

5.2.2 Case VI - Hurricane Gilbert (9 – 14 September 1988)

While its center passed far north of Belize, Hurricane Gilbert's size, strength, minimum pressure, maximum wind, storm surge and damage to life⁹³ and property dictate its inclusion as a case study. When Hurricane Gilbert made landfall on the northeastern Yucatan Peninsula, it was the first category 5 hurricane (>135 mph) to make landfall in the western hemisphere since Hurricane Camille in 1969.

The tropical wave that was to become Hurricane Gilbert emerged from the northwest African coast on 3 September. The *preliminary* best track of Hurricane Gilbert by the National Hurricane Center (NHC, 1988) is presented in Fig. 5.78. (Unless stated otherwise, the following data concerning Hurricane Gilbert⁹⁴ are from the Diagnostic Report of the National Hurricane Center-August and September 1988 (NHC, 1988)).

9 September 1988

The 1000 mb analysis of Fig. 5.79 shows station observations at 1200 UTC on 9 September as Tropical Depression #12 approaches the Windward Islands. Note the correlation of the following station observations with the visible imagery of Fig. 5.80 (although 3 1/2 hours later at 1531 UTC): overcast with a rain shower at Le Lamentin, Martinique (station 78925), with a thunderstorm reported at the station to the southeast (Barbados); overcast with continuous rain at San Juan, Puerto Rico (station 78526); lightning with towering cumulus clouds at Kingston, Jamaica (station 78397); *yet* only 1/4 sky cover at the station reporting from eastern Cuba and 1/8 sky cover at Playa Giron, Cuba (station 78333). Hurricane Florence is seen moving inland across the Louisiana coastline in Fig. 5.80.

Moving on a west northwest course at ~15 kt, Tropical Depression #12 is classified as Tropical Storm Gilbert at 1800 UTC on 9 September.

10 September 1988

The IR imagery of Fig. 5.81 shows the intense convection associated with Tropical Storm Gilbert at 0001 UTC on 10 September 1988. At this time the tropical storm is located at 14.8°N, 61.5°W, with a minimum sea-level pressure of 1002 mb and sustained surface winds of 40 kt. Figures 5.82 and 5.83 are the Navy's FNOC low-level and upper-level wind analyses at 0000 UTC on 10 September. Even this coarse 5-degree grid wind analysis depicts the cyclonic rotation of the tropical storm at the 925 mb pressure surface in the eastern Caribbean Sea. The 200 mb wind analysis shows strong anticyclonic flow above the convection, associated with the tropical storm and its release of latent heat.

The visible imagery of Fig. 5.84 at 1731 UTC on 10 September shows the increase in the storm's circulation. 30 minutes later at 1800 UTC, the storm is located by NHC at 15.7°N, 65.4°W, with a sea-level pressure of 992 mb and 55 kt winds.

⁹³As of 26 October 1988, in addition to large losses of life in Mexico (202) and Jamaica (45), the following Central American countries attributed storm related deaths to Hurricane Gilbert: Guatemala 12, Honduras 12, Nicaragua 2 and Costa Rica 2.

⁹⁴This is in contrast to the data presented in the preceding case study of Hurricane Joan in which operational warning positions, etc. were presented.

11 September 1988

At 0000 UTC on 11 September, the tropical cyclone was upgraded to a hurricane. The NMC ATOLL and 200 mb streamline analyses (Figs. 5.85 and 5.86) depict the low-level and upper-level flow at this time. The hurricane is located at 15.9°N, 66.8°W (~ 120 n mi south of Puerto Rico), with a sea-level pressure of 989 mb and 65 kt winds.

The station observations at 1200 UTC (Fig. 5.87) may be compared to the visible satellite imagery (Fig. 5.88, 1 1/2 hours later): overcast with a rain shower and ESE winds at San Juan, Puerto Rico (station 78526); overcast with towering cumulus and SW winds at Curaçao, Netherlands Antilles (station 78988); yet, only calm winds with 1/8 sky cover at Kingston, Jamaica (station 78397) and 1/8 sky cover at Camaguey, Cuba (station 78283).

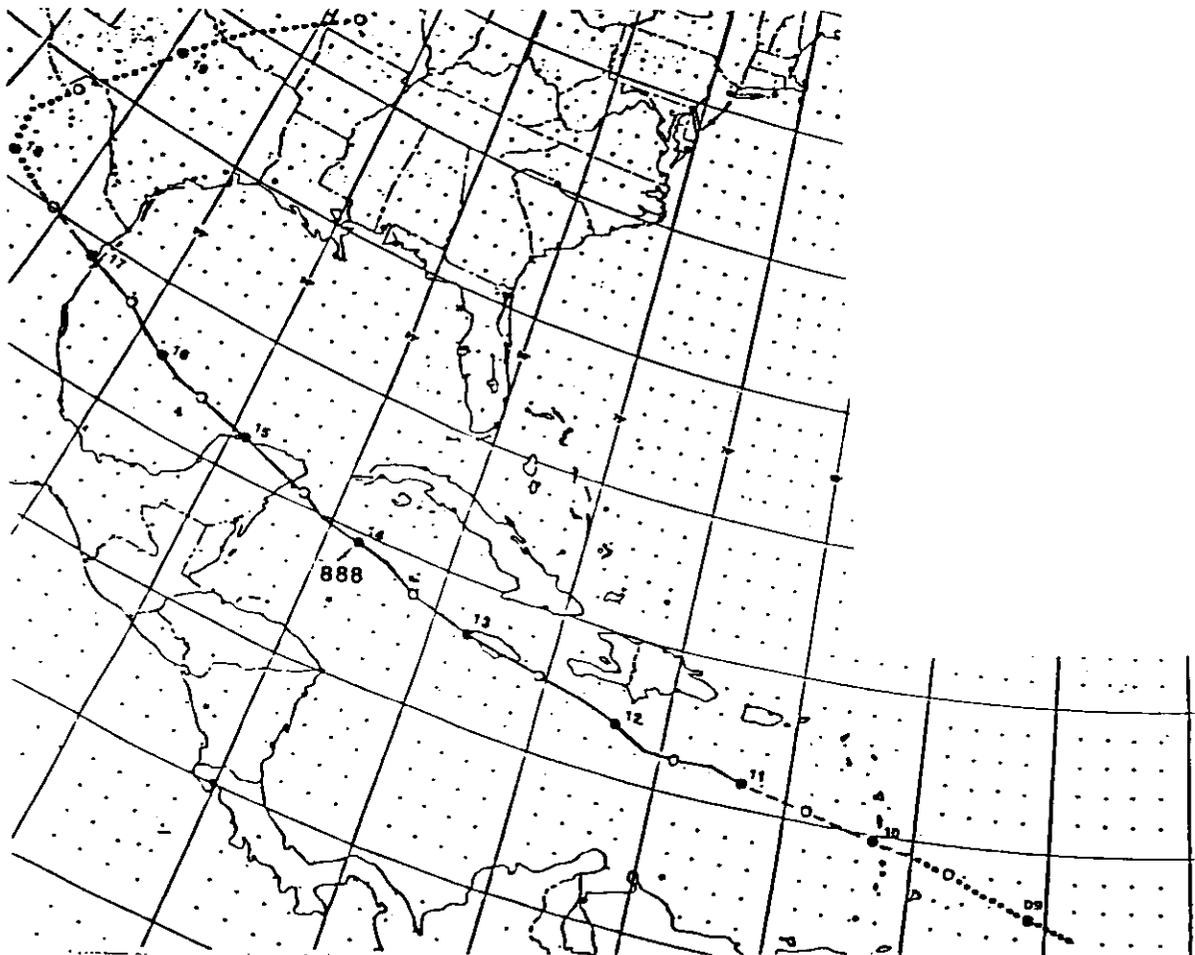


Figure 5.78: Best Track Positions for Hurricane Gilbert, 8–19 September 1988
(From NHC, 1988)

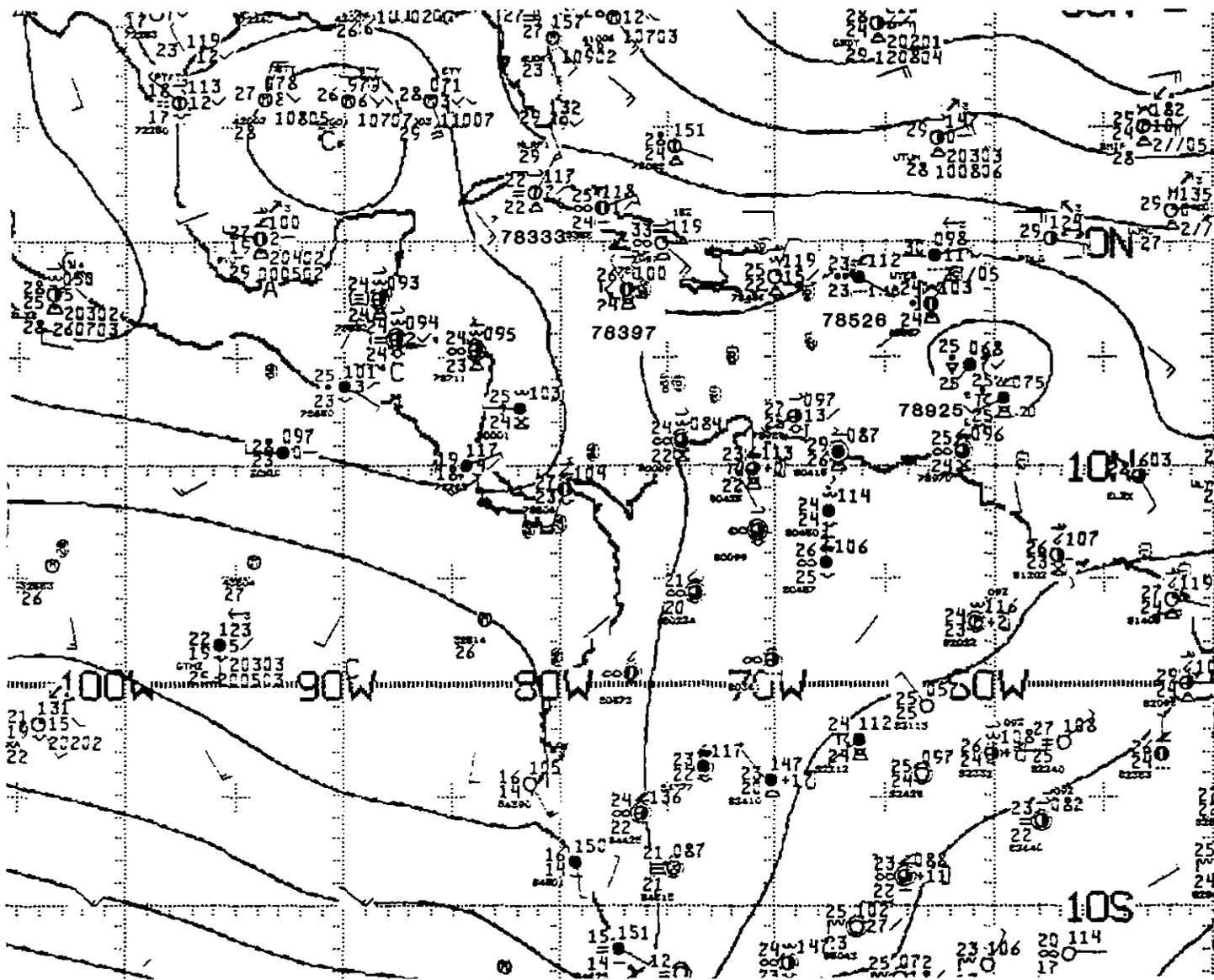


Figure 5.79: NMC 1000 mb Analysis, 1200 UTC 9 SEP 1988. As in Fig.2.21.

