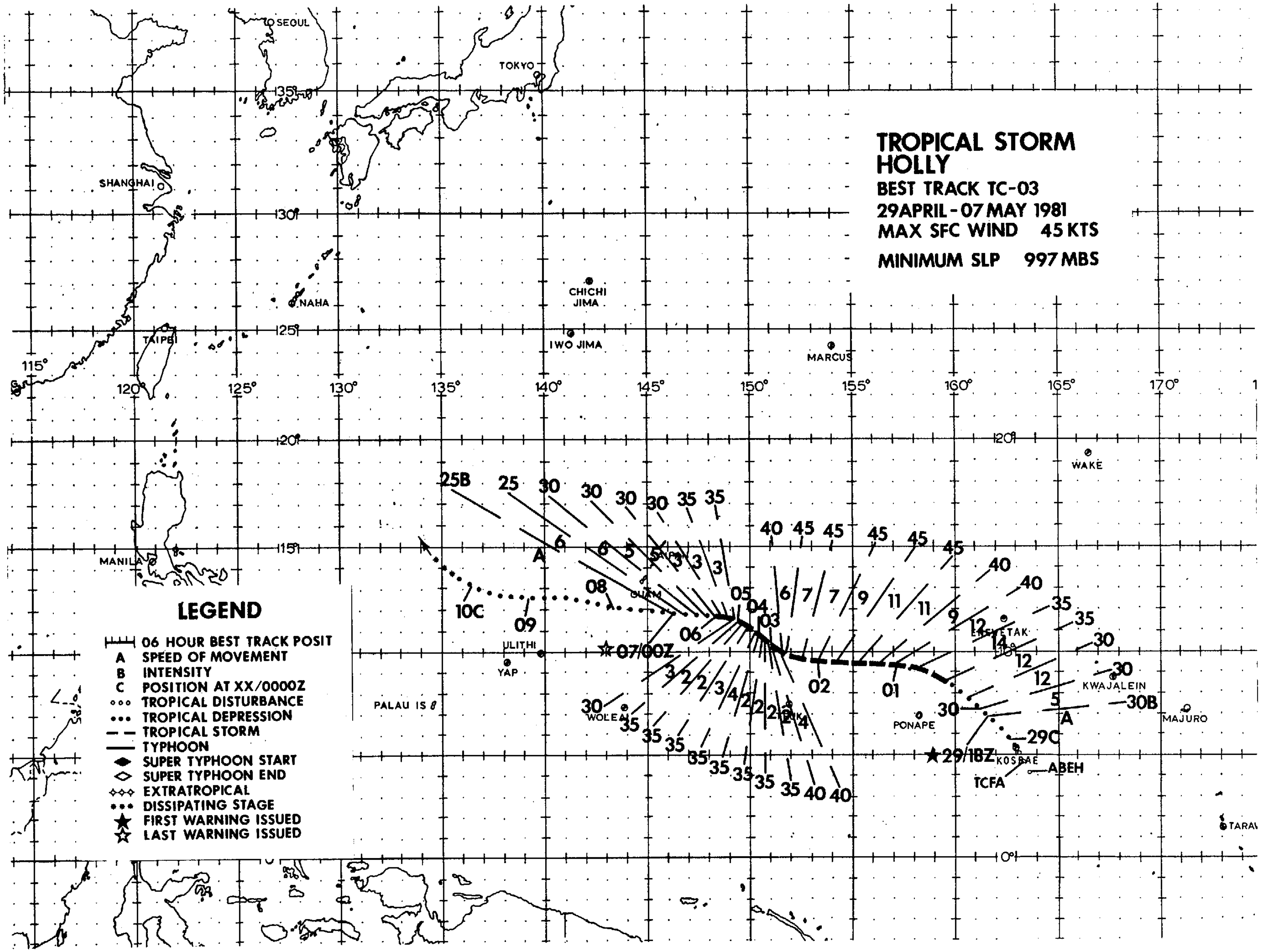

TROPICAL STORM
HOLLY
BEST TRACK TC-03
29APRIL - 07 MAY 1981
MAX SFC WIND 45 KTS
MINIMUM SLP 997 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
SEOUL
TOKYO
SHANGHAI
NAHA
CHICHI JIMA
IWO JIMA
MARCUS
TAIPEI
MANILA
WAKE
ULITHI
YAP
PALAU IS
GUAM
WOLEAI
PONAPE
KWAJALEIN
MAJURO
KOSRAE
TARAWA
TCFA
ABEH
07/00Z
29/18Z
115°
120°
125°
130°
135°
140°
145°
150°
155°
160°
165°
170°

Development of Tropical Storm Holly followed a ten-day period of relative calm in the tropical northwest Pacific Ocean. Holly was interesting in several ways during her lifetime. Southern Hemisphere interaction, intensity fluctuations, weak mid-level steering flow, and strong upper-level shear will be discussed in relation to Holly's development and dissipation.

