PICTURES OF THE MONTH

A Case of Cross-Equatorial Displacement of a Vortex

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Due to the vanishing Coriolis parameter in the equatorial region, it is possible for a vortex of given pressure distribution to rotate in either direction. On the other hand, a vortex originating on one side of the equator with a direction of rotation dictated by the sign of the Coriolis parameter, if displaced to the other side of the equator, may maintain its original direction of rotation for a period of time as long as it is not displaced too far away from the equator. This situation is more likely to arise if the scale of motion is small. How-

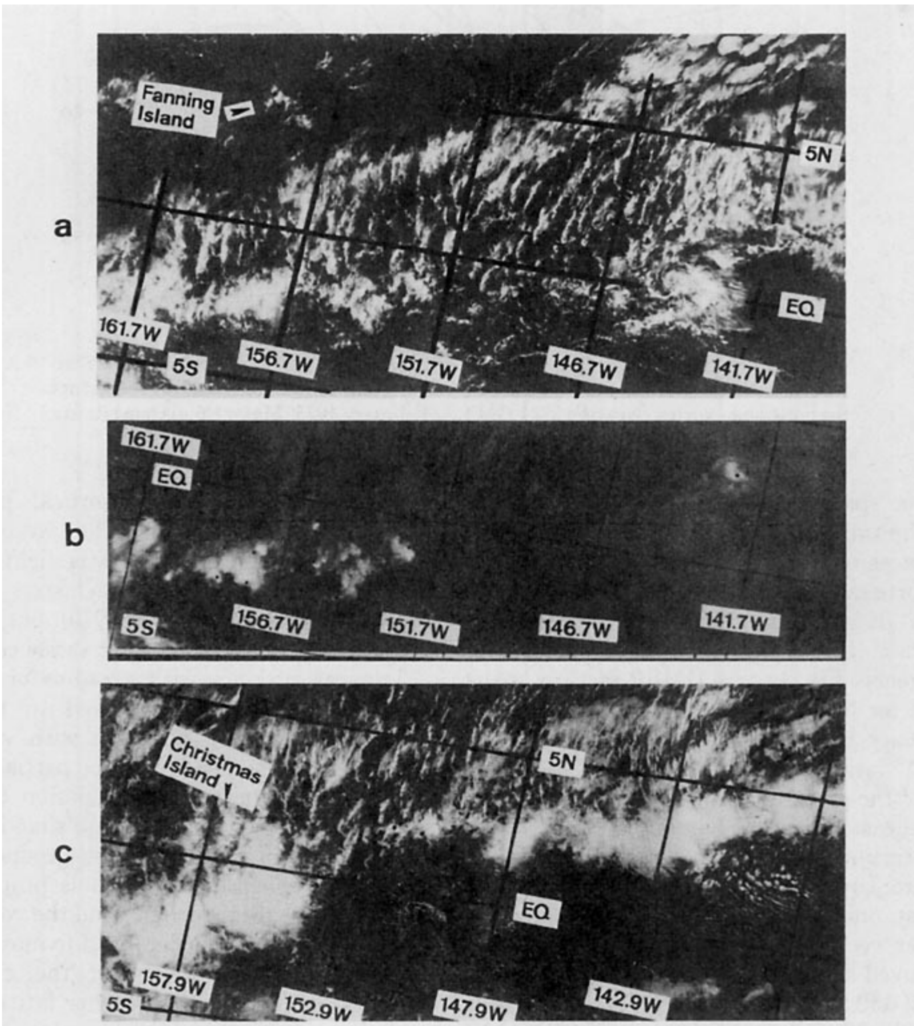

FIG. 1. DMSP visible picture for 2236 GMT 21 February 1973 (a), DMSP infrared picture for 2236 GMT 21 February 1973 (b), and DMSP visible picture for 2221 GMT 22 February 1973 (c).

