

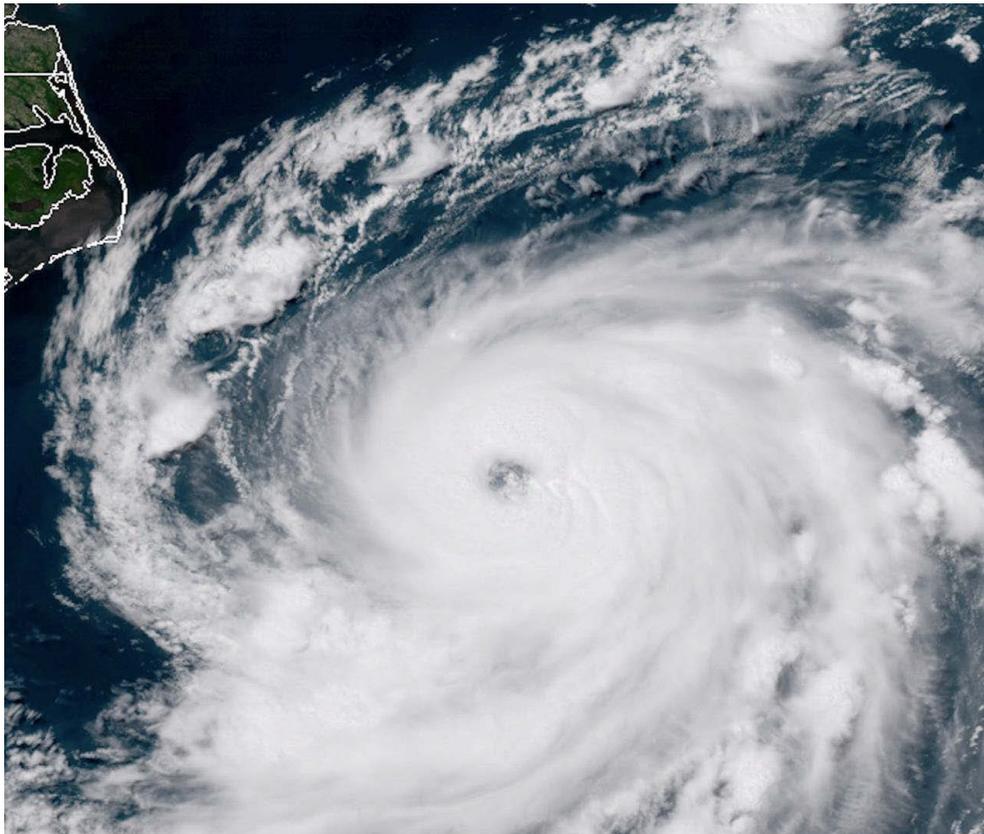


NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE CHRIS (AL032018)

6–12 July 2018

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National Hurricane Center
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VIIRS SATELLITE IMAGE OF HURRICANE CHRIS OFFSHORE OF NORTH CAROLINA AT 1735 UTC 10 JULY 2018

Chris moved slowly offshore of the east coast of the United States as a tropical storm for a few days before intensifying to a category two hurricane (on the Saffir-Simpson Hurricane Wind Scale) as it headed northeastward out of sea.

Hurricane Chris

6–12 JULY 2018

SYNOPTIC HISTORY

Chris originated from a frontal system that moved offshore of the northeast coast of the United States on 29 June. The system headed slowly southeastward for the next couple of days, producing a large area of showers and thunderstorms extending from near Bermuda northeastward for several hundred miles, and the surface front dissipated over the warm Atlantic waters by 2 July. On that day, a large middle- to upper-level low formed north of Bermuda and moved southwestward beneath a strengthening ridge over eastern North America. This evolution caused the remnants of the front to move southward, with the cloud shield contracting noticeably on the north side, and by 3 July the system was situated just southeast of Bermuda. A new upper-level disturbance invigorated deep convection over the system on that day and although the convection did not persist, a broad surface low formed late on 4 July and moved westward. The low became well defined on the next day, but thunderstorm activity was minimal at times near the center. Deep convection finally became more organized early on 6 July, marking the formation of a tropical depression at 1200 UTC that day about 300 n mi south-southeast of Cape Hatteras, North Carolina. Dry mid-level air near the cyclone prevented strengthening at first, and deep convection significantly decreased that night while the depression moved northwestward. The system gradually intensified on 7 July due to a resumption of significant thunderstorm activity, and Tropical Storm Chris formed 42 h after its initial formation as a tropical depression, moving little. The “best track” chart of Chris’s path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1¹.