The source for the initial energy impulse in the development of TD-03 is an interesting point for speculation. A review of satellite imagery back to 21 April showed that varying amounts of convection existed almost continuously in the region of 5.0N from 160.0E to 165.0E from 211200Z to 260000Z. Satellite data suggest that this convection was related to a fairly active convective region just south of the equator (5.0-10.0S, 160.0E-175.0W). By 230000Z, satellite imagery showed that the southern hemisphere tropical system was interacting vigorously with a rather strong mid-latitude system. At the same time, the northern hemisphere convection increased. Although again weaker, some curvature in the convective pattern was noted by 250000Z, and a weak, broad low-level circulation developed by 251200Z near 4.0N 169.0E. This circulation was not analyzed consistently prior to Holly's formation. Sparsity of data and weakness of the circulation may have prevented detection of the circulation in synoptic data. Undisturbed easterlies existed in the area prior to development of the low-level circulation center. The surface/gradient level analysis showed cross-equatorial interaction, and with the evidence from satellite data, it appears that TD-03 was initiated through interaction with a southern hemisphere system.

The initial satellite alert by Det 1, 1WW on the disturbance which produced Holly was issued at 260000Z. Continued improvement of the convective signature led to issuance of a Tropical Cyclone Formation Alert 280255Z. At 290153Z, the first reconnaissance aircraft investigative mission was flown into TD-03. TD-03 was well defined at this time, and the circulation was closed easily at the surface and 1500-ft (457 m) level. The extrapolated central pressure was 1003 mb, while the maximum observed surface wind was 25 kt (13 m/sec). By 282106Z, the circulation was also evident on satellite imagery as an exposed low-level circulation (Fig. 3-03-1). A Dvorak satellite intensity analysis showed a weakening trend for the past 24 hours and forecast the trend to continue.

Early fluctuations in the satellite-derived intensity analysis produced the first interesting characteristic associated with TD-03. By 300000Z, a steady trend toward intensification was established. By 010300Z May 1981, both aircraft and satellite data suggested possible development of a banding-type eye. It certainly appeared that Holly was on the verge of becoming a major tropical cyclone; however, during the next 24 hours, Holly's satellite signature again weakened. A maximum intensity of 45 kt (23 m/sec) was reached at 011200Z and was maintained for 24 hours before the final weakening trend started (Fig. 3-03-2). From this point, Holly gradually weakened although there were continued fluctuations in the amount and intensity of convection.

Figure 3-03-1. Exposed low-level circulation of TD 03 approximately 5 hours prior to aircraft investigative mission, 28 April 1981, 2106Z. (NOAA 6 visual imagery)

