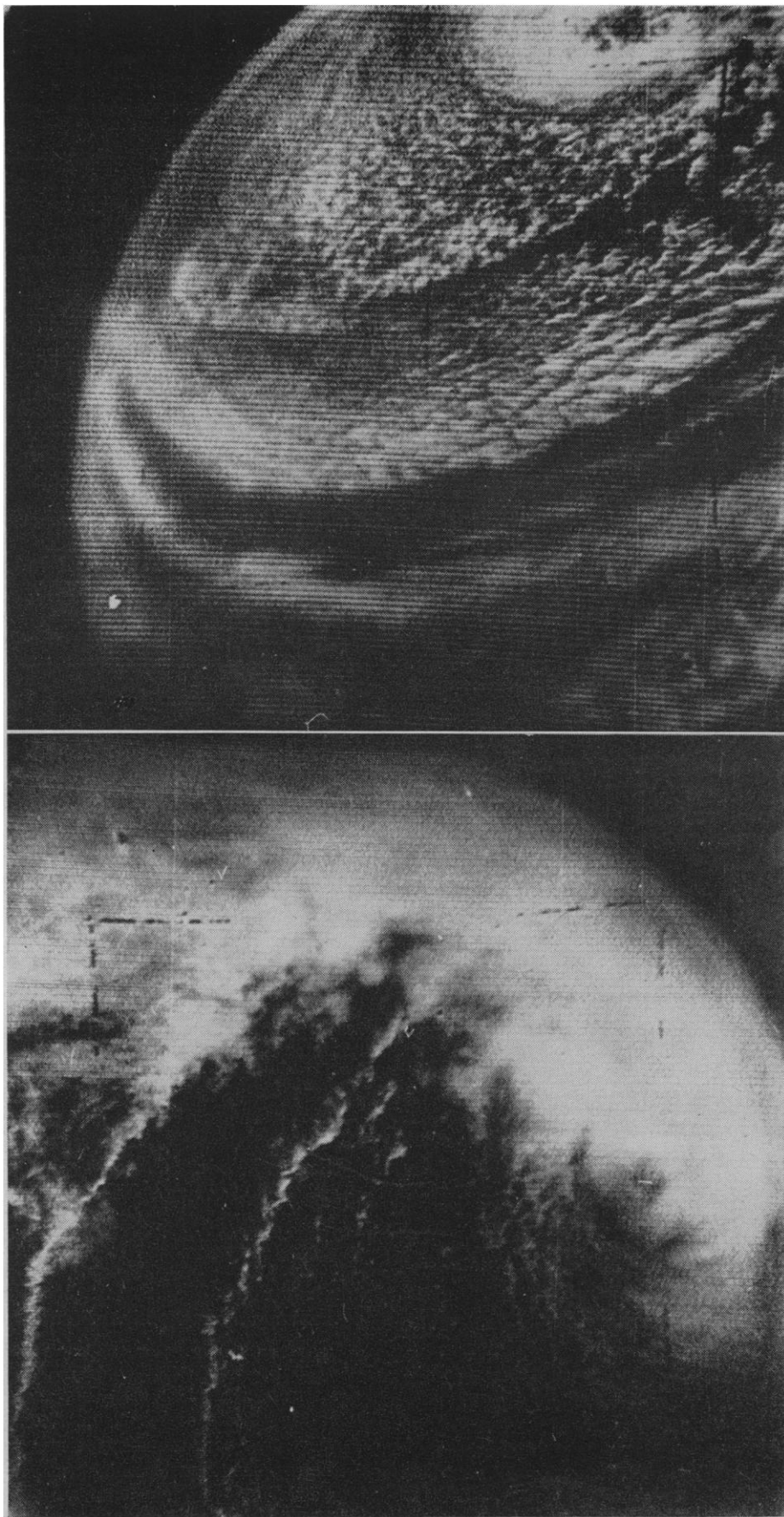
Figure 1 (above) shows the cloud formation associated with one of the first storms observed by Tiros on the launching date, 1 April 1960. The storm was located 120 miles east of Cape Cod (Massachusetts) and had a well-marked counterclockwise rotation. Dry, cloudless continental air, indicated by the dark area in the lower left, is streaming eastward off the middle Atlantic coast, while moist air from the south moves northward and westward around the storm center. These air movements produced widespread clouds and precipitation as far north as the Gulf of St. Lawrence.