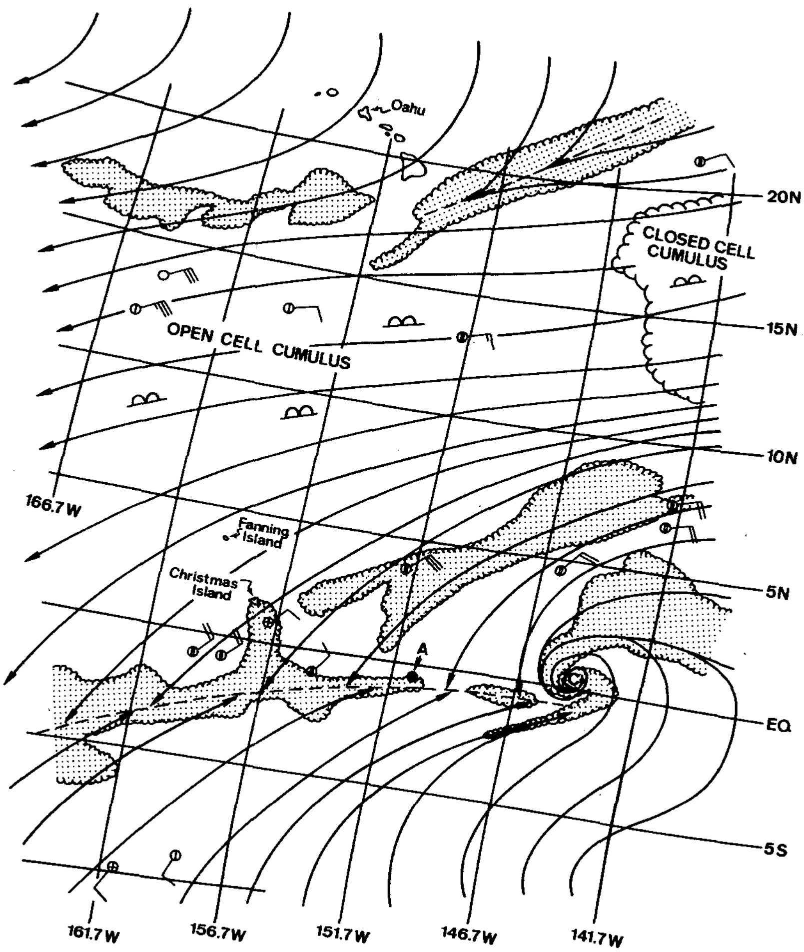

FIG. 2. Streamline analysis of surface winds for 0000 GMT 22 February 1973. Ship reports within 6 h of the map time are included. Point A (0.5°S, 150.6°W) represents the position of vortex center on 2221 GMT 22 February 1973. Major cloud elements are also depicted.

ever, due to the sparsity of the tropical observational network and the small space and time scales involved, actual occurrences of cross-equatorial displacement of atmospheric vortices are not easy to detect. The recent high-resolution data of the Defense Meteorological Satellite Program (DMSP) provide visual evidence of such an occurrence. Fig. 1a is a DMSP picture in the visible channel for the central tropical Pacific at 2236 GMT 21 February 1973. A vortical cloud pattern with a radius of ~1° latitude is seen near 0.4°N, 144.6°W. The gridding of the picture can be checked against the northwest-southeast oriented Fanning Island whose periphery appears at 3.9°N, 159.3°W. Fig. 1b is an infrared picture covering the same time and area. It is clear that only low-level clouds are associated with the vortex center. On the next day this vortex center had moved westward and across the equator to about 0.5°S, 150.5°W, as shown in Fig. 1c which is the 2221 GMT 22 February 1973 visible DMSP picture. The convective activity appears to have weakened on this day as indicated by the reduced cloud amount, but a definitive vortical pattern remains evident from the cloud lines. The westward movement speed of ~6° longitude per day is slightly less than that typically observed for cloud clusters between 5 and 10°N in the Pacific (Chang, 1970), but is quite close to the low-level mean zonal wind at the equator.

Tropical cyclones with a radius of a few hundred kilometers have been observed to have a general tendency of moving poleward with very rare exceptions. This phenomenon may be partially explained by Kuo's (1969) theoretical calculation of vortices in a shear flow with friction. In Kuo's model the variation in the shear of the basic flow produces an absolute vorticity gradient force which is proportional to the product of the total vorticity and the vorticity gradient. Positive (cyclonic) vortices tend to move toward higher absolute vorticity, which, in the case of tropical cyclones, is equivalent to higher latitudes due to the variation of the Coriolis parameter. In addition, the surface frictional drag would cause a positive vortex to deflect to the right of the basic flow. The counterclockwise-rotating equatorial vortex shown here appears to have a cyclonic vorticity (while north of the equator) as indicated by the low-level streamline analysis given in Fig. 2. This analysis was based on all available ship reports from 1800 GMT 21 February 1973 to 0600 GMT 22 February 1973, as well as low-level cloud patterns. The southward movement of the cyclonic vortex center is apparently due to the strong cold outbreak into the subtropical latitudes during this period. (Note the remains of the polar front east and south of the Hawaiian Islands near 20°N in Fig. 2.) This advective effect obviously overcame the vorticity gradient force and the frictional effect and caused the cross-equatorial displacement. After the displacement, the northerly flow north of the vortex center [indicated by the cloud lines north of the Intertropical Convergence Zone (ITCZ) in Fig. 1c] spirals counterclockwise into the vortex center from the western side, suggesting that the vorticity of the vortex remains positive south of the equator.

In order to trace the history of the formation of the vortex center the DMSP pictures for 20 February 1973 (not shown) were also examined. The general area was covered by high ITCZ cloudiness which would have obscured the vortex even if it existed. The vortex center shown in Fig. 1a resembles somewhat the remains of the center of a tropical storm, but no storm was observed prior to the vortex and the time period is completely outside the normal eastern Pacific hurricane season. Thus the only reasonable conjecture that can be made at this time is that the vortex is a manifestation of an eddy in the ITCZ north of the equator which organizes the cloud pattern. Whether the vorticity of the wind field was much weakened as the vortex drifted across the equator cannot be definitely ascertained because the interaction relationship between the clouds and the wind field is not clear. However, the vortex had disappeared 24 h later, based on the DMSP picture of 23 February 1973.

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