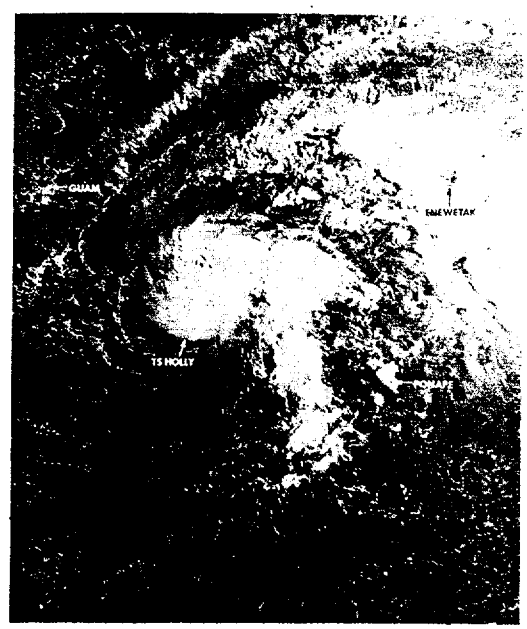
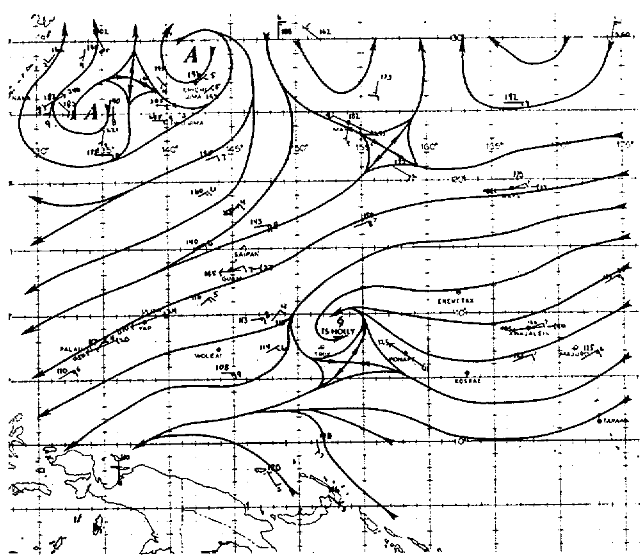


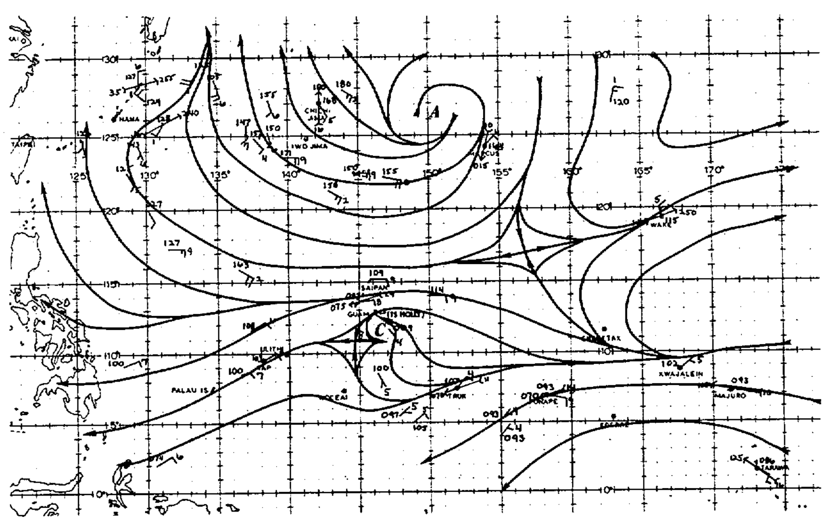
Figure 3-03-2. Tropical Storm Holly during the period of maximum intensity, 1 May 1981, 1238Z. (NOAA 6 visual imagery)

A second interesting characteristic associated with Holly was her extremely slow movement. From 300000Z through 020000Z, Holly averaged a forward speed of 11 kt (20 km/hr); from 020000Z through 030000Z, the average speed was 6 kt (11 km/hr); and from 030000Z through 060000Z, Holly's average speed was slightly less than 3 kt (6 km/hr). Due to sparseness of data, it is impossible to state with complete certainty why Holly slowed so dramatically. The surface/gradient level and 500 mb analysis, however, offer possible explanations. At the surface/gradient level, Holly's path was across the main stream of the northeast trade regime. The stream was significantly stronger on the north side of Holly, and this "crosswind" apparently helped in the retardation of forward speed as far as the lower tropospheric steering was concerned. When Holly finally began to accelerate, the trade winds were deflected more easterly and more toward a direction parallel to Holly (Fig. 3-03-3).

The second possible explanation for the sudden deceleration and extremely slow movement lies in the mid-troposphere. Wind analyses at 500 mb consistently showed weak steering surrounding the cyclone's environment. The weak flow was due in part to a cut-off low which was located near 30N and between 155E and 165E during the period of Holly's slow movement. The gradient between this cut-off low and the ridge placed major wind currents well northeast and northwest of Holly's 500 mb cyclone. This gradient slackened just north of Holly and winds that were not considered storm induced generally were 10 kt (5 m/s) or less. This was clearly evidenced by reconnaissance tracks flown



(a)



(b)

Figure 3-03-3. Surface (⟶)/gradient (⟵) level analyses: (a) at 020000Z which was typical during Holly's period of slow movement and (b) at 070000Z showing the pattern as Holly began to accelerate. Winds are in knots.

north of Holly. Furthermore, these same analyses showed Holly remained south of the ridge in the weak easterly current. A break in the ridge never occurred in suitable position to allow Holly any other possibility (Fig. 3-03-4).