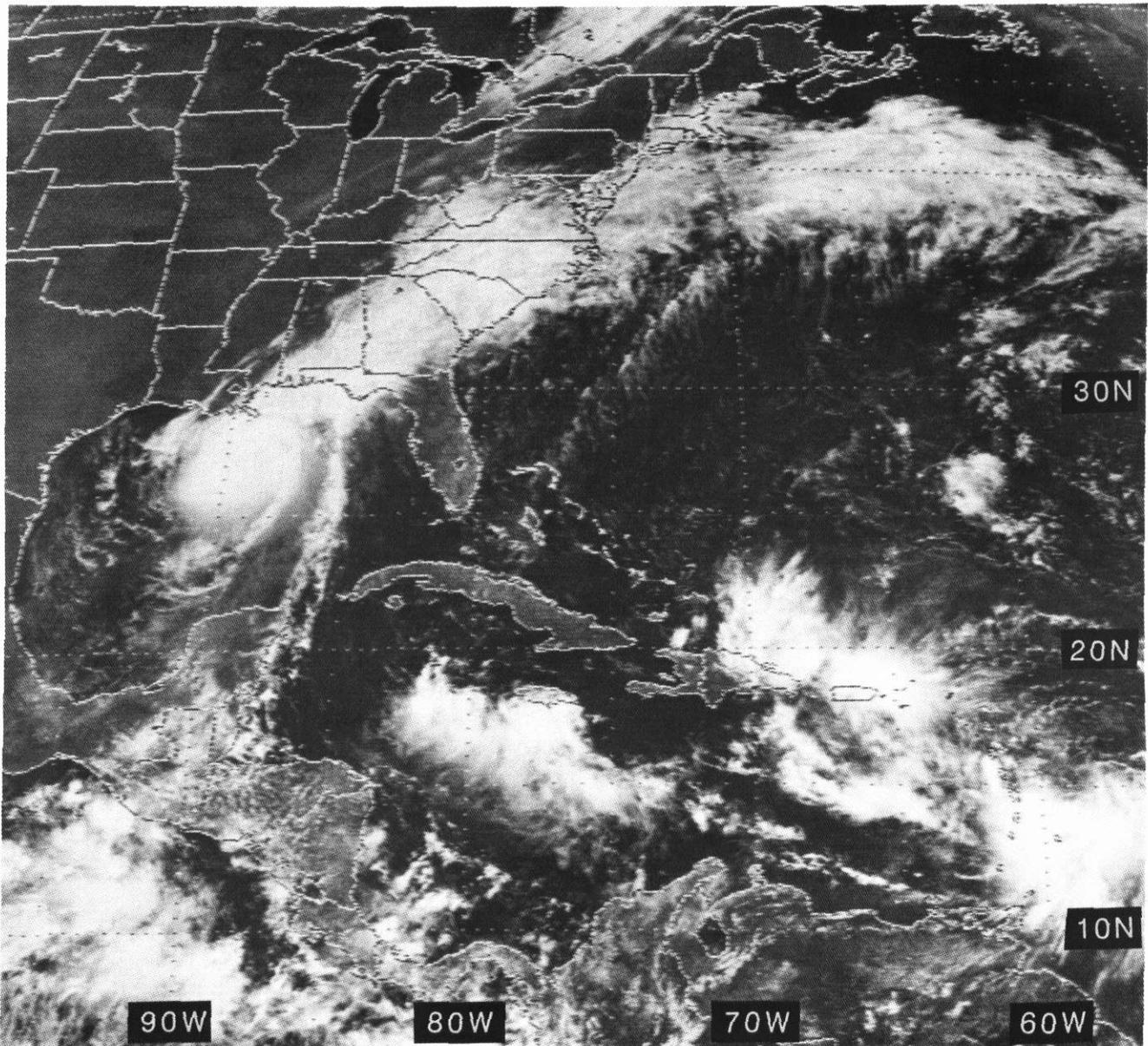


Figure 5.80: GOES East Visible Satellite Imagery, 1531 UTC 9 SEP 1988

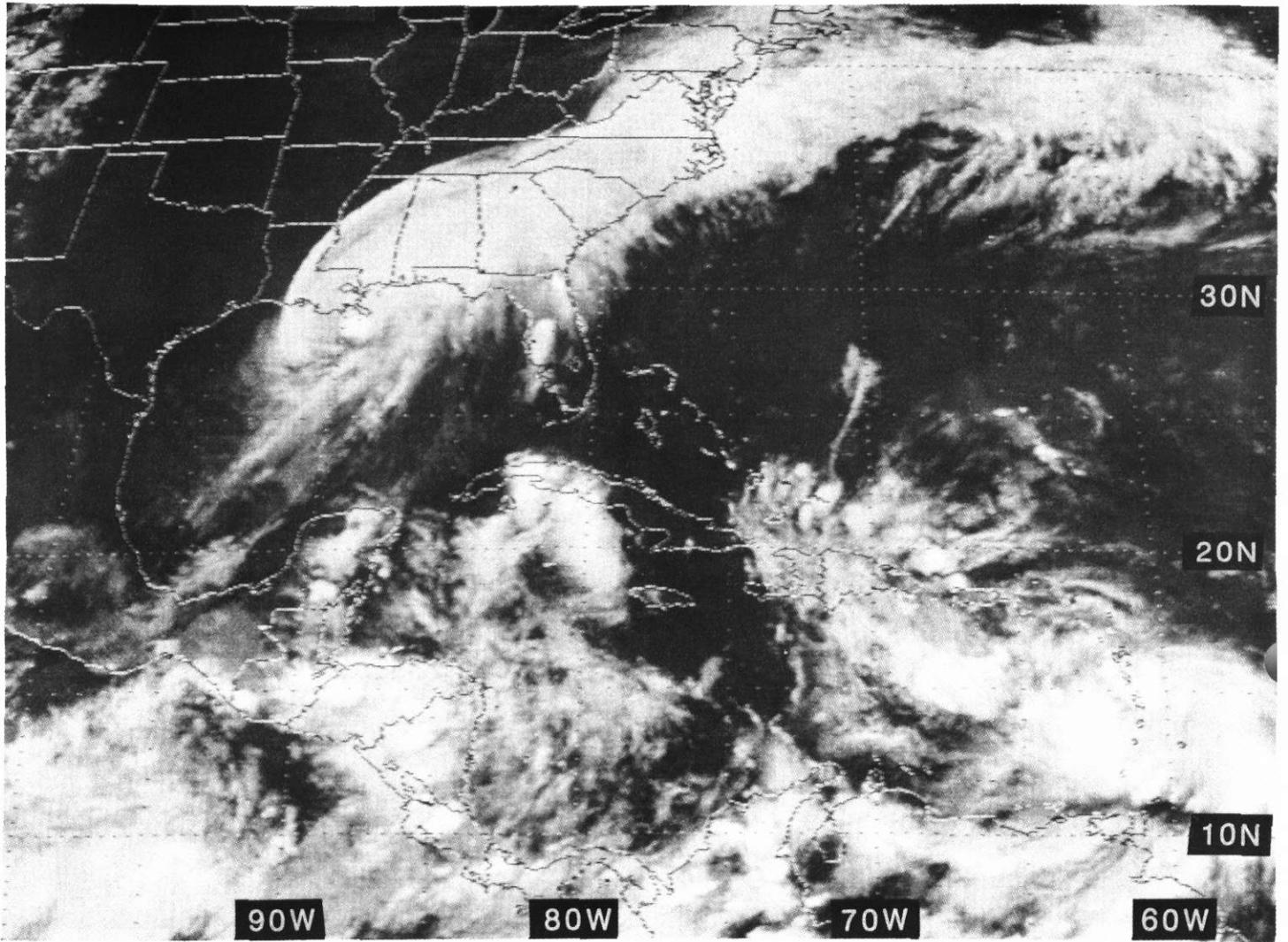


Figure 5.81: GOES East Infrared Satellite Imagery, 0001 UTC 10 SEP 1988

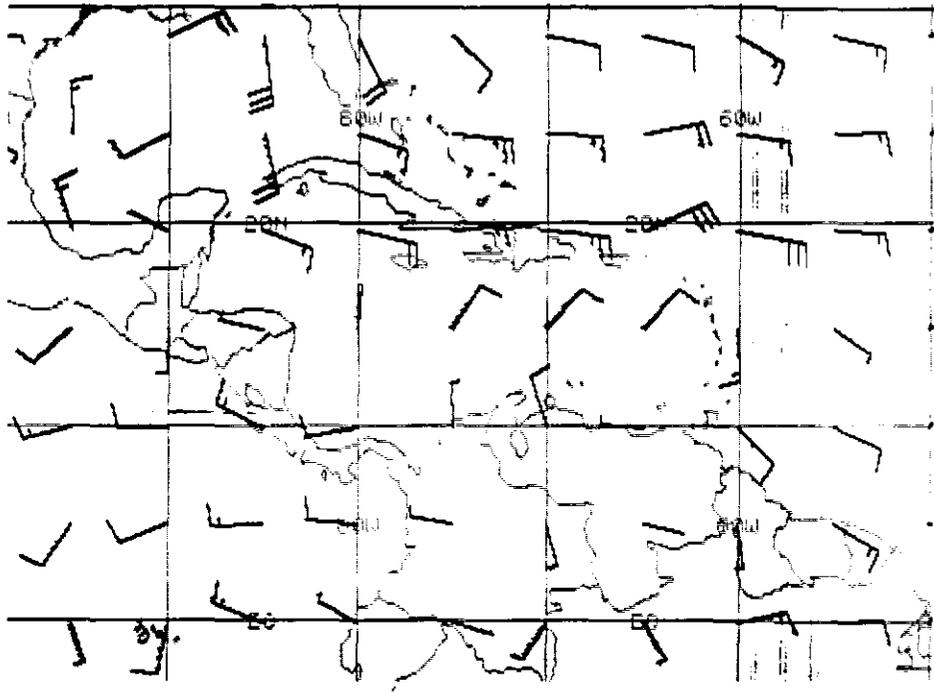


Figure 5.82: FNOC 925 mb Winds, 0000 UTC 10 SEP 1988. As in Fig. 2.19.

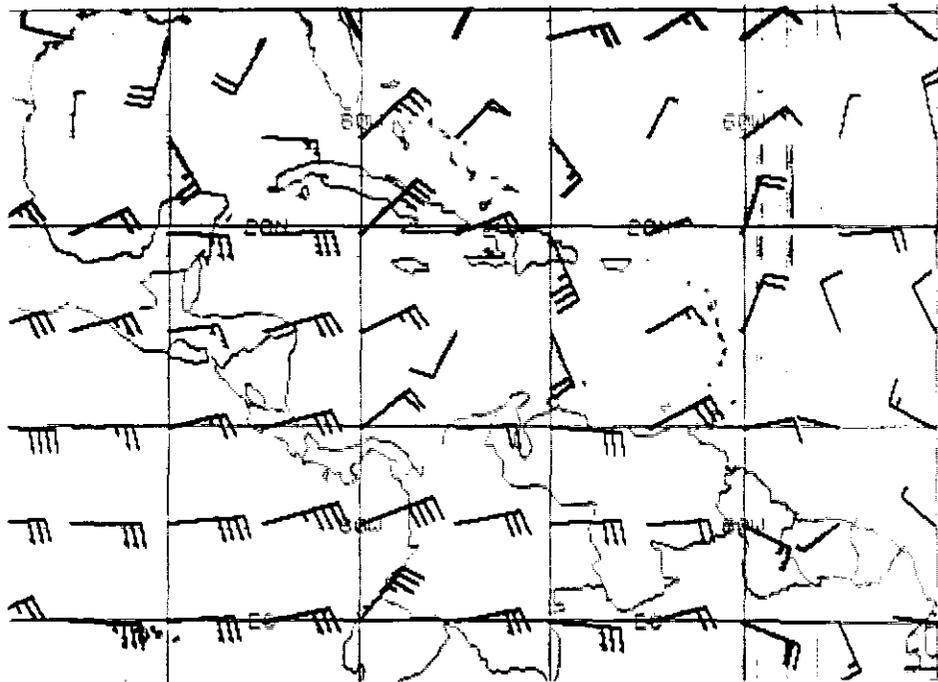


Figure 5.83: FNOC 200 mb Winds, 0000 UTC 10 SEP 1988. As in Fig. 2.20.

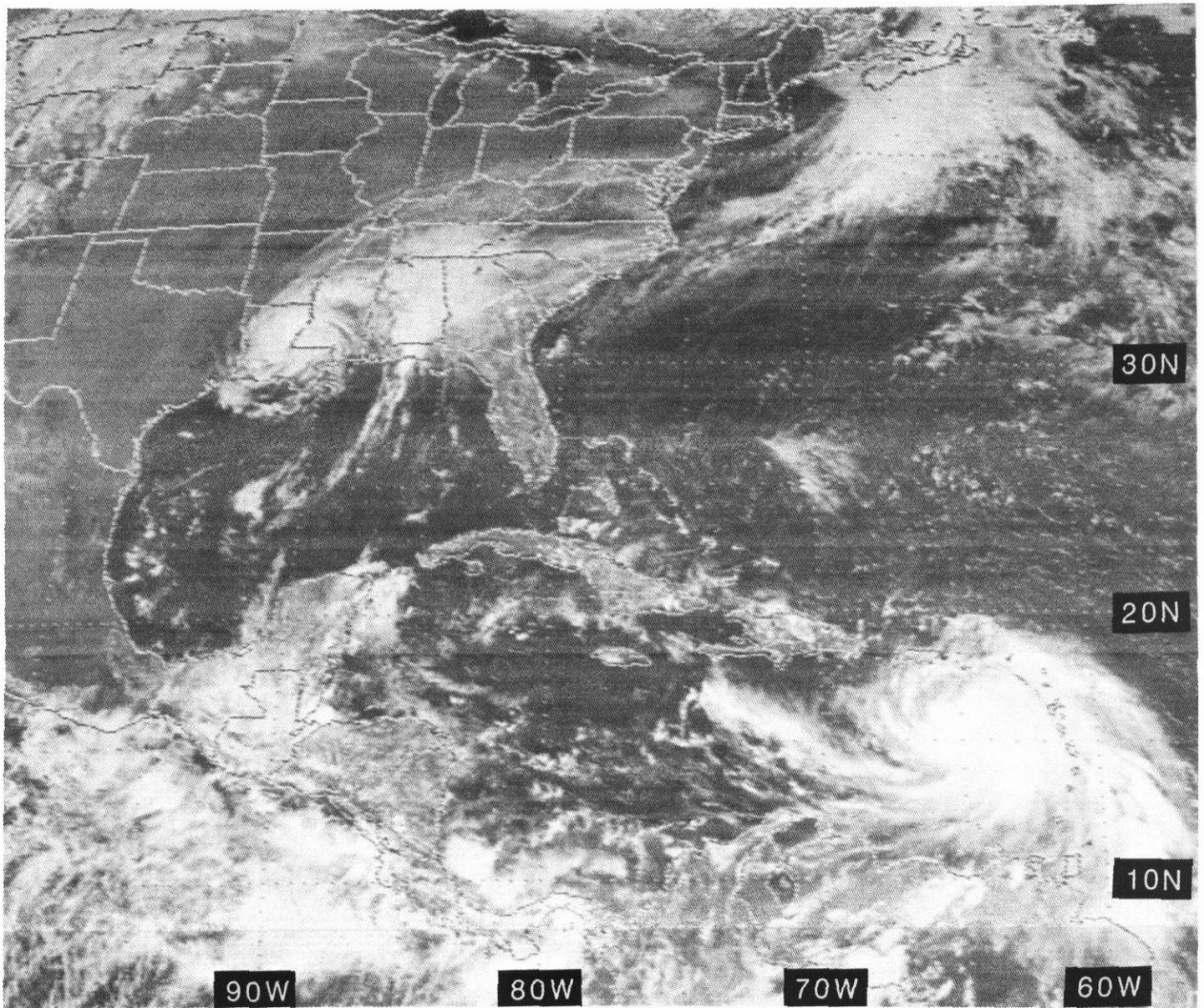


Figure 5.84: GOES East Visible Satellite Imagery, 1731 UTC 10 SEP 1988

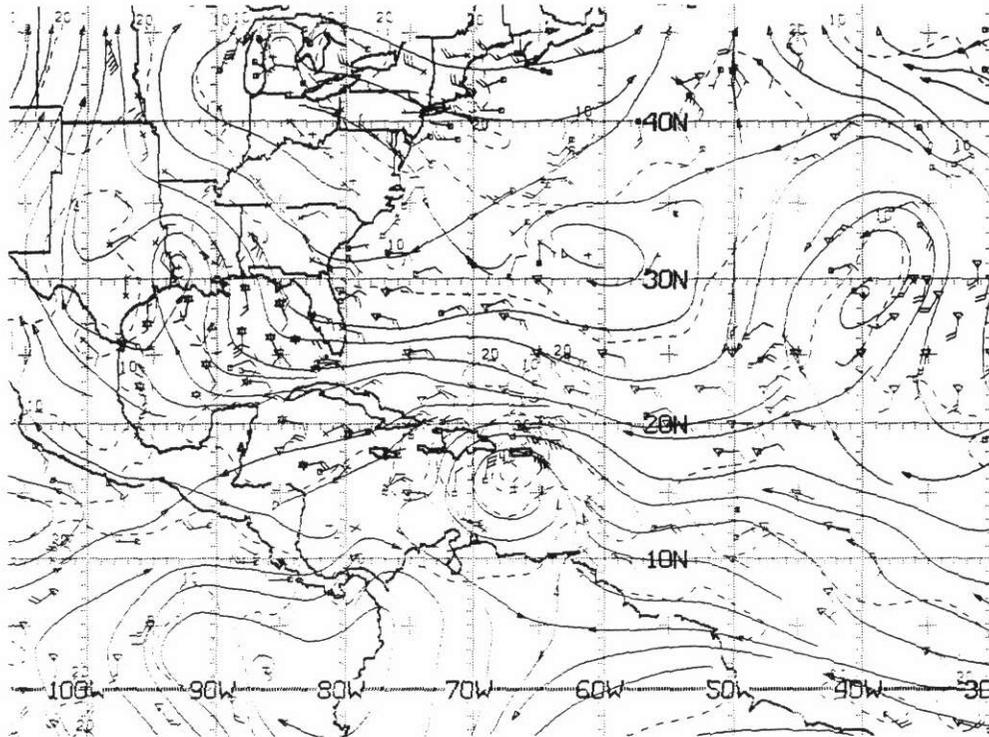


Figure 5.85: NMC ATOLL Operational Streamline Chart, 0000 UTC 11 SEP 1988
As in Fig. 2.4.

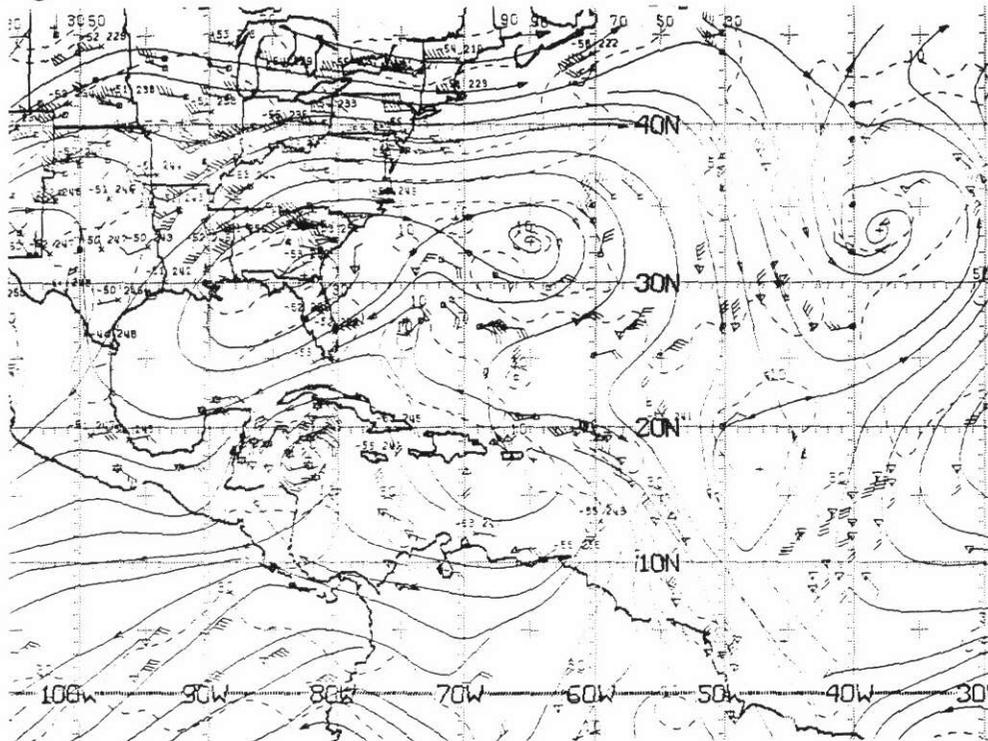


Figure 5.86: NMC 200 mb Operational Streamline Chart, 0000 UTC 11 SEP 1988
As in Fig. 2.7.

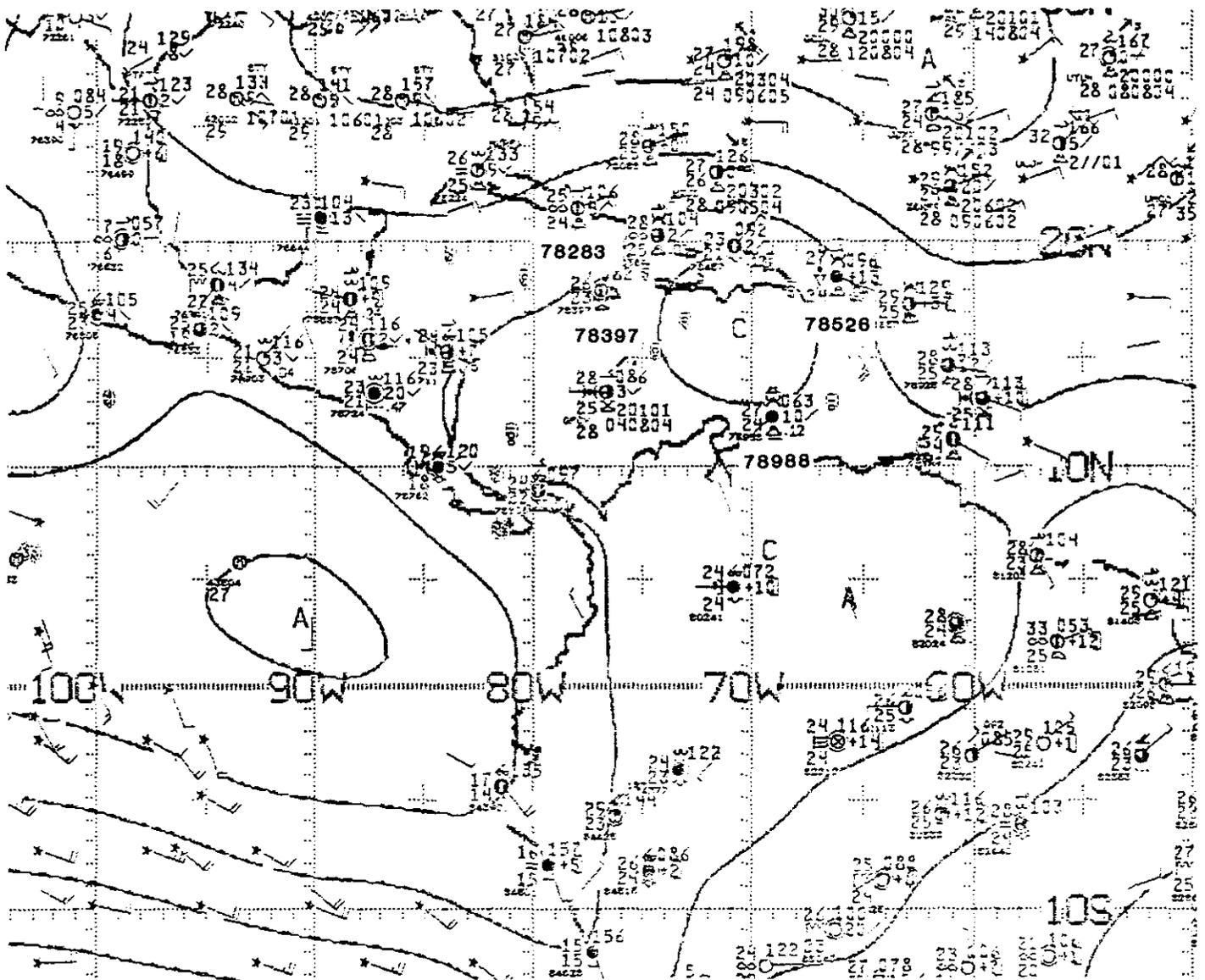


Figure 5.87: NMC 1000 mb Analysis, 1200 UTC 11 SEP 1988. As in Fig. 2.21.