The cyclone gradually strengthened over warm water while it drifted southeastward due to an approaching cold front. Chris stayed separate from that feature, however, and overnight on 9 July an inner core formed with hints of an eye observed in satellite imagery. The steering pattern around Chris was also changing as a weakening mid-level ridge over the central Atlantic and a new trough over the northeastern United States began to impart a slow eastward motion on the cyclone. By 1200 UTC 10 July, Chris accelerated to the northeast ahead of the trough and became a hurricane. The cyclone began a short period of rapid intensification with its peak winds increasing about 25 kt in the next 12 h due to a combination of low shear and Chris moving across fresh warm waters that hadn’t been previously upwelled by the system. The small hurricane reached a peak intensity of 90 kt around 0000 UTC 11 July about 210 n mi east-southeast of Cape Hatteras and started moving much faster toward the northeast. Chris weakened later that day as it moved over cooler waters, growing in size as it interacted with a mid-latitude trough early on 12 July - a hallmark of extratropical transition. Chris transitioned into a strong extratropical

¹ A digital record of the complete best track, including wind radii, can be found on line at <ftp://ftp.nhc.noaa.gov/atcf>. Data for the current year’s storms are located in the *btk* directory, while previous years’ data are located in the *archive* directory.

storm shortly after 1200 UTC 12 July a couple of hundred miles southwest of Newfoundland. The extratropical storm raced northeastward for a few days and generally maintained an intensity of 40–45 kt until early on 15 July when it gradually weakened and decelerated over the far North Atlantic. The low moved slowly eastward then northeastward for the next couple of days as its winds diminished, and it opened up into a trough just southeast of Iceland around midday on 17 July.

METEOROLOGICAL STATISTICS

Observations in Chris (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), and the objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) estimates from CIMSS at the University of Wisconsin. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from 11 flights of the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command and the NOAA P-3 aircraft. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), the European Space Agency’s Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track.

The estimated peak intensity of 90 kt at 0000 UTC 11 July is based on a blend of lower TAFB/SAB subjective Dvorak estimates and higher ADT estimates from UW-CIMSS and is closest to the SATCON estimate. There were no reconnaissance data available around the time of Chris’ peak intensity.

While there were no ship reports of tropical-storm-force winds, one buoy (NOAA 41002) well offshore of North Carolina recorded sustained winds of 42 kt with a gust to 50 kt at 1200 UTC 9 July.

CASUALTY AND DAMAGE STATISTICS

Although Chris stayed offshore, the slow motion of the cyclone caused large swells along many parts of the U.S. East Coast, which were enhanced by strong northeasterly synoptic-scale flow. One direct² drowning death from rough surf was noted in the coastal waters near Kill Devil Hills, North Carolina. At least 20 water rescues were reported by Ocean Rescue in that town, dozens were reported along the New Jersey coast, and 225 rescues were reported by Ocean City

² Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as “direct” deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered “indirect” deaths.

Beach Patrol in Maryland. Damage from the hurricane was generally minor, although one home was declared uninhabitable in Rodanthe, North Carolina, due to the swells and wave action.

FORECAST AND WARNING CRITIQUE

The genesis forecasts for Chris (Table 2) were good at long range, with some problems noted at short range. The system was introduced into the Tropical Weather Outlook 84 h before genesis occurred with a low (< 40% chance) of formation within 5 days, and the probabilities reached the medium (40–60%) category 60 h before genesis occurred. For the 2-day predictions, the system was given a low chance 66 h before it formed, with a medium probability first issued 48 h before genesis. However, none of the NHC forecasts reached the high category (> 60% chance) until the time of formation in the best track, and the NHC probabilities actually decreased somewhat for about a day beforehand. This was due to a reduction in the system's convection and model guidance suggesting that the disturbance could merge with a front before genesis could occur.

A verification of NHC official track forecasts for Chris is given in Table 3a. Official forecast track errors were lower than the 5-yr mean official errors at 12 h, 24 h and 120 h, and above the 5-yr mean errors in between those periods. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The official forecast (OFCL) was better than most of the model guidance, with the GFS (at 24–48 h) and the GFS ensemble (AEMI) having some of the best forecasts for Chris. Among the other aids, the UKMET (EGRI) and ECMWF (EMXI) models had a poorer performance than normal for this cyclone.

A verification of NHC official intensity forecasts for Chris is given in Table 4a. Official forecast intensity errors were below the mean official errors for the previous 5-yr period except at 12 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. NHC had a great performance for this hurricane, with no guidance consistently beating the official forecast, which was better than any aid from 24–48 h. While there is no obvious reason for this performance, the NHC forecasts did not have the low bias of many of the aids, such as the LGEM and the HWRF, and was consistent in calling for Chris to eventually become a hurricane.

There were no land-based watches or warnings issued in association with Chris.