The final interesting characteristic was Holly's failure to develop a significant outflow pattern. At 010000Z and again at 040900Z, Holly appeared to be developing a good outflow channel to the northeast. On each occasion, however, the outflow was not maintained and a southwest outflow channel never developed. The 200 mb wind pattern was fairly strong throughout Holly's lifetime with a large amplitude ridge anchored off the Asian coast. The position of this ridge forced additional pressure on the preexisting southwesterly subtropical jet which had been lying just west of Holly. Convergence of the two upper level wind streams induced a 40 to 60 kt (21-31 m/s) wind maximum just northwest of Holly's upper level center (Fig. 3-03-5). This persistent feature eroded Holly's convective organization and 062125Z satellite imagery showed a totally exposed low level circulation with the formerly associated convective 50 nm (93 km) east of the center. Once this shearing took place, Holly eventually spun down and dissipated over open tropical water.

Tropical Storm Holly never reached typhoon strength as originally expected. The intensity fluctuations, weak mid-level steering, and shearing flow at both low- and upper-tropospheric levels all contributed to Holly's eventual demise.

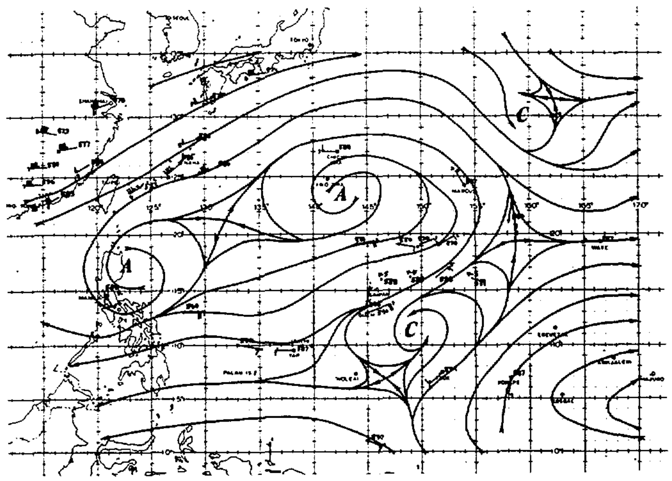


Figure 3-03-4. 500 mb streamline analysis at 051200Z. This analysis was typical of the pattern existing during Holly's lifetime. Wind data are a combination of RAOBS, RECON, and satellite-derived winds (←). Wind speeds are in knots.

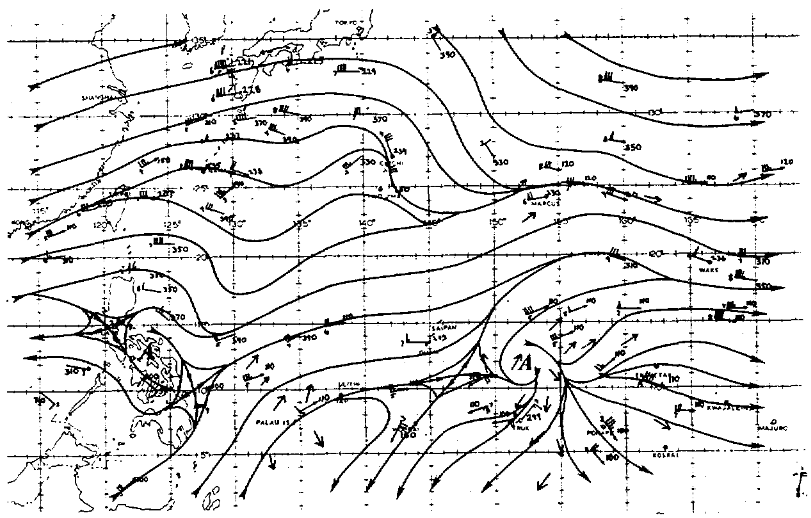


Figure 3-03-5. 200 mb streamline analysis at 031200Z. Wind data are a combination of RAOBS, AIREPS, and satellite-derived winds (←) and blow-off wind directions (←). Wind speeds are in knots.