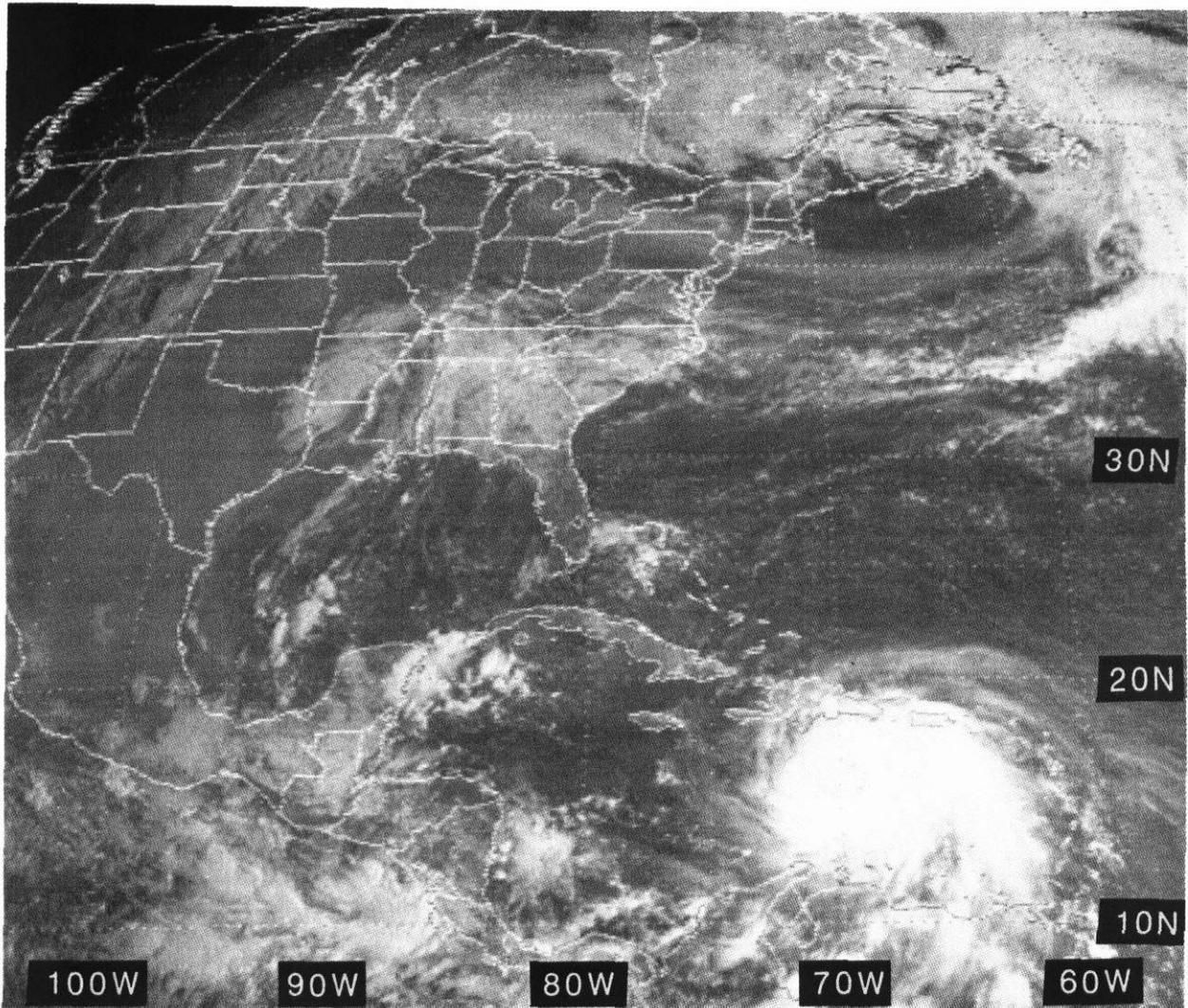


Figure 5.88: GOES East Visible Satellite Imagery, 1331 UTC 11 SEP 1988

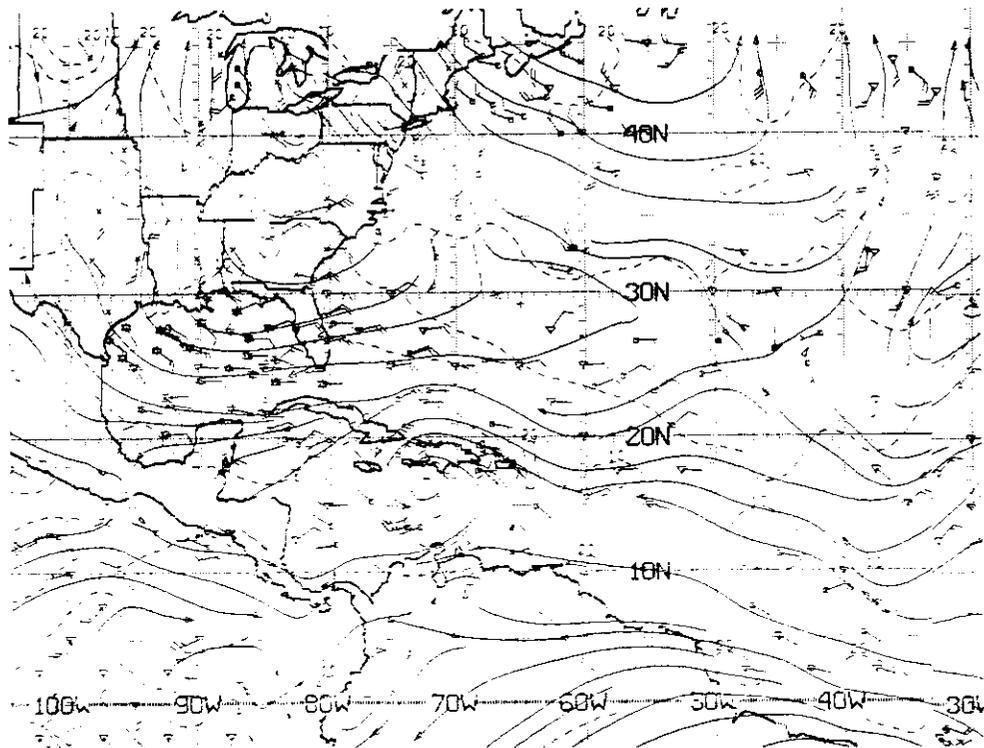
12 September 1988

The low-level and upper-level streamlines associated with Hurricane Gilbert at 0000 UTC on 12 September are depicted by the NMC charts (Figs. 5.89 and 5.90). The Navy wind analyses (Figs. 5.91 and 5.92) are included for comparison. At this time the hurricane is located at 16.8°N, 72.0°W (see the IR imagery at 0001 UTC in Fig. 5.93), with a sea-level central pressure of 964 mb and sustained winds of 105 kt.

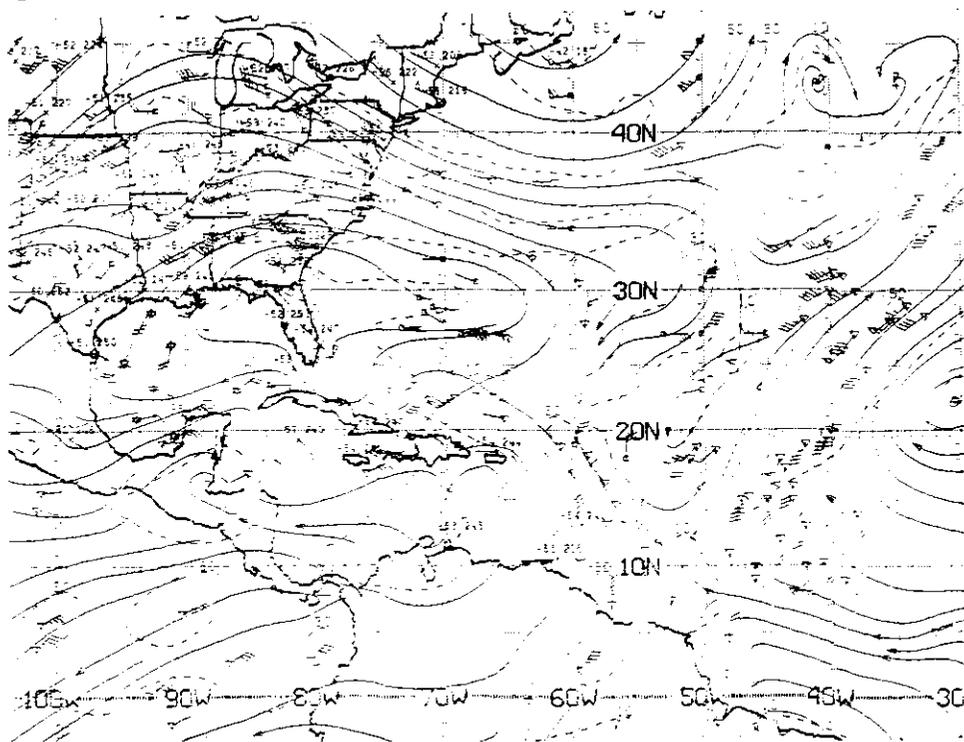
The Navy NOGAPS 24-hour 925 mb wind prognosis verifying at 0000 UTC 12 September (Fig. 5.94) provides a good forecast of Hurricane Gilbert's peripheral winds—recall that at the time this prognosis was prepared, Hurricane Gilbert was located at 15.9°N, 66.8°W, i.e., south of Puerto Rico.

Six hours later (0600 UTC 12 September), Fig. 5.95 shows the official forecast of the expected path of Hurricane Gilbert for the next 72 hours. Despite the erroneous “recurvature” forecast, which places the hurricane track to the right of its landfall on the northeast coast of the Yucatan Peninsula coast, the 48-h error is relatively small—compare with the preliminary best track in Fig 5.78.

Figure 5.96 gives the surface observations at 1200 UTC, while the visible imagery of Figs. 5.97 and 5.98 show the eye of the hurricane approaching the eastern tip of Jamaica. At 1730 UTC, Kingston, Jamaica reported its maximum wind of 101 kt with gusts to 122 kt. Then at 1815 UTC, Kingston, Jamaica reported its lowest pressure (964.8 mb). The northeast coast of Jamaica reported tides 9 feet above normal (NHC, 1988).



**Figure 5.89: NMC ATOLL Operational Streamline Chart, 0000 UTC 12 SEP 1988
As in Fig. 2.4.**



**Figure 5.90: NMC 200 mb Operational Streamline Chart, 0000 UTC 12 SEP 1988
As in Fig. 2.7.**

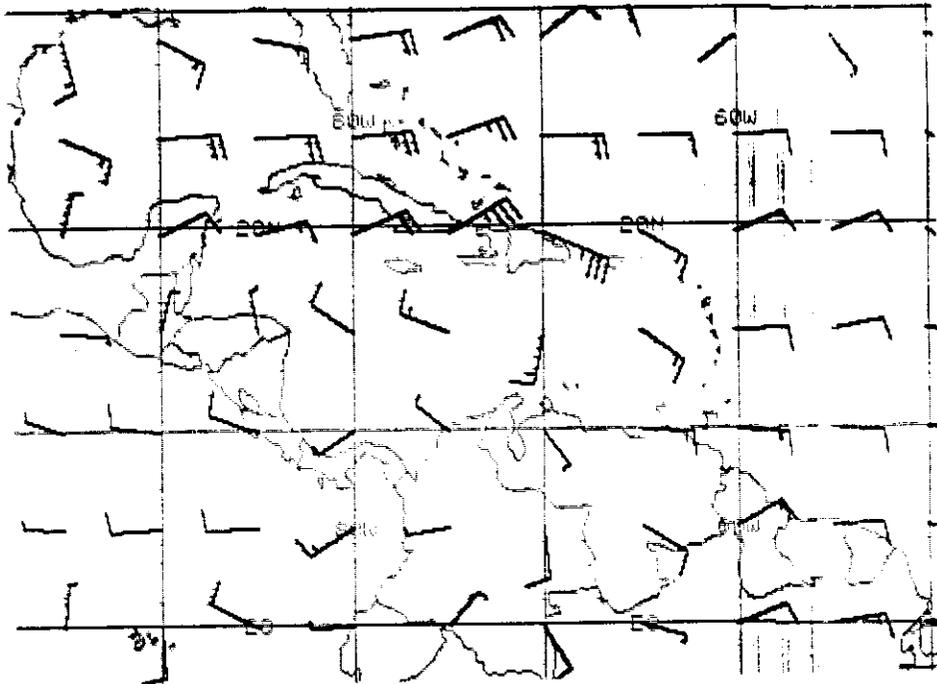


Figure 5.91: FNOC 925 mb Winds, 0000 UTC 12 SEP 1988. As in Fig. 2.19.

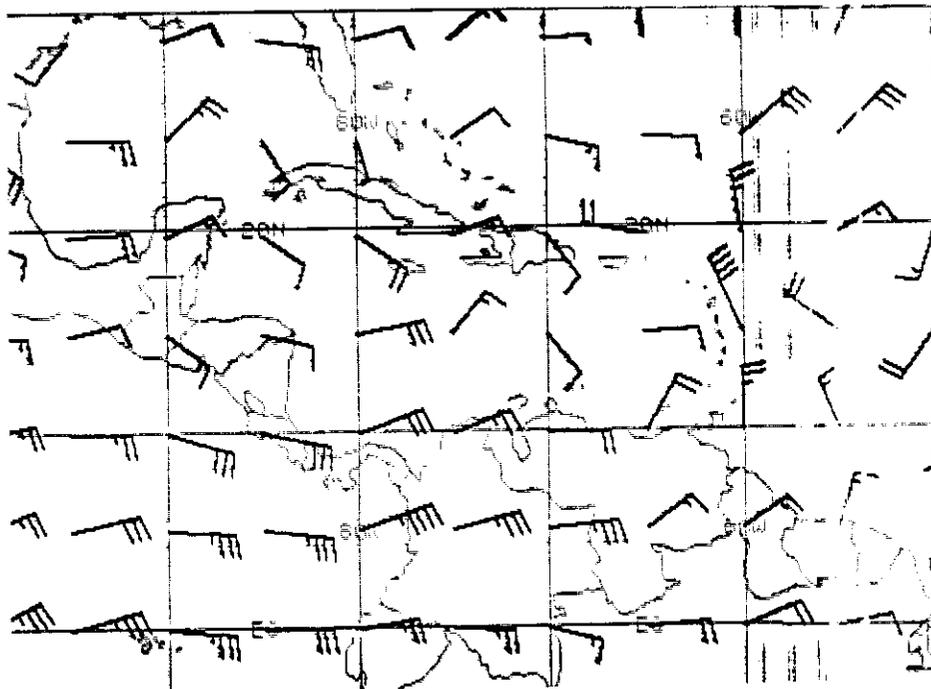


Figure 5.92: FNOC 200 mb Winds, 0000 UTC 12 SEP 1988. As in Fig. 2.20.

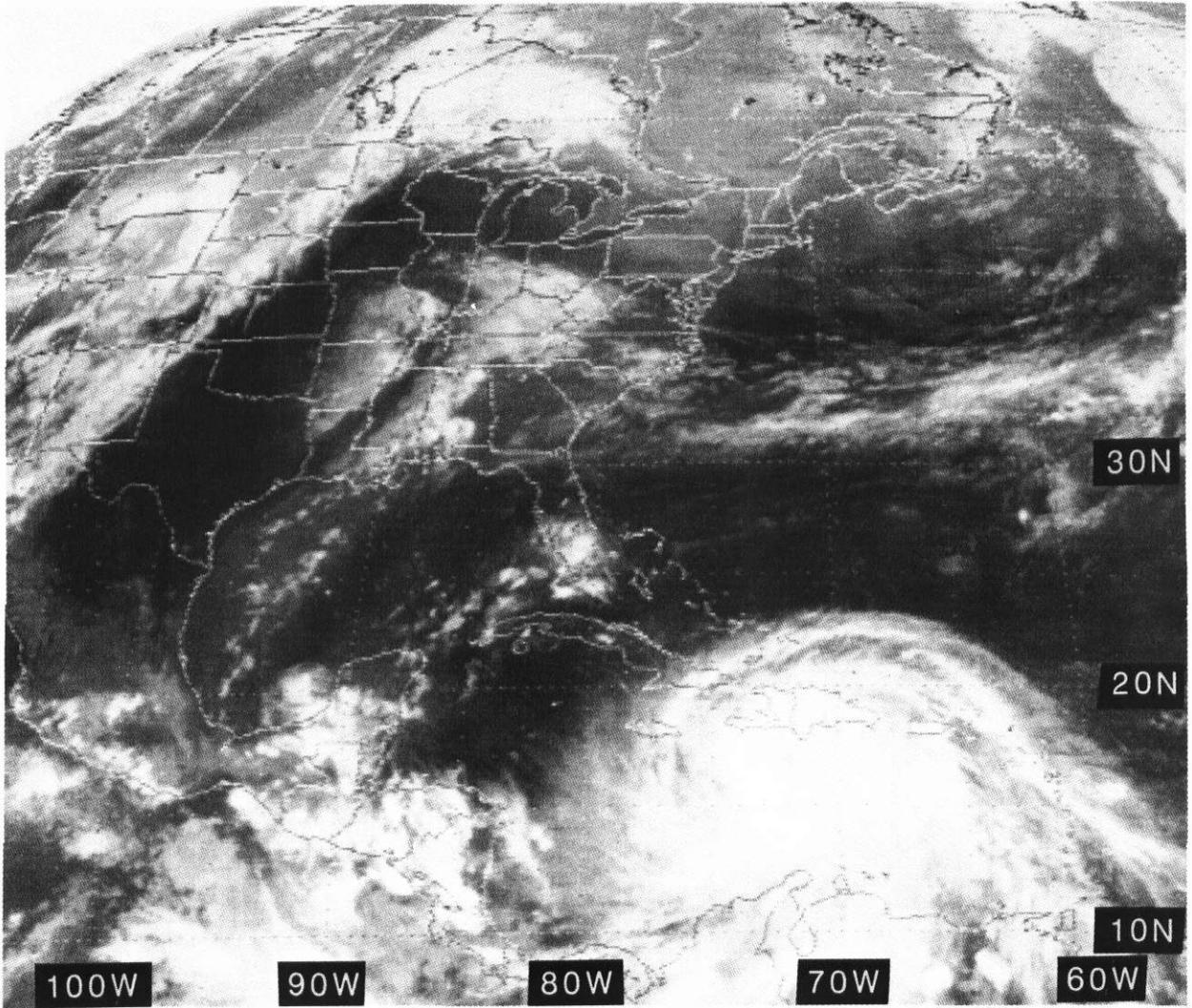


Figure 5.93: GOES East Infrared Satellite Imagery, 0001 UTC 12 SEP 1988

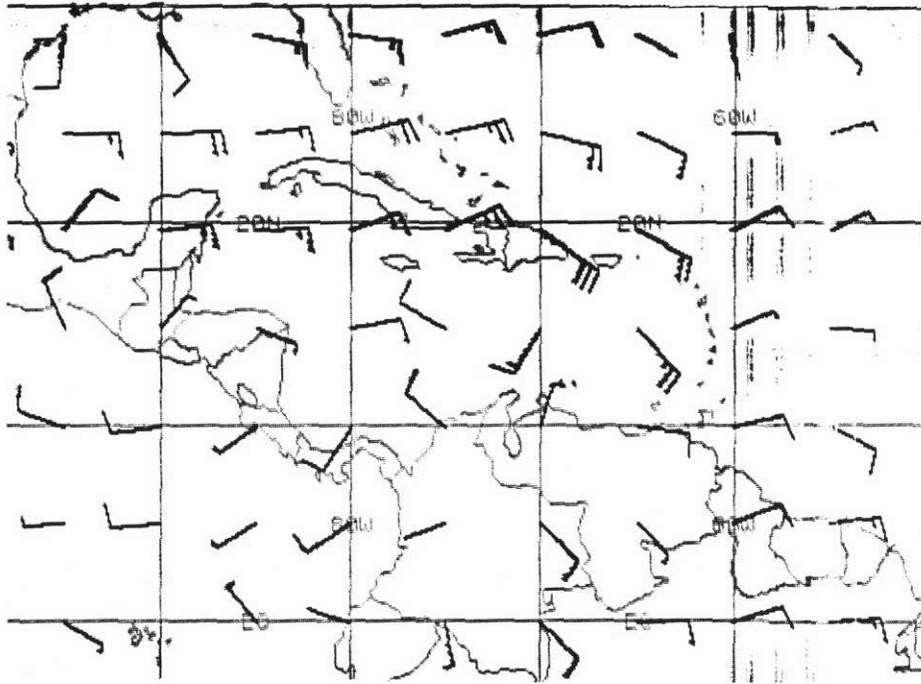


Figure 5.94: FNOC 925 mb Winds 24-h PROG VT 0000 UTC 12 SEP 1988.
As in Fig. 2.19.