Table 1. Best track for Hurricane Chris, 6–12 July 2018.

| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage |
|-----------------|---------------|----------------|---------------|-----------------|---------------------|
| 05 / 0600 | 30.7 | 68.5 | 1021 | 20 | low |
| 05 / 1200 | 30.7 | 69.7 | 1021 | 20 | " |
| 05 / 1800 | 30.8 | 70.7 | 1020 | 20 | " |
| 06 / 0000 | 30.9 | 71.7 | 1019 | 25 | " |
| 06 / 0600 | 31.2 | 72.6 | 1018 | 25 | " |
| 06 / 1200 | 31.5 | 73.1 | 1016 | 25 | tropical depression |
| 06 / 1800 | 31.8 | 73.6 | 1016 | 25 | " |
| 07 / 0000 | 32.2 | 74.2 | 1015 | 25 | " |
| 07 / 0600 | 32.6 | 74.6 | 1015 | 25 | " |
| 07 / 1200 | 32.7 | 74.9 | 1015 | 25 | " |
| 07 / 1800 | 32.8 | 75.2 | 1014 | 30 | " |
| 08 / 0000 | 32.9 | 75.3 | 1012 | 30 | " |
| 08 / 0600 | 33.1 | 75.4 | 1010 | 35 | tropical storm |
| 08 / 1200 | 33.1 | 75.0 | 1008 | 35 | " |
| 08 / 1800 | 32.8 | 74.8 | 1007 | 40 | " |
| 09 / 0000 | 32.6 | 74.6 | 1005 | 45 | " |
| 09 / 0600 | 32.4 | 74.5 | 1001 | 45 | " |
| 09 / 1200 | 32.2 | 74.6 | 999 | 50 | " |
| 09 / 1800 | 32.1 | 74.4 | 996 | 55 | " |
| 10 / 0000 | 32.2 | 74.3 | 994 | 60 | " |
| 10 / 0600 | 32.4 | 74.1 | 992 | 60 | " |
| 10 / 1200 | 32.9 | 73.5 | 990 | 65 | hurricane |
| 10 / 1800 | 33.4 | 72.8 | 983 | 75 | " |
| 11 / 0000 | 33.9 | 71.9 | 969 | 90 | " |
| 11 / 0600 | 34.6 | 70.7 | 969 | 90 | " |
| 11 / 1200 | 35.6 | 69.1 | 973 | 85 | " |



| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage |
|-----------------|---------------|----------------|---------------|-----------------|------------------------------------|
| 11 / 1800 | 37.0 | 66.8 | 976 | 80 | " |
| 12 / 0000 | 38.5 | 64.3 | 980 | 75 | " |
| 12 / 0600 | 40.9 | 61.7 | 985 | 65 | " |
| 12 / 1200 | 43.3 | 59.2 | 987 | 60 | tropical storm |
| 12 / 1800 | 45.7 | 56.4 | 989 | 55 | extratropical |
| 13 / 0000 | 48.0 | 53.4 | 998 | 45 | " |
| 13 / 0600 | 50.0 | 50.0 | 999 | 45 | " |
| 13 / 1200 | 51.0 | 45.0 | 1000 | 40 | " |
| 13 / 1800 | 52.0 | 39.0 | 1000 | 40 | " |
| 14 / 0000 | 53.5 | 33.5 | 997 | 40 | " |
| 14 / 0600 | 56.0 | 28.0 | 993 | 45 | " |
| 14 / 1200 | 58.0 | 25.0 | 988 | 45 | " |
| 14 / 1800 | 59.5 | 22.5 | 986 | 45 | " |
| 15 / 0000 | 60.5 | 21.0 | 983 | 45 | " |
| 15 / 0600 | 60.6 | 20.6 | 985 | 40 | " |
| 15 / 1200 | 60.7 | 20.3 | 988 | 35 | " |
| 15 / 1800 | 60.9 | 19.5 | 990 | 30 | " |
| 16 / 0000 | 61.0 | 18.5 | 992 | 25 | " |
| 16 / 0600 | 61.1 | 16.3 | 994 | 25 | " |
| 16 / 1200 | 61.3 | 13.7 | 996 | 25 | " |
| 16 / 1800 | 62.1 | 12.5 | 999 | 25 | " |
| 17 / 0000 | 63.1 | 12.0 | 1002 | 20 | " |
| 17 / 0600 | 63.3 | 11.8 | 1005 | 20 | " |
| 17 / 1200 | 63.5 | 11.5 | 1007 | 15 | " |
| 17 / 1800 | | | | | dissipated |
| 11 / 0000 | 33.9 | 71.9 | 969 | 90 | minimum pressure and maximum winds |

Table 2. Number of hours in advance of the formation of Chris associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the “Low” category do not include forecasts of a 0% chance of genesis.

| | Hours Before Genesis | |
|------------------|----------------------|------------------|
| | 48-Hour Outlook | 120-Hour Outlook |
| Low (<40%) | 66 | 84 |
| Medium (40%-60%) | 48 | 60 |
| High (>60%) | - | - |