Figure 2 (left), which was taken on the same day, shows clouds associated with a large storm centered over southeastern Nebraska. Again, the central dark portion of the picture is an area where the ground is visible through the dry, cloudless air from Canada that is circulating counterclockwise about the storm center, while, to the east, the moist, warm air from the Gulf of Mexico enters the storm circulation, causing widespread rains and snows. A rather bright, broad band of clouds, located over the lower Mississippi Valley, is shown in the lower portion of the picture. Some of these clouds are quite bright, suggesting that they are of greater thickness. Thunderstorms were imbedded in this cloud mass.

The third vortex, also observed on 1 April (Fig. 3, right), was located over the Gulf of Alaska, about 500 miles southeast of Kodiak Island. The vortex circulation is clearly indicated by the spiral array of cloud bands and a clear area in the center of the storm. In this oceanic storm, much more fine structure is visible than in the continental and coastal storms shown in Figs. 1 and 2.



Figures 4 and 5 (left, top and bottom) are views of the cloud cover associated with a large storm located about 400 miles west of Ireland on 2 and 3 April. This old, occluded storm had no fronts associated with it, but a marked banded structure is visible on 2 April (Fig. 4, top). The centrally located clouds in Fig. 4 are surrounded by a solid mass of stratiform clouds with a sharp boundary as revealed on adjacent frames taken during the same orbit of Tiros. Parts of this sharp, circular cloud boundary are seen in the arrow-like cloud near the top and in the lower right of Fig. 4. This cloud boundary is near and parallel to a region of a 60-knot wind speed maximum, on the 500-millibar constant pressure map (about 17,500 feet), which circled the storm. On the next day (Fig. 5, bottom) there seems to be one very large band winding around the center. Future photogrammetric measurements may reveal the nature of the change in cloud pattern from 2 to 3 April.



In Fig. 6 (top left) is shown another vortex, quite different from the others. This is a cloud vortex, about 1000 miles in diameter, located 800 miles west of southern California on 4 April. Here are superimposed bands of several different scales. Several wide bands separated by narrow clear areas may be clearly seen. Each of these individual large bands is composed of a series of smaller bands. The differences in band width illustrate the great variety in scale of motion which characterizes the atmosphere.

In Fig. 7 (bottom left) there is another type of vortex, this time observed in the Southern Hemisphere, where cyclonic storms rotate clockwise instead of counterclockwise. This storm, a typhoon which was known to meteorologists in that area for several days before Tiros was programmed to observe it, displays a pattern of spiral bandedness similar to precipitation echoes observed by radar. This storm was located about 300 miles north of the northern tip of New Zealand. The cloudless eye of the storm is quite visible as a dark spot on the right center of the picture. The storm was at the time moving southeastward, which is toward the upper right of the picture.

As Tiros observes future cloud-storm systems, it will be interesting to study the distinction between the fine-structure cloud-bandedness already observed in several maritime storms and the lack of such fine detail that is associated with the two continental or coastal storms mentioned above.

HARRY WEXLER
SIGMUND FRITZ

*U.S. Weather Bureau,
Washington, D.C.*

References and Notes

1. This work has been supported by the National Aeronautics and Space Administration.
2. S. Fritz, *Weatherwise* 12, 139, 163 (1959); P. Means, *Missiles and Rockets* 6, 21 (1960).
3. S. Fritz and H. Wexler, *Monthly Weather Rev.* 88, No. 3 (1960).