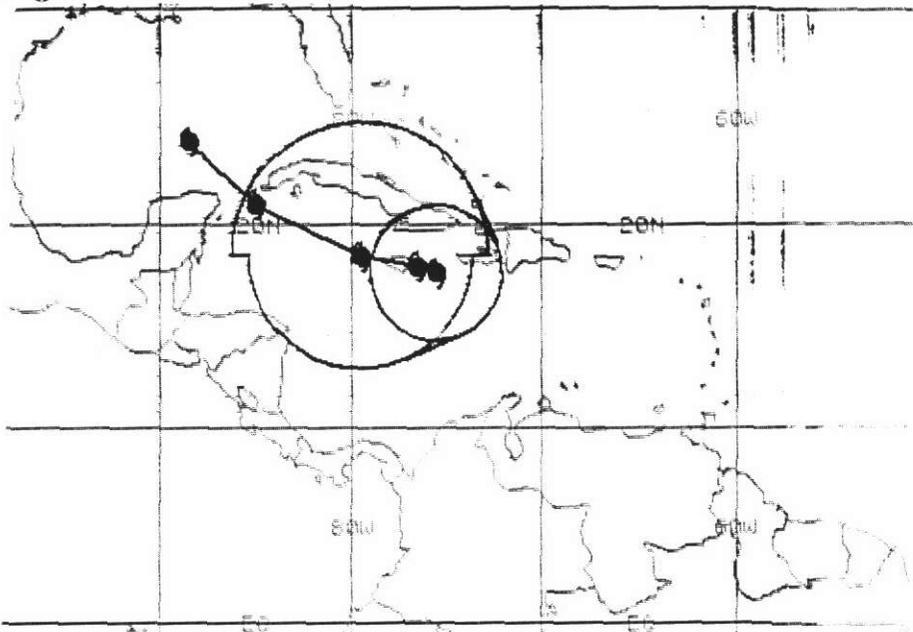


Figure 5.95: Tropical Cyclone FORECAST Track from 0600 UTC 12 SEP 1988.
Current position of Gilbert is the rightmost hurricane symbol *enclosed* by the circle depicting the radius of gale force winds. The 12-, 24-, 48- and 72-h forecast positions follow toward the northwest, with the larger semicircles indicating the probable radii of gale force winds in 24 hours.

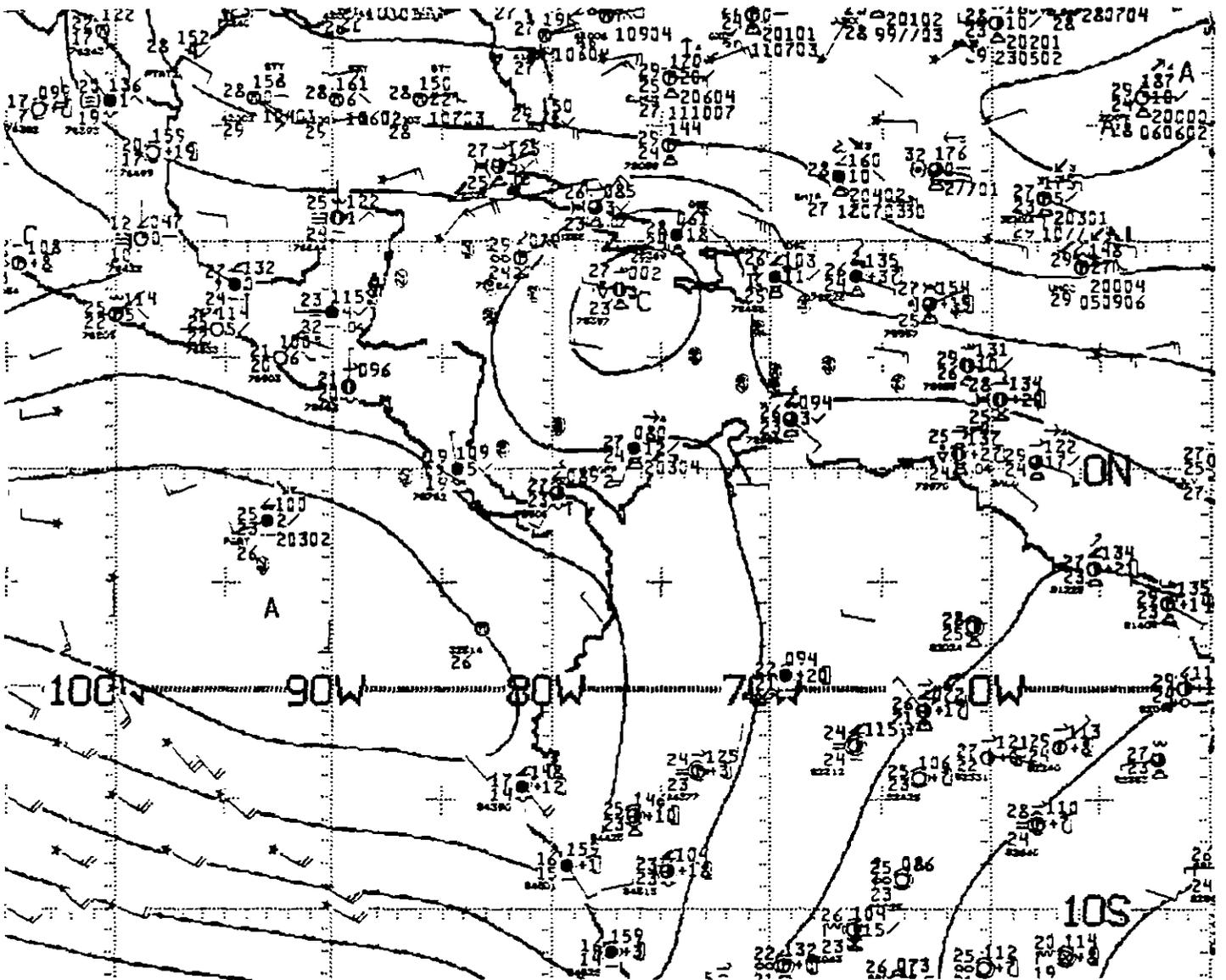


Figure 5.96: NMC 1000 mb Analysis, 1200 UTC 12 SEP 1988. As in Fig.2.21.

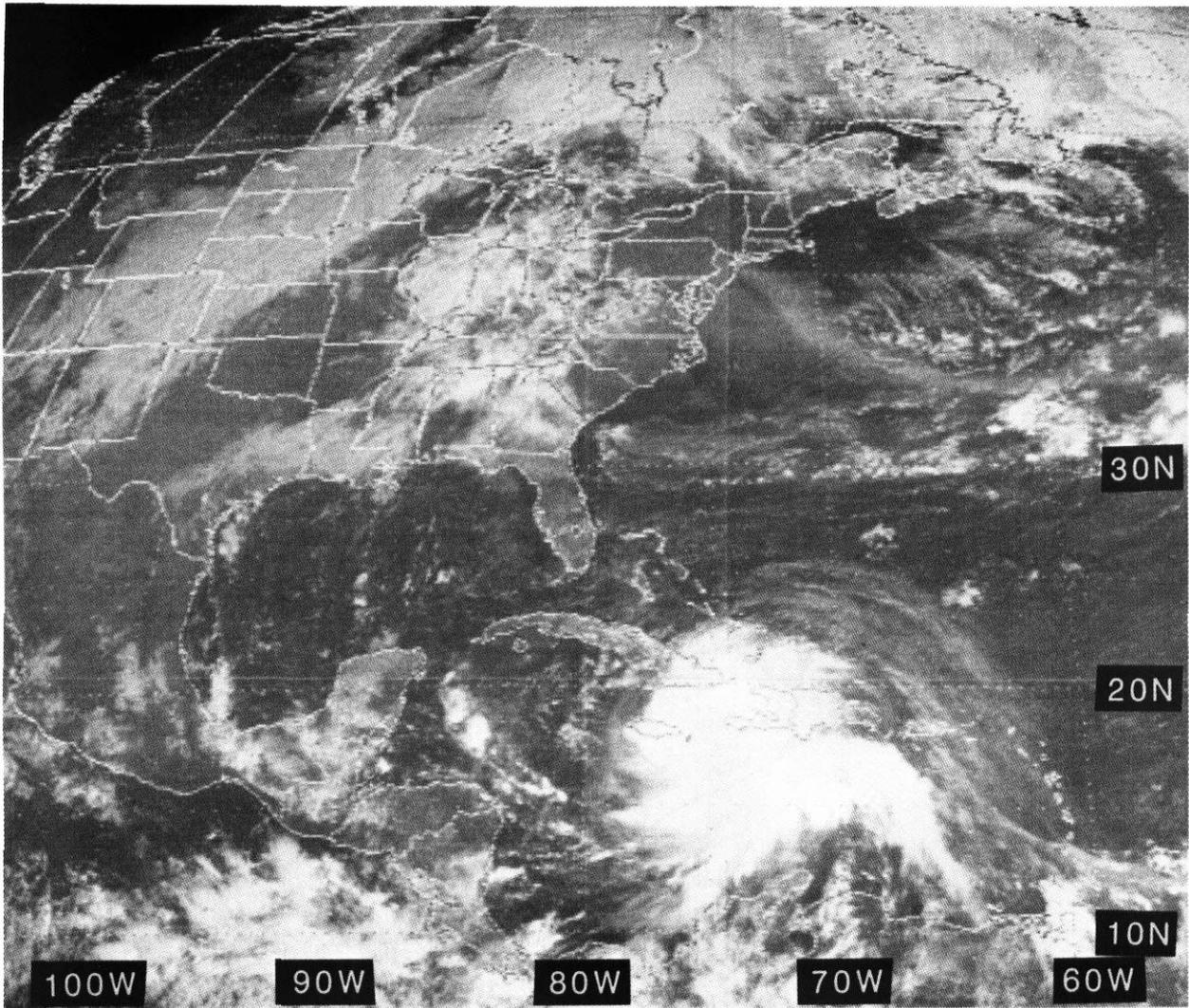


Figure 5.97: GOES East Visible Satellite Imagery, 1431 UTC 12 SEP 1988

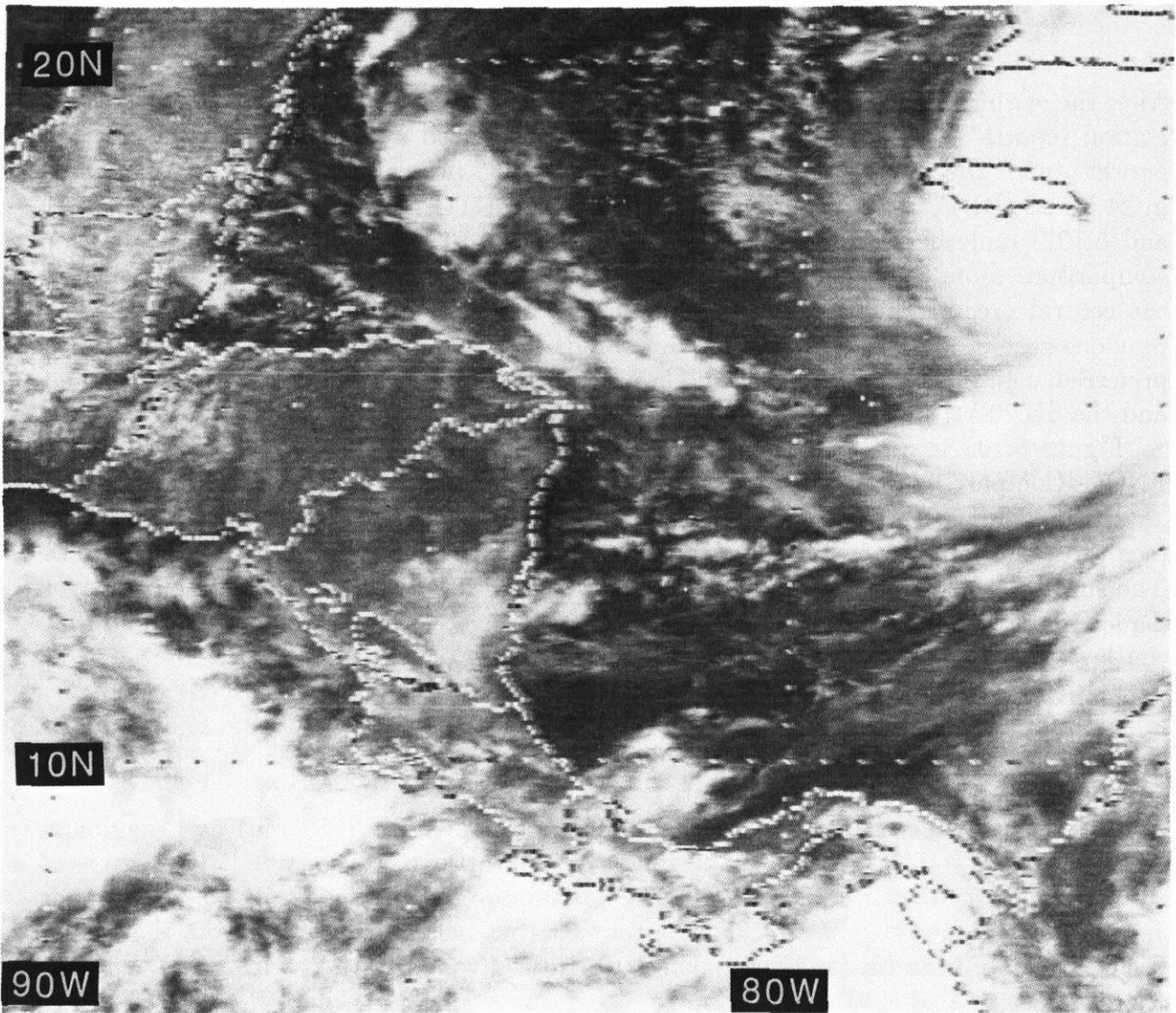


Figure 5.98: GOES E. Visible Imag. ("Zoomed"), 1531 UTC 12 SEP 1988

13 September 1988

After the eye of Hurricane Gilbert moved west of Jamaica at ~0000 UTC, (see Fig. 5.99 and station reports⁹⁵ on Fig. 5.100), the hurricane experienced a “remarkable intensification period”, with the pressure falling from 960 mb (28.35 inches) to 888 mb (26.22 inches) in 24 hours (NHC, 1988). As on the 12th, the 0000 UTC NMC streamlines (Figs. 5.101 and 5.102) and the FNOC NOGAPS winds (Figs. 5.103 and 5.104) are presented for comparison—note the strong low-level confluence and upper-level diffluence, even before the central pressure of the hurricane commences its plunge. (However, as identified in previous case studies the 200 mb satellite winds plotted on the NMC analysis are much preferred, e.g., the 35-kt southerly wind between Cuba and Florida on Fig. 5.102 is accepted and the SE 20-kt wind on Fig. 5.104 rejected.)

Figure 5.108 is an example of the discontinuous streamline analysis available from FNOC. Compare to Fig. 5.103 (FNOC) and Fig. 5.101 (NMC).

By 1200 UTC, Hurricane Gilbert is passing just south of the Grand Cayman Island (see the early morning visible imagery of Fig. 5.105 and the IR imagery of Fig. 5.106). The surface station reports for 1200 UTC are shown in Fig. 5.107. The satellite images depict that the hurricane circulation is producing convection over the Gulf of Honduras, southward to Nicaragua and Costa Rica.

Figure 5.109 shows the official forecast of the expected path of the hurricane commencing at 1800 UTC. While the hurricane is now forecast to strike the Yucatan Peninsula, its subsequent forecast track *north northwestward* toward the northern Texas coastline was in error—compare with the preliminary best track in Fig 5.78.