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Chris. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

| | Forecast Period (h) | | | | | | |
|----------------|---------------------|-------------|-------|-------|-------|-------|--------------|
| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
| OFCL | 22.0 | 34.6 | 54.7 | 85.5 | 149.7 | 180.0 | 160.9 |
| OCD5 | 42.1 | 107.1 | 179.7 | 254.3 | 332.2 | 324.5 | 203.4 |
| Forecasts | 22 | 20 | 18 | 16 | 12 | 8 | 4 |
| OFCL (2013-17) | 24.1 | 37.4 | 50.5 | 66.6 | 98.4 | 137.4 | 180.7 |
| OCD5 (2013-17) | 44.7 | 95.8 | 153.2 | 211.2 | 318.7 | 416.2 | 490.6 |



Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Chris. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 3a due to the homogeneity requirement.

| Model ID | Forecast Period (h) | | | | | | |
|-----------|---------------------|-------------|-------------|-------------|--------------|--------------|--------------|
| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
| OFCL | 20.4 | 30.1 | 50.7 | 80.3 | 160.9 | 224.1 | 189.9 |
| OCD5 | 41.7 | 106.7 | 171.5 | 214.8 | 320.6 | 289.1 | 170.3 |
| GFSI | 21.6 | 28.0 | 32.1 | 53.6 | 151.8 | 283.2 | 315.7 |
| AEMI | 21.1 | 31.9 | 48.5 | 72.0 | 141.8 | 204.9 | 173.1 |
| HMNI | 23.3 | 36.5 | 54.7 | 83.1 | 126.9 | 195.8 | 164.8 |
| HWFI | 26.5 | 46.1 | 62.8 | 89.6 | 152.4 | 248.4 | 203.6 |
| EGRI | 23.7 | 45.0 | 81.0 | 133.8 | 274.0 | 355.1 | 269.8 |
| EMXI | 26.8 | 48.4 | 78.1 | 113.4 | 221.5 | 261.3 | 224.4 |
| CMCI | 30.3 | 59.0 | 94.7 | 123.3 | 186.4 | 180.3 | 356.4 |
| NVGI | 33.2 | 50.2 | 63.5 | 96.4 | 161.2 | 208.9 | 216.4 |
| HCCA | 19.0 | 29.6 | 49.8 | 84.0 | 174.9 | 242.3 | 260.9 |
| TVCA | 21.7 | 35.8 | 56.3 | 91.0 | 182.9 | 252.9 | 233.4 |
| TVCX | 21.8 | 37.0 | 58.4 | 93.3 | 187.0 | 253.4 | 230.0 |
| GFEX | 19.3 | 33.7 | 50.6 | 77.4 | 177.3 | 261.5 | 261.4 |
| TABD | 28.3 | 47.2 | 63.9 | 90.2 | 161.6 | 269.9 | 557.0 |
| TABM | 32.2 | 49.0 | 59.6 | 68.8 | 122.1 | 171.5 | 284.0 |
| TABS | 43.9 | 79.8 | 107.2 | 110.1 | 173.3 | 234.6 | 238.0 |
| Forecasts | 18 | 16 | 14 | 12 | 10 | 6 | 2 |

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Chris. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

| | Forecast Period (h) | | | | | | |
|----------------|---------------------|------------|------------|------------|-------------|-------------|------------|
| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
| OFCL | 6.4 | 7.5 | 5.6 | 4.7 | 10.4 | 13.8 | 7.5 |
| OCD5 | 5.5 | 8.9 | 10.6 | 11.1 | 16.7 | 21.1 | 21.5 |
| Forecasts | 22 | 20 | 18 | 16 | 12 | 8 | 4 |
| OFCL (2013-17) | 5.5 | 8.0 | 10.1 | 11.4 | 12.7 | 14.5 | 15.0 |
| OCD5 (2013-17) | 7.1 | 11.1 | 14.4 | 17.4 | 20.6 | 22.3 | 23.7 |

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Chris. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 4a due to the homogeneity requirement.

| Model ID | Forecast Period (h) | | | | | | |
|-----------|---------------------|------|------|------|-------------|-------------|------------|
| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
| OFCL | 6.5 | 6.4 | 5.9 | 4.3 | 10.4 | 13.8 | 7.5 |
| OCD5 | 5.4 | 7.0 | 9.6 | 11.7 | 16.7 | 21.1 | 21.5 |
| GFSI | 7.3 | 8.3 | 11.0 | 11.0 | 16.8 | 27.0 | 23.2 |
| EMXI | 7.2 | 10.3 | 15.3 | 19.3 | 29.1 | 39.1 | 41.0 |
| HMNI | 7.4 | 10.6 | 11.6 | 9.1 | 10.9 | 22.9 | 38.8 |
| HWFI | 8.6 | 11.4 | 11.7 | 11.6 | 10.1 | 20.9