As the hurricane is reaching its minimum central pressure (888 mb) and maximum sustained winds (~160 kt), Figs. 5.110 and 5.111 show its eye position about 100 n mi west of the Grand Cayman Island. At 1900 UTC, as the pressure in the eye of the hurricane is approaching its lowest value and despite the fact that it is moving away from the island, Grand Cayman Island records its maximum sustained wind of 119 kt with gusts to 136 kt (NHC, 1988).

Figures 5.112 and 5.113 present the best track minimum central pressure curve and maximum wind speed curve, respectively, for Hurricane Gilbert from the various sources and analysis centers (NHC, 1988).

⁹⁵The SSE 70 kt surface wind at Belize City (station 78583) on Fig.5.100 must be rejected.

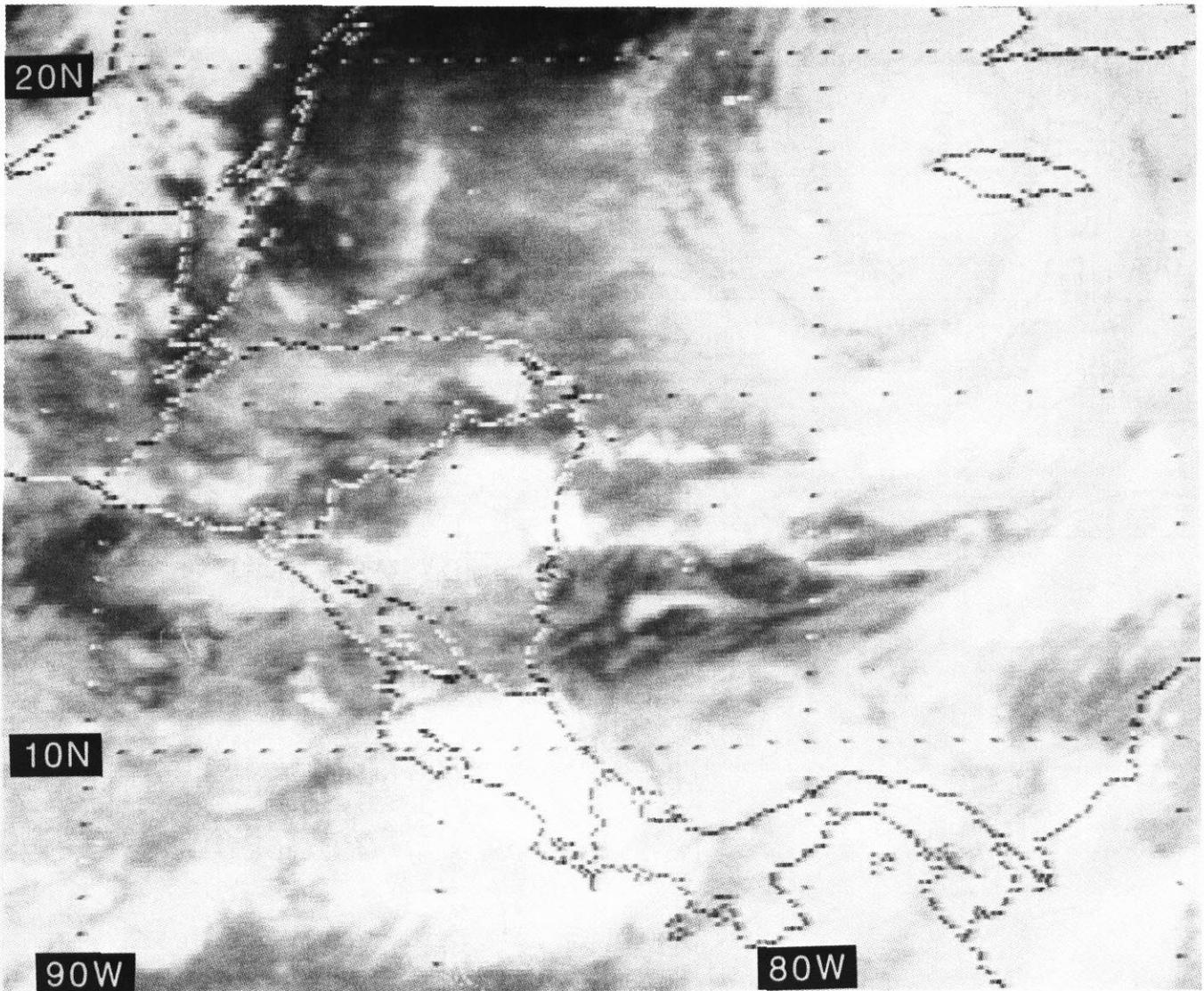


Figure 5.99: GOES E. IR Imagery ("Zoomed"), 0001 UTC 13 SEP 1988

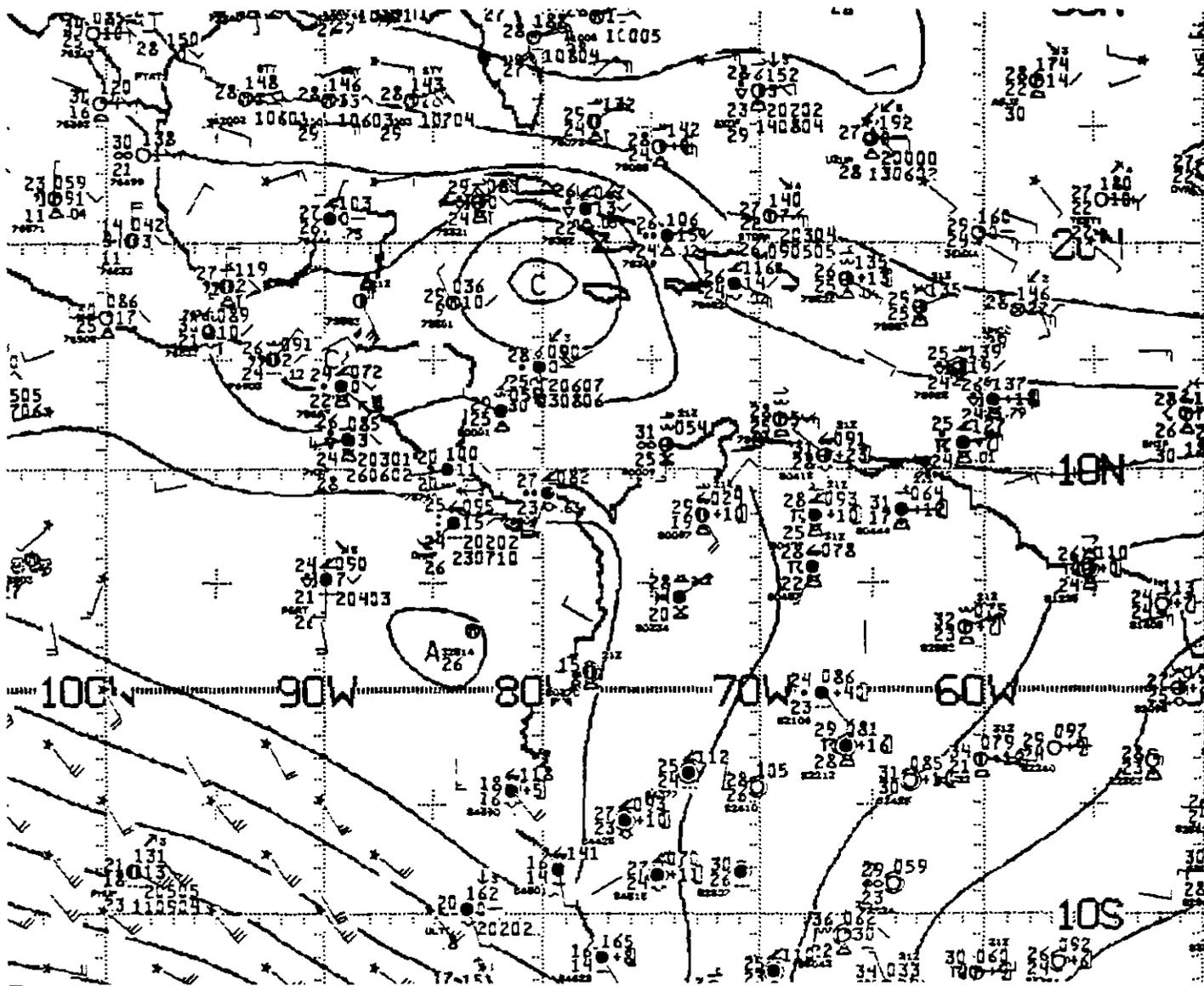


Figure 5.100: NMC 1000 mb Analysis, 0000 UTC 13 SEP 1988. As in Fig.2.21.

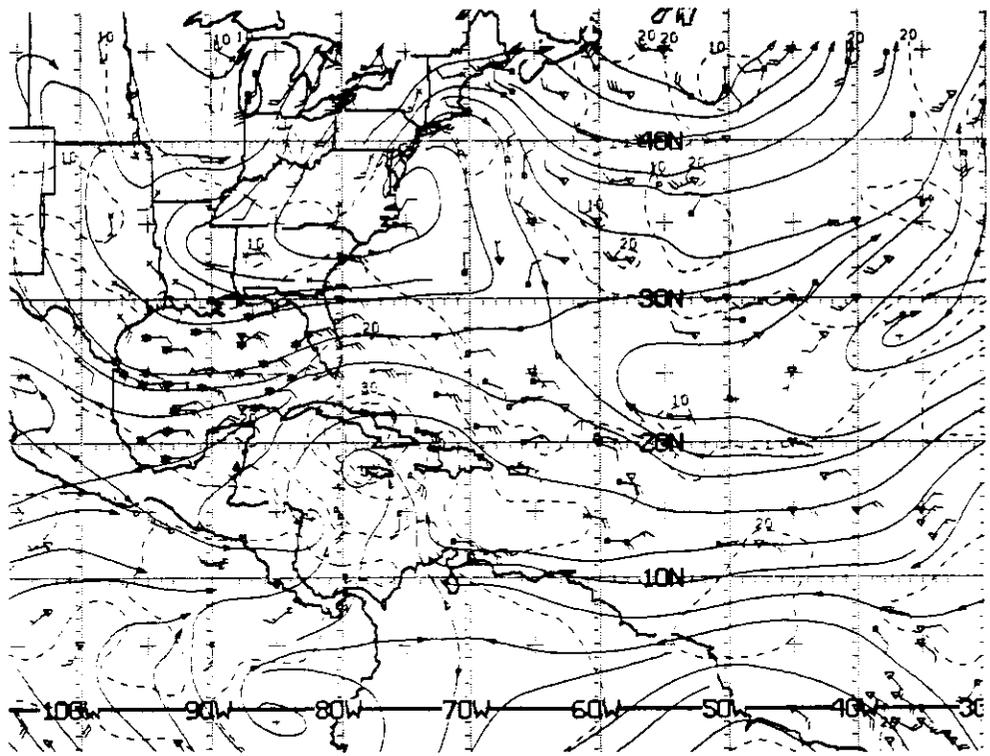


Figure 5.101: NMC ATOLL Operational Streamline Chart, 0000 UTC 13 SEP 1988
As in Fig. 2.4.

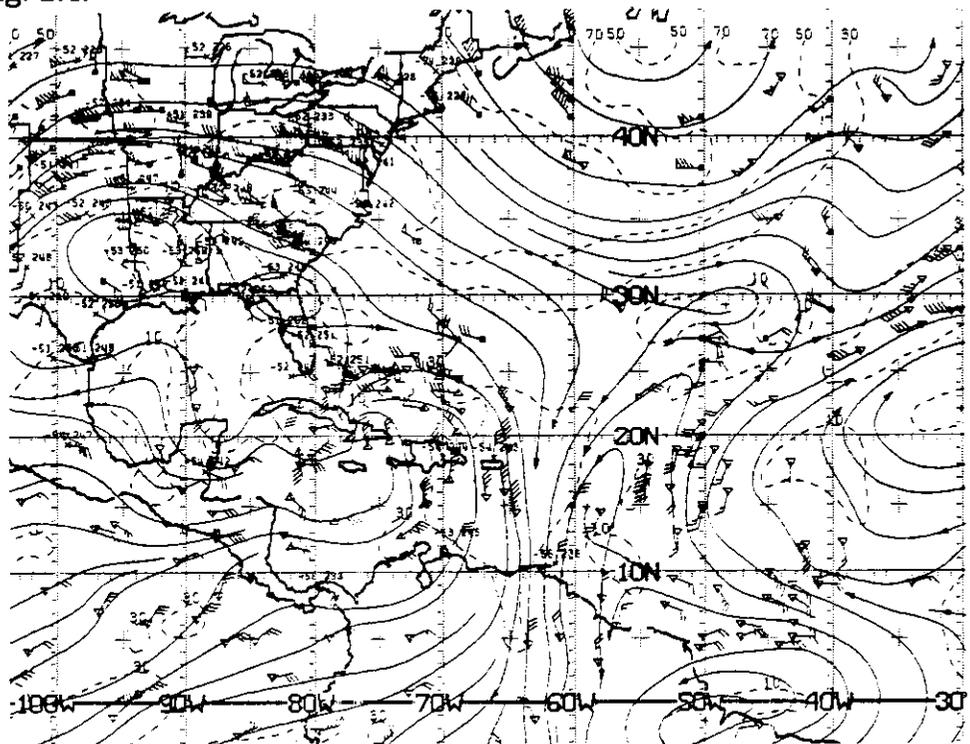


Figure 5.102: NMC 200 mb Operational Streamline Chart, 0000 UTC 13 SEP 1988
As in Fig. 2.7.

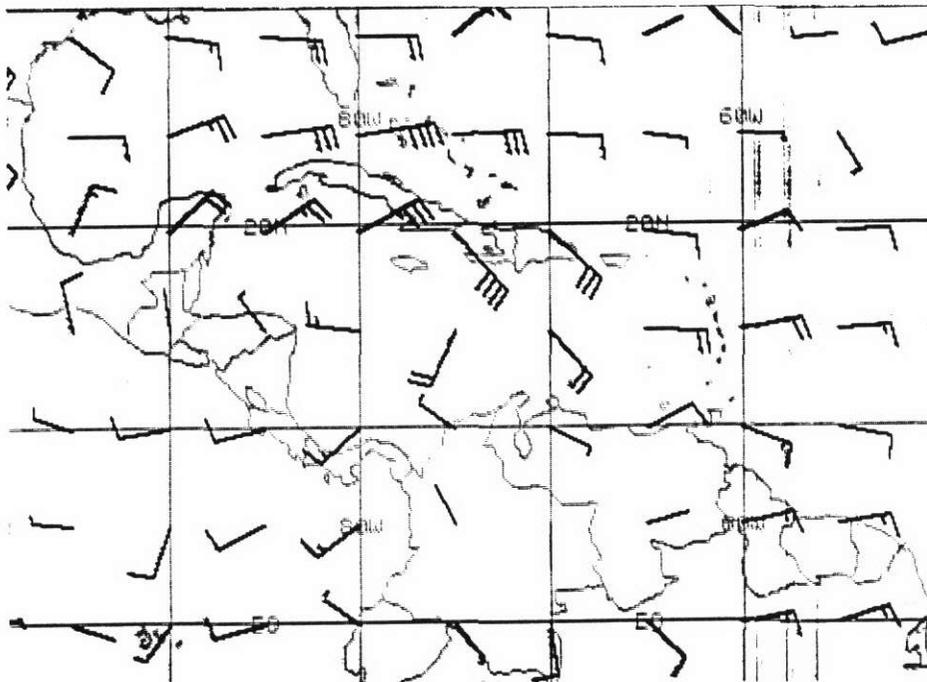


Figure 5.103: FNOc 925 mb Winds, 0000 UTC 13 SEP 1988. As in Fig. 2.19.

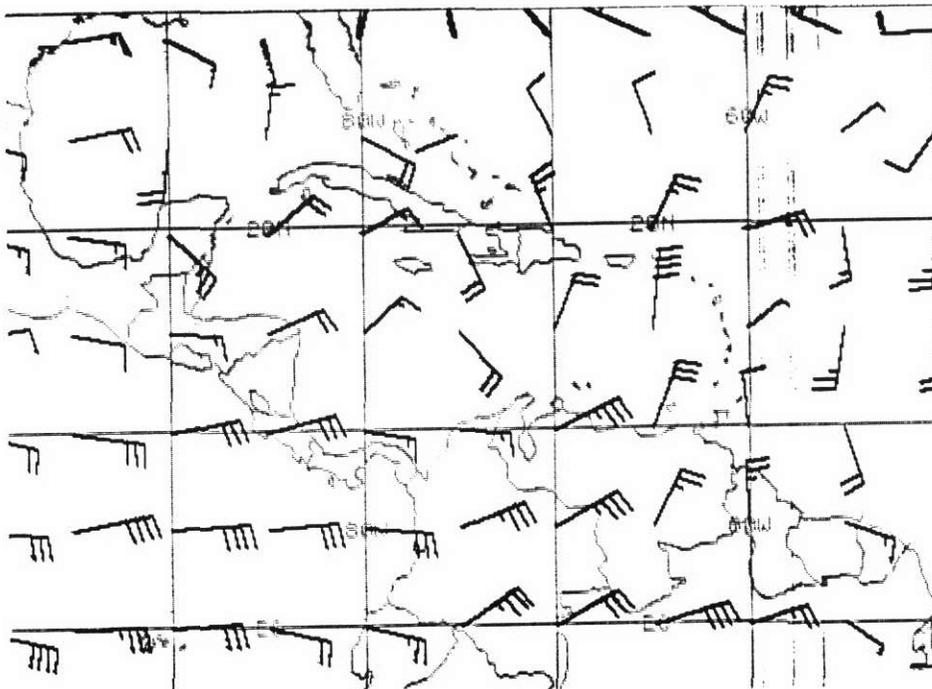


Figure 5.104: FNOc 200 mb Winds, 0000 UTC 13 SEP 1988. As in Fig. 2.20.

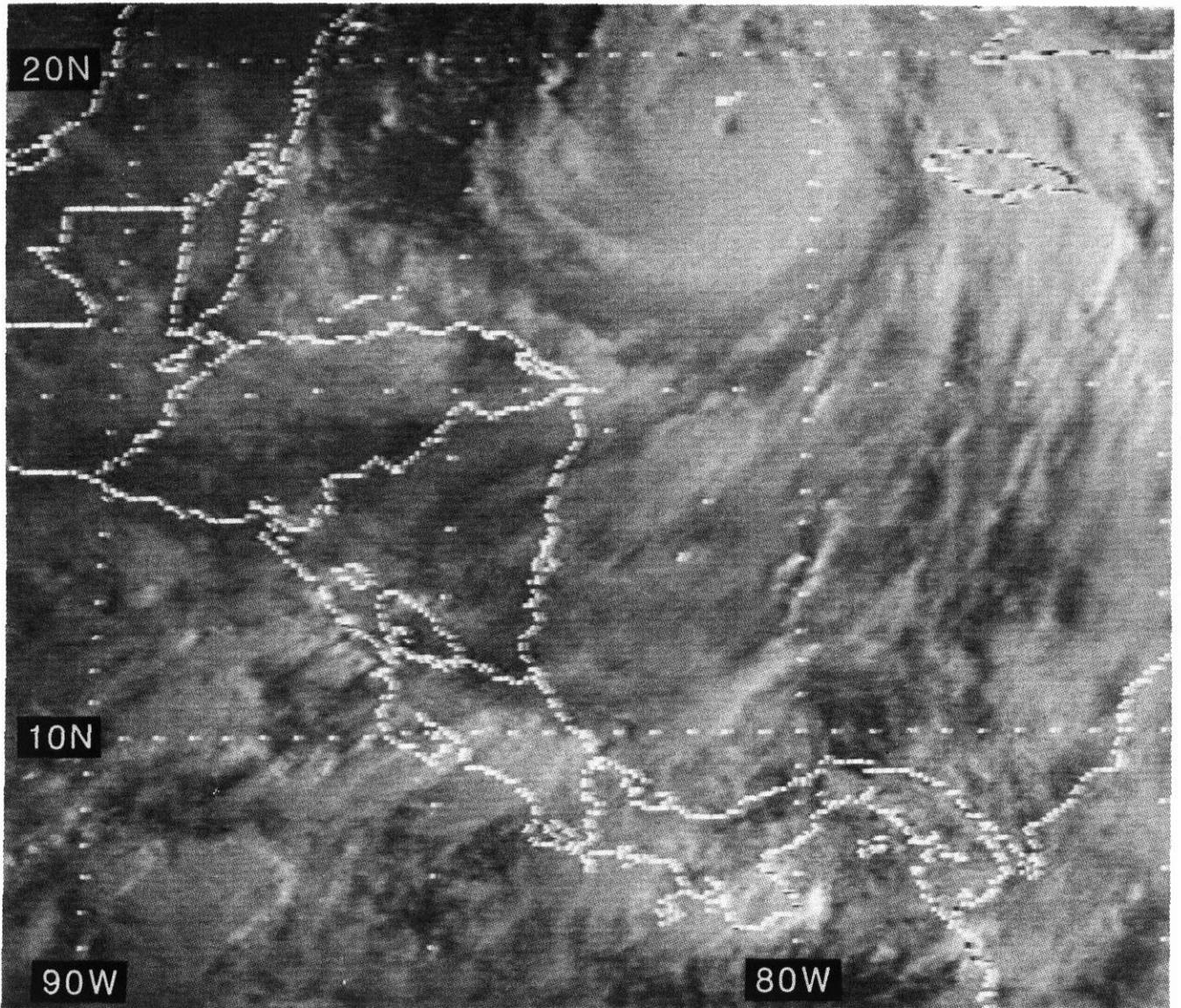


Figure 5.105: GOES E. Visible Imag. ("Zoomed"), 1231 UTC 13 SEP 1988
Grand Cayman Island is the "white" plot just north of the hurricane eye.

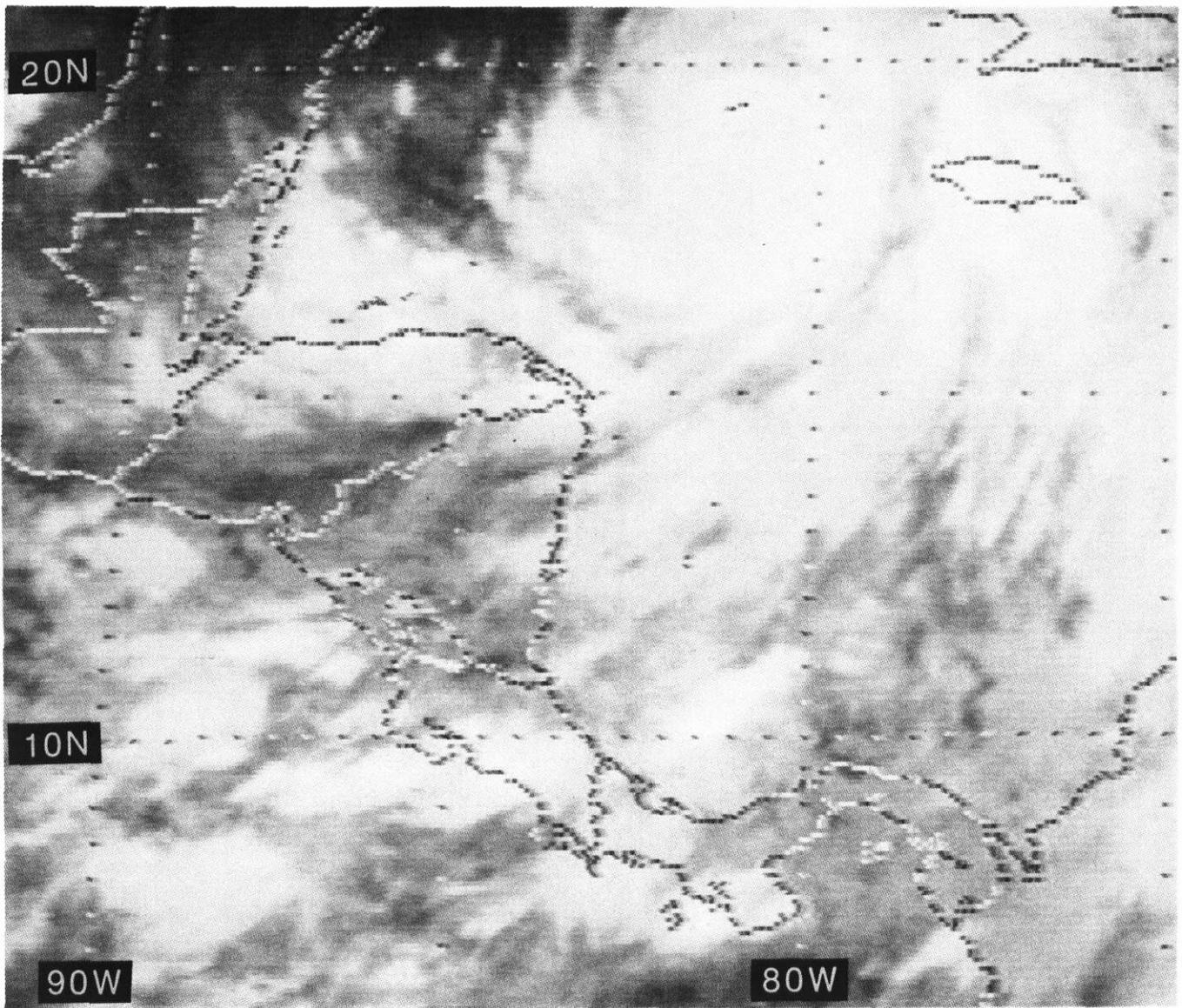


Figure 5.106: GOES E. IR Imagery (“Zoomed”), 1201 UTC 13 SEP 1988

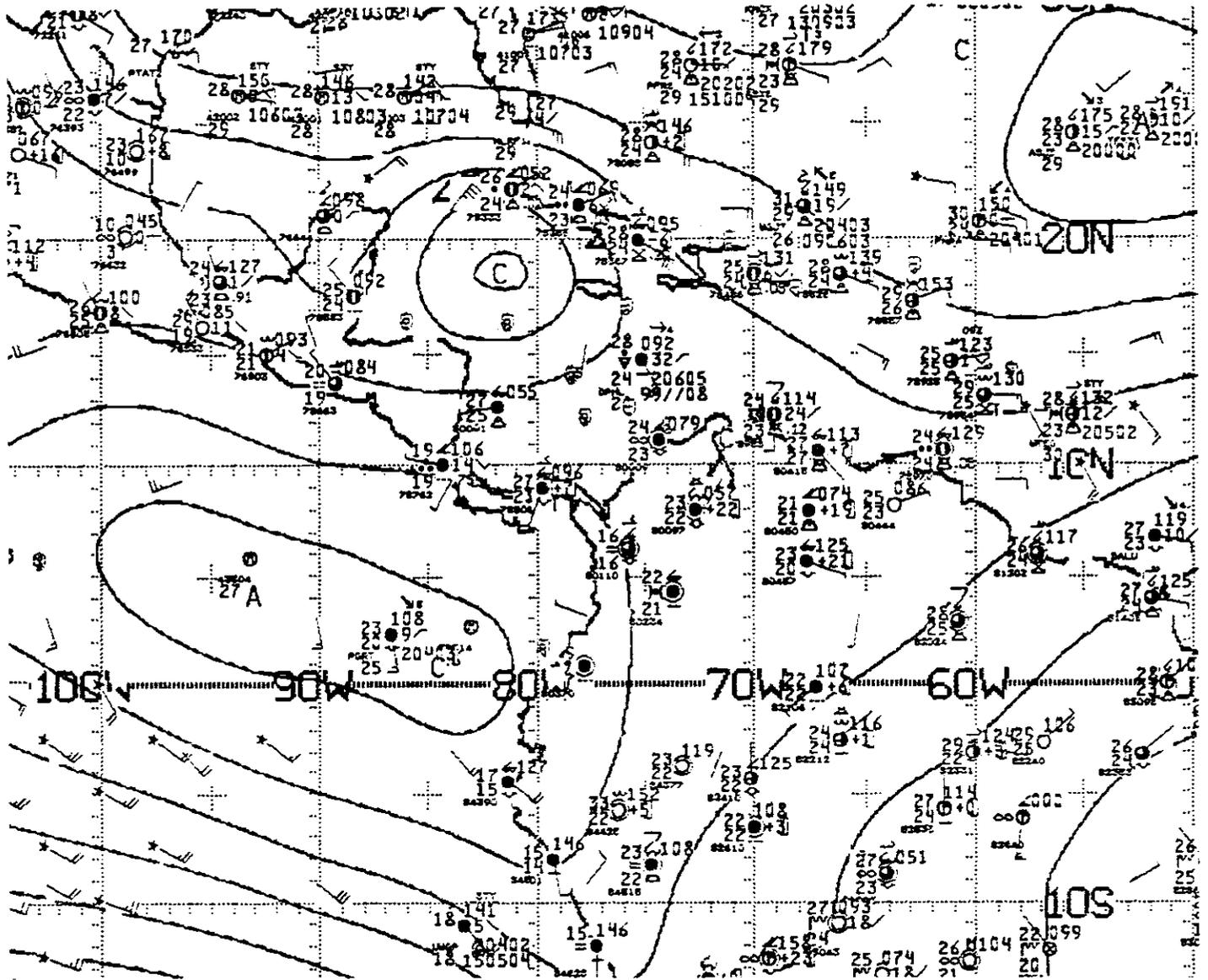


Figure 5.107: NMC 1000 mb Analysis, 1200 UTC 13 SEP 1988. As in Fig.2.21.

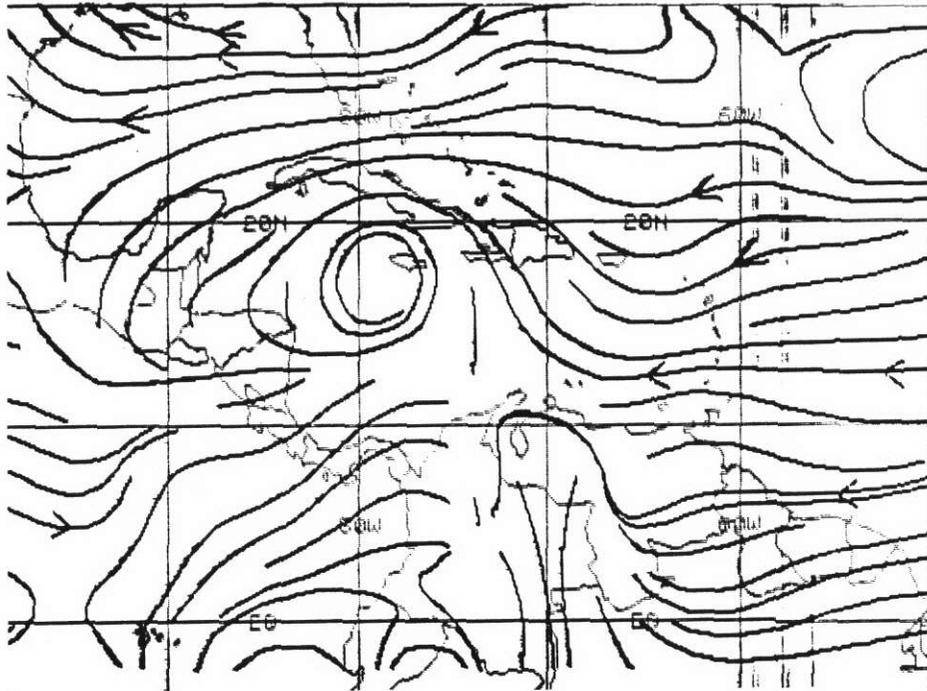


Figure 5.108: FNOc 925 mb Streamlines, 0000 UTC 13 SEP 1988.

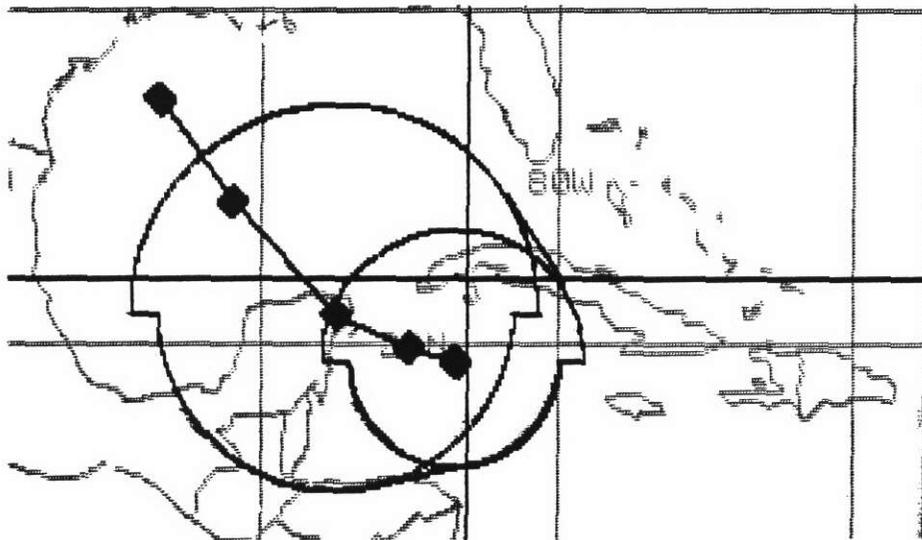
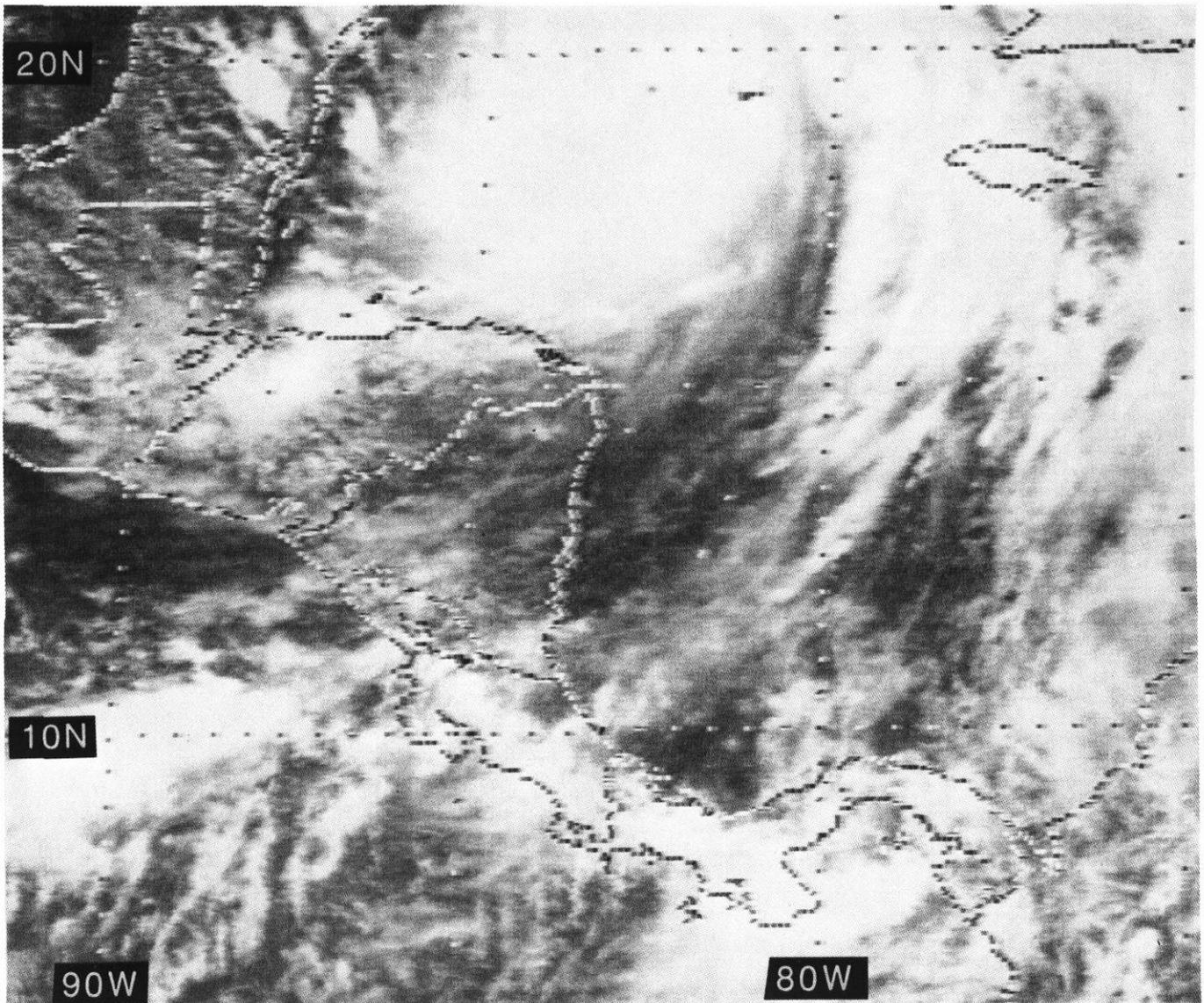


Figure 5.109: Tropical Cyclone FORECAST Track from 1800 UTC 13 SEP 1988. Current position of Gilbert is the rightmost black diamond symbol. The 12-, 24-, 48- and 72-h forecast positions follow toward the northwest. The smaller semicircles define the outer radii of gale force winds at the current position, while the larger semicircles define the probable outer radii of gale force winds in 24 hours. (The diamond symbol was erroneously plotted vice the hurricane symbol.)



**Figure 5.110: GOES E. Visible Imag. ("Zoomed"), 1831 UTC 13 SEP 1988
Grand Cayman Island is the "white" plot just north of the hurricane eye.**

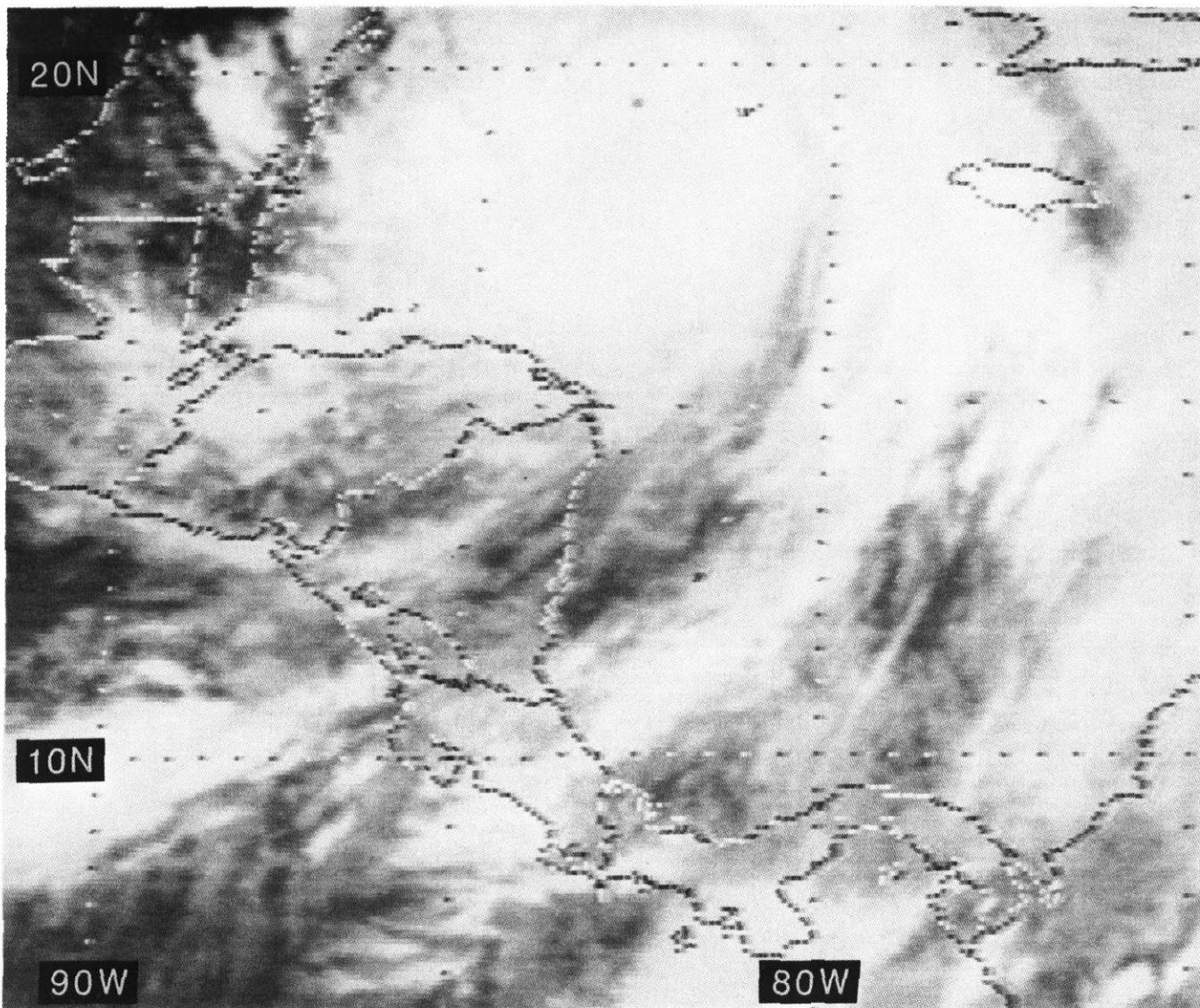


Figure 5.111: GOES E. IR Imagery ("Zoomed"), 1901 UTC 13 SEP 1988

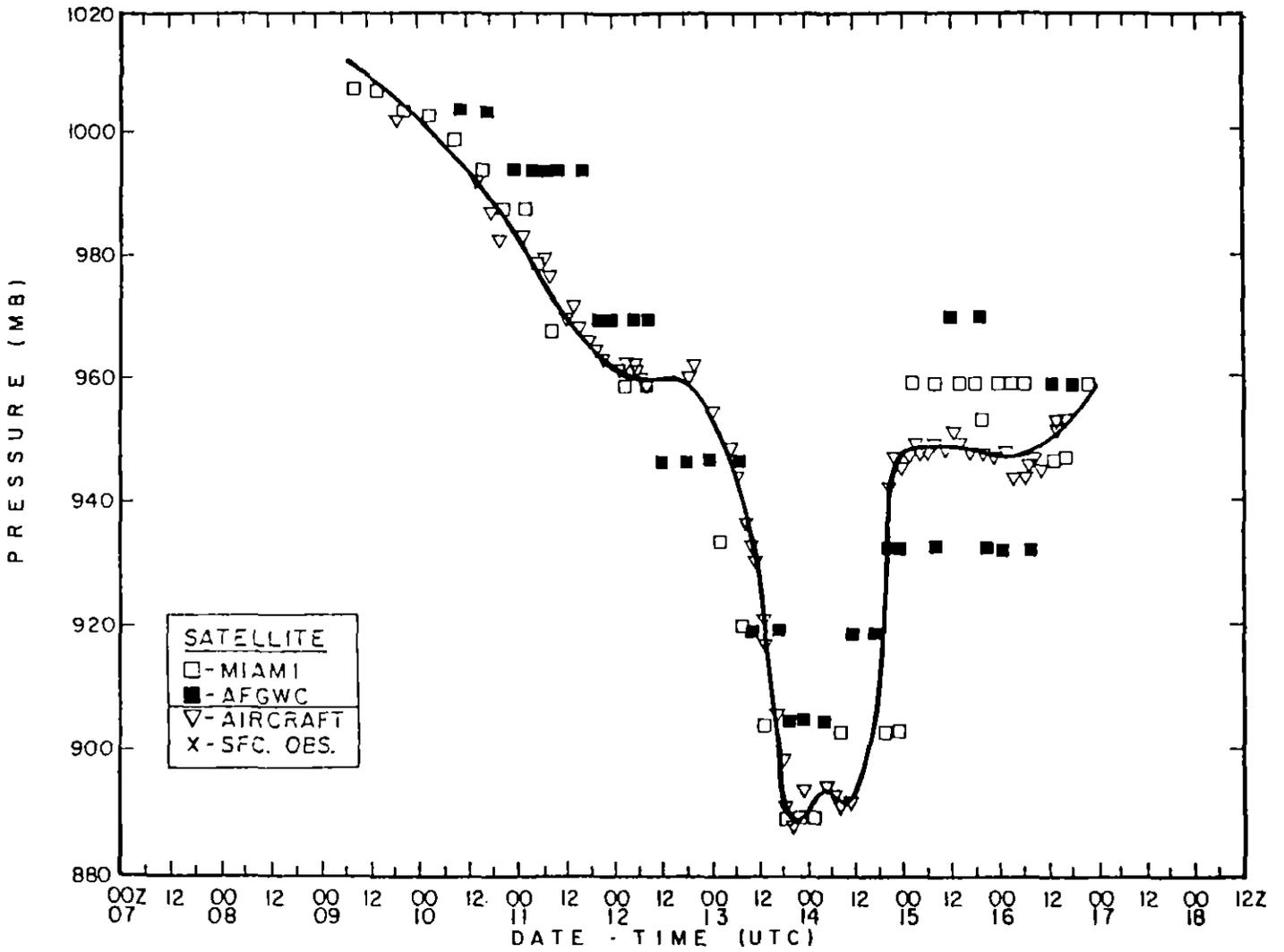


Figure 5.112: Best Track Minimum Pressure Curve for Hurricane Gilbert, 8-19 SEP 1988 (From NHC, 1988)

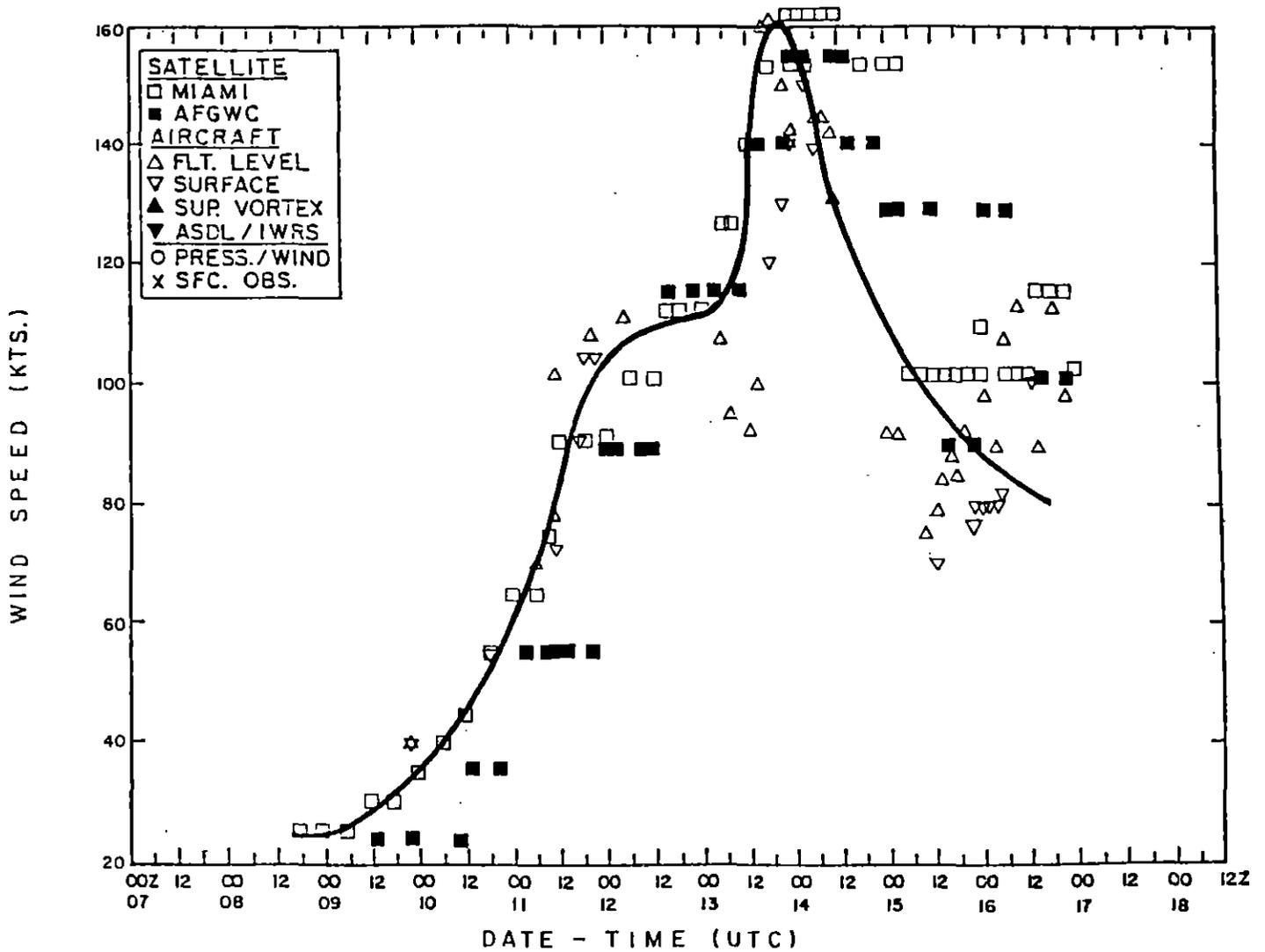


Figure 5.113: Best Track Maximum Sustained Wind Speed Curve for Hurricane Gilbert, 8-19 SEP 1988 (From NHC, 1988)

14 September 1988

The station observations and 1000 mb analysis of Fig. 5.114 and the IR imagery of Fig. 5.115 (2301 UTC on 13 September) clearly indicate that the circulation of Hurricane Gilbert is bringing convection to all the Central American countries at 0000 UTC on 14 September. At this time the hurricane is located at 19.7°N, 83.8°W, with a central pressure of 888 mb (the lowest recorded in the western hemisphere) and sustained winds of 160 kt. Figures 5.116 and 5.117 show the NMC low-level and upper-level streamlines, while Figs. 5.118 and 5.119 provide the Navy's wind analyses for comparison. (Again, as on the 13th, the NOGAPS 200 mb wind between Cuba and Florida is suspect.) Continuing on a north northwest course at 15 kt, Hurricane Gilbert moves over the northeast portion of the Yucatan Peninsula shortly after 1200 UTC (NHC, 1988).

The National Hurricane Center (1988) reports that a 15–20 foot storm surge (rise of the level of the sea) likely occurred along the immediate coast just to the north of where the hurricane center moved inland over the northeast Yucatan Peninsula, with a 8–13 foot surge farther north of the landfall. Although the northern Central American nations (Guatemala, Belize and Honduras) were no closer than ~200 n mi to the track of the hurricane, they experienced heavy precipitation from the peripheral circulation of this Western Hemisphere record hurricane.

The visible imagery of Fig. 5.120 shows the center of Hurricane Gilbert over the Yucatan Peninsula at 1831 UTC. At 1800 UTC (30 minutes earlier), the hurricane was at 20.9°N, 87.8°W, and its central pressure (925 mb) had commenced to rise with a maximum sustained wind of 130 kt. Figure 5.121 contains the radiosonde sounding taken at Belize City, Belize (station 78583) at 1800 UTC. Although the center of the Hurricane was 200 n mi north, the entire sounding is very moist (with a saturated layer between ~650 mb and ~475 mb) and Belize City is experiencing 50 kt winds at 850 mb.

By end of 14 September, the central pressure has increased to near 950 mb and the surface winds of Hurricane Gilbert have decreased to <100 kt, mostly due to the land friction. Moving over water, the hurricane's winds increase to 115 kt before striking Mexico south of Brownsville, Texas, about 48 hours later (see Fig. 5.78). This portion of the history of the hurricane will not be discussed since the the hurricane is neither over the Caribbean Sea nor over Central America. Interested readers may refer to National Hurricane Center (1988) for a discussion of the final days in the life of Hurricane Gilbert.

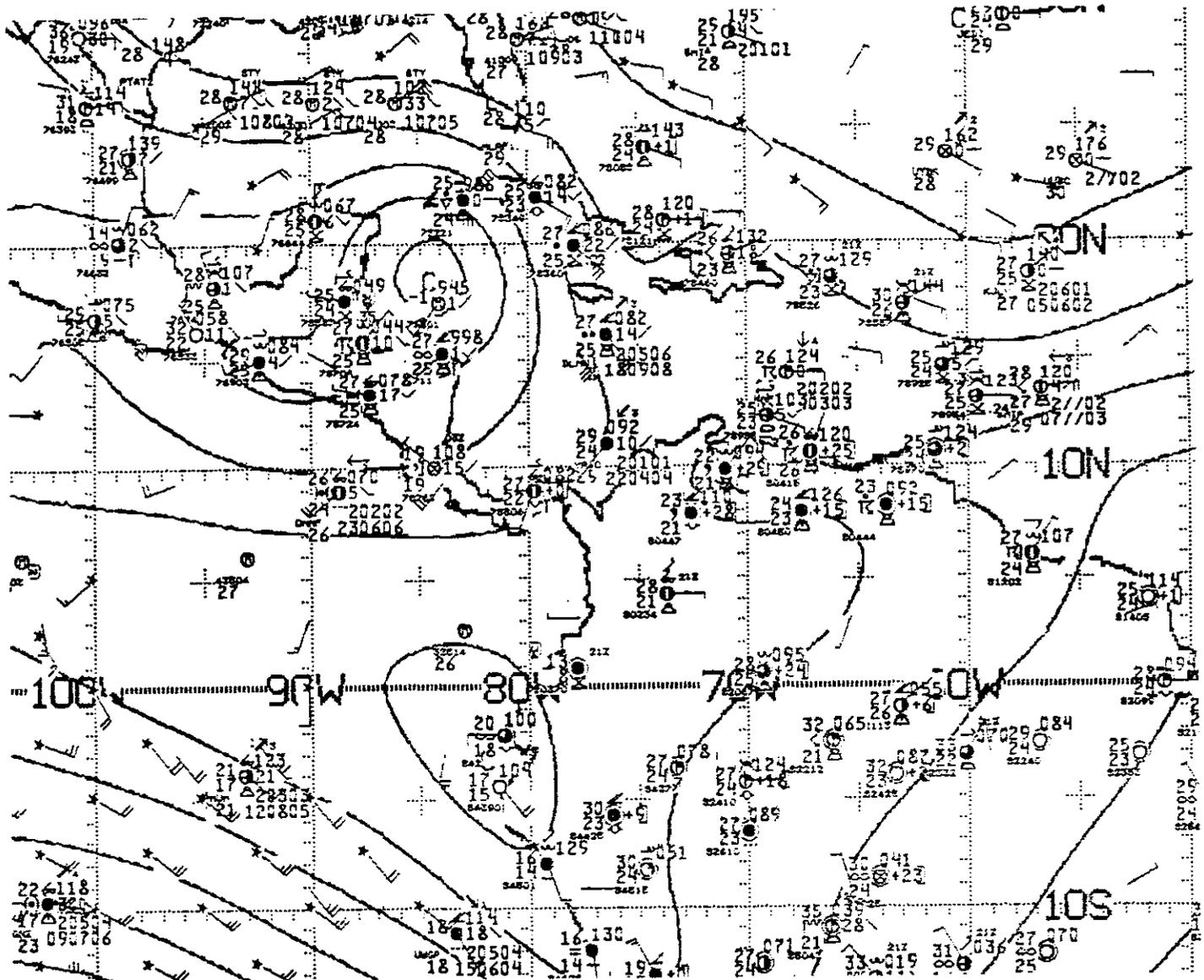


Figure 5.114: NMC 1000 mb Analysis, 0000 UTC 14 SEP 1988. As in Fig. 2.21.

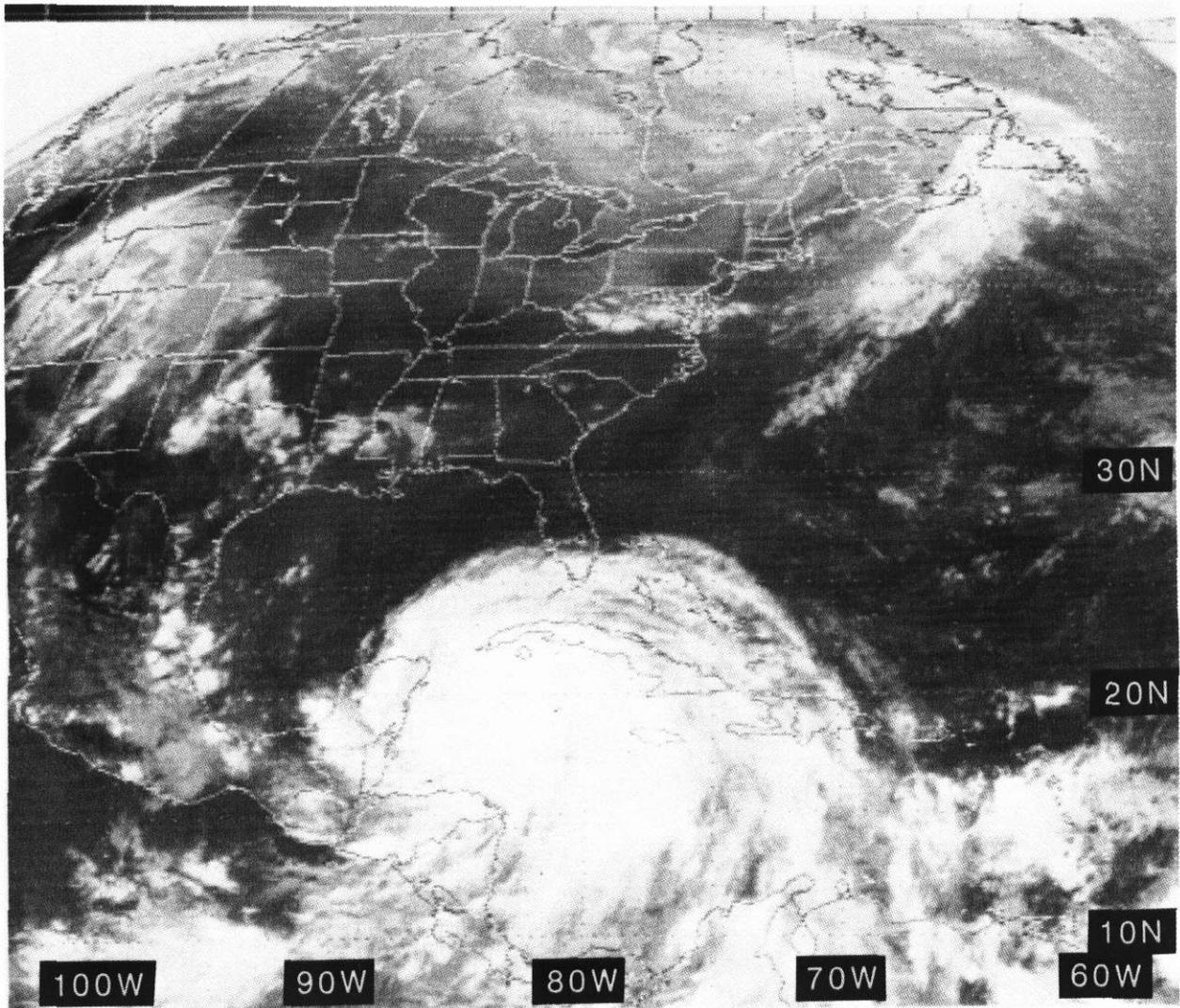


Figure 5.115: GOES East IR Imagery, 2301 UTC 13 SEP 1988

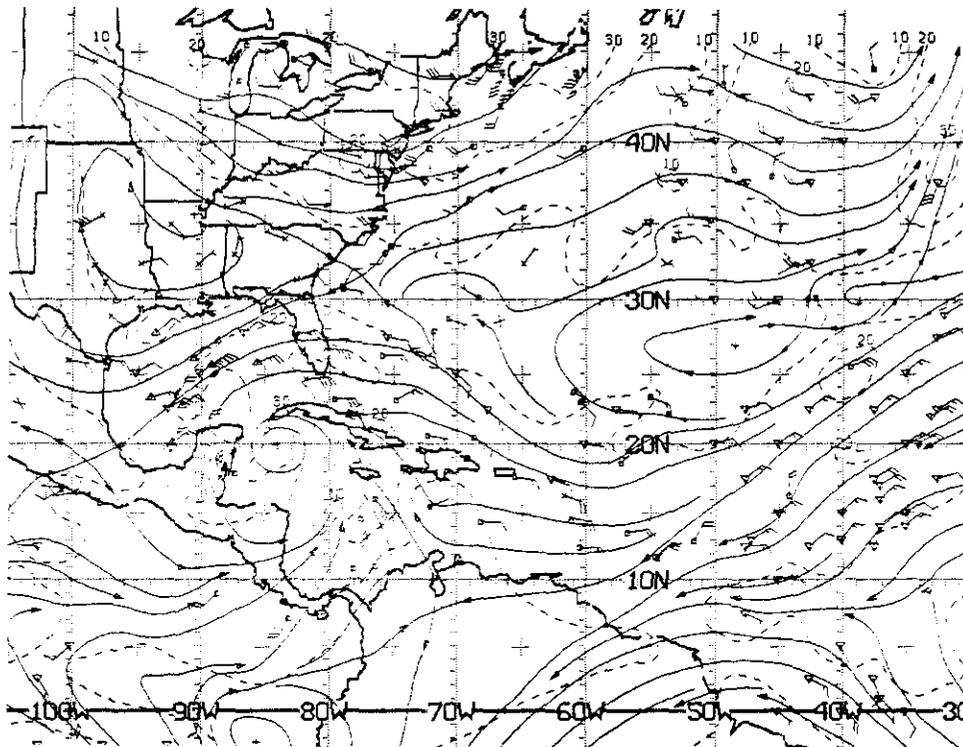


Figure 5.116: NMC ATOLL Operational Streamline Chart, 0000 UTC 14 SEP 1988
As in Fig. 2.4.

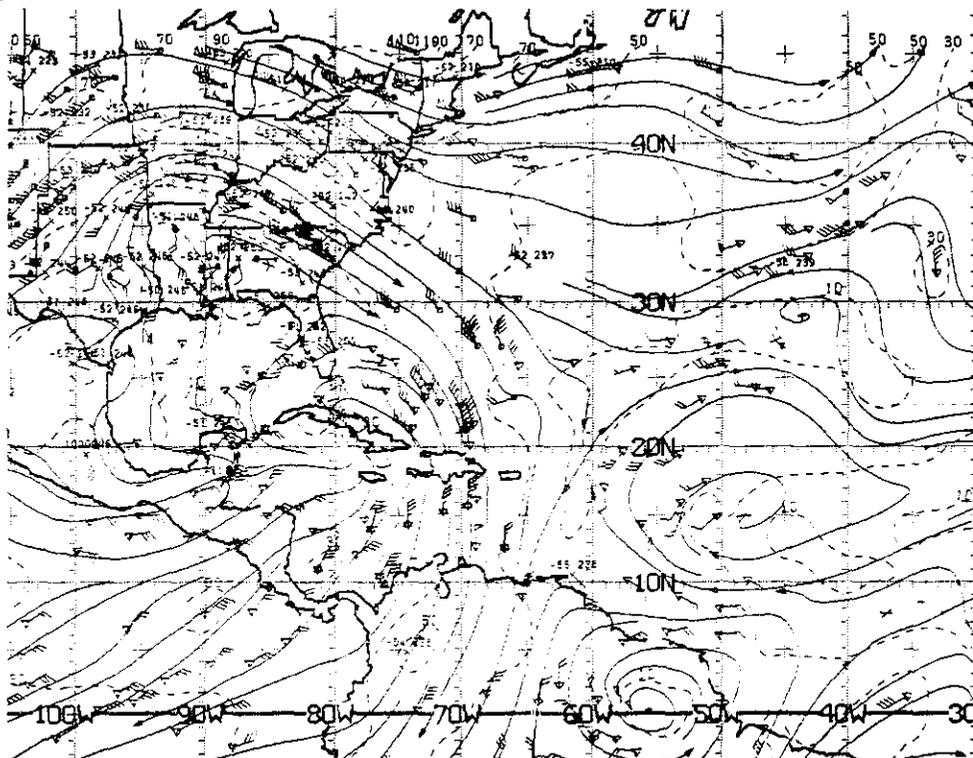


Figure 5.117: NMC 200 mb Operational Streamline Chart, 0000 UTC 14 SEP 1988
As in Fig. 2.7.

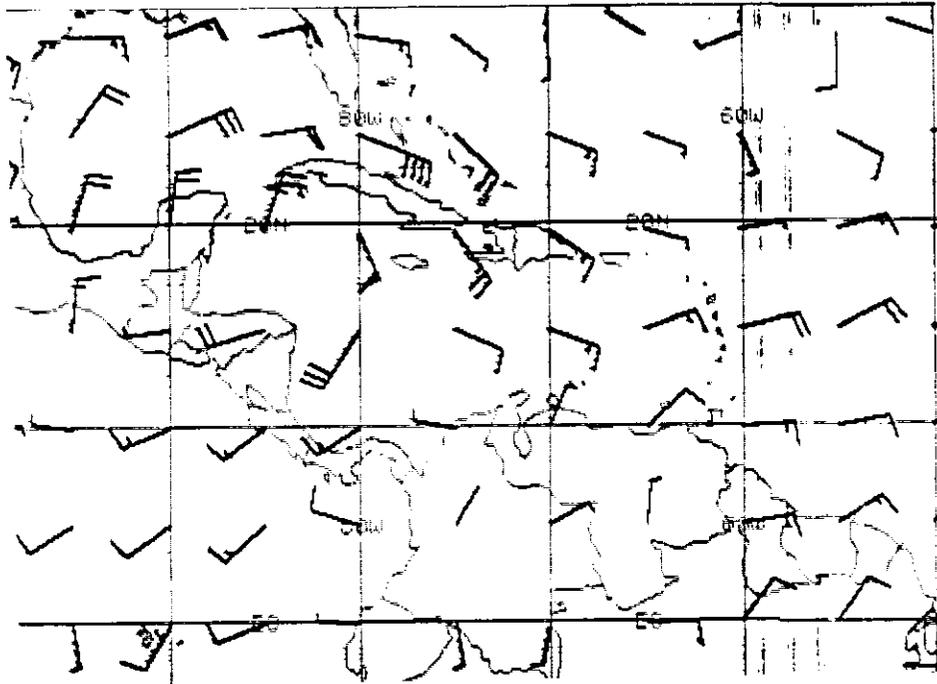


Figure 5.118: FNOC 925 mb Winds, 0000 UTC 14 SEP 1988. As in Fig. 2.19.

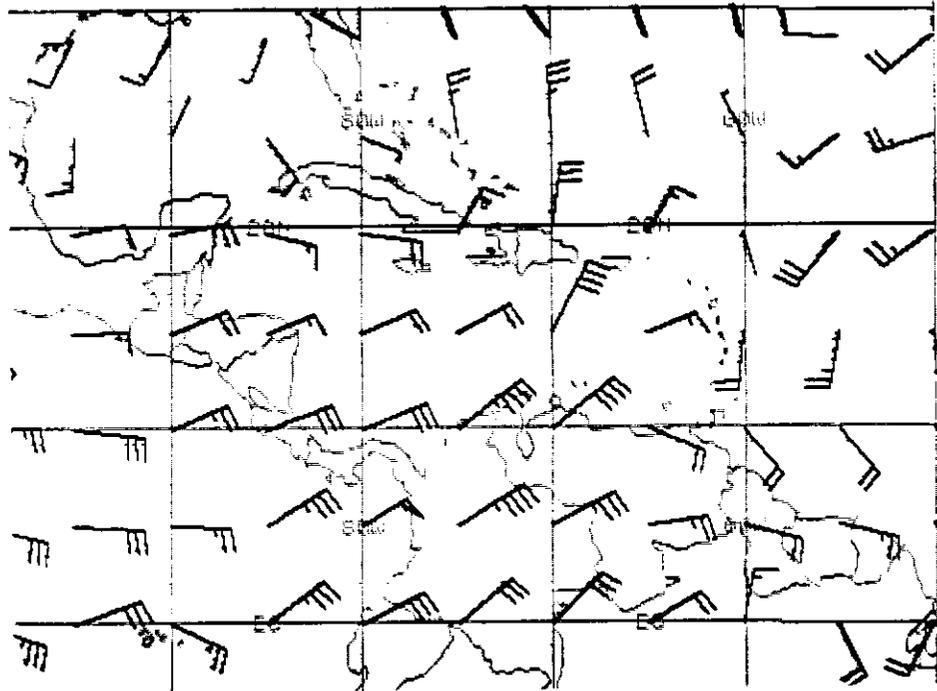


Figure 5.119: FNOC 200 mb Winds, 0000 UTC 14 SEP 1988. As in Fig. 2.20.



Figure 5.120: GOES East IR Imagery, 1831 UTC 14 SEP 1988

890914/1800 78583 MZBZ LIFT TOTL KINK SMET
 -2 42 34 311

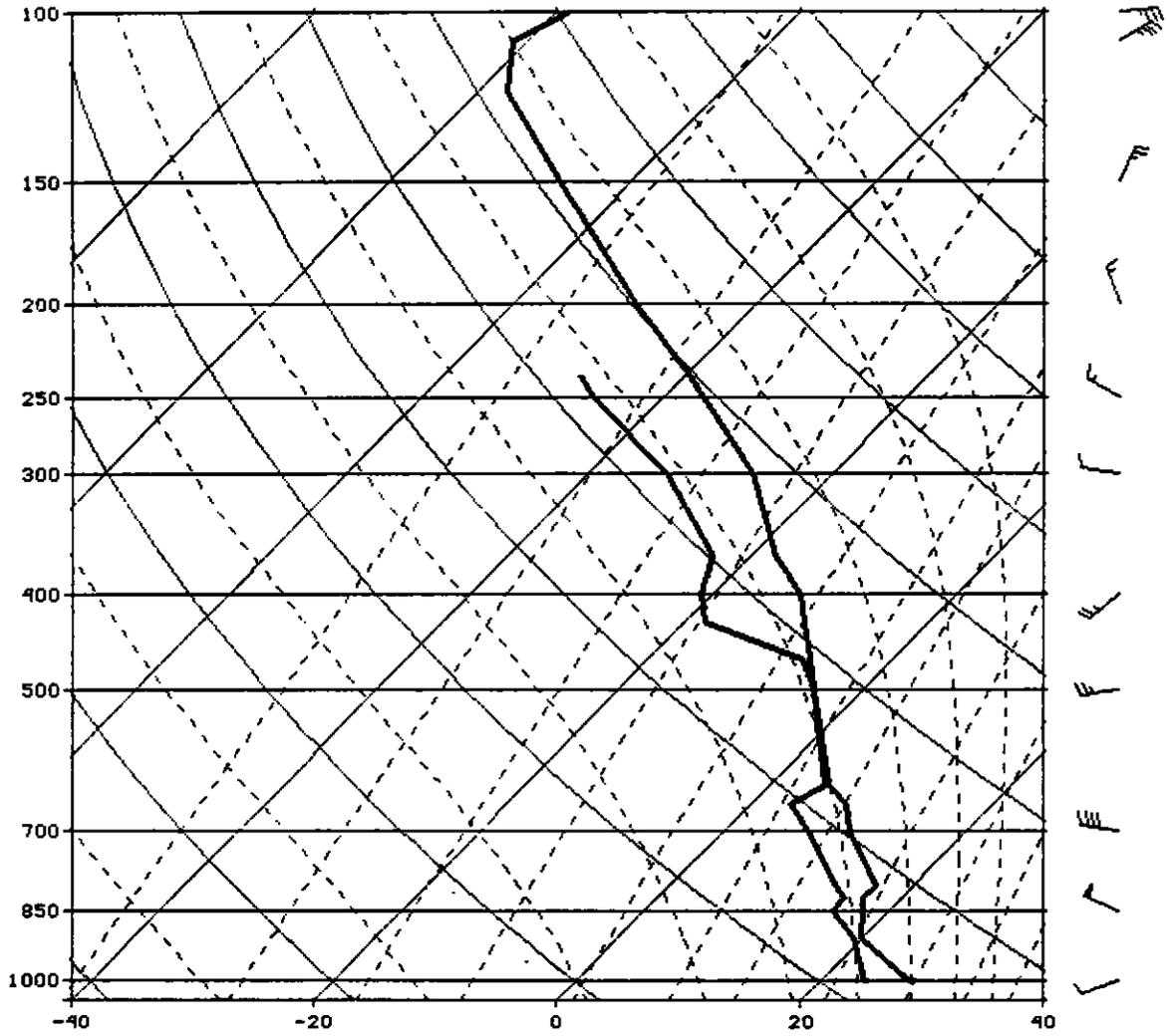


Figure 5.121: Belize City, Belize Sounding (solid lines) 1800 UTC 14 SEP 1988. The data for this sounding were received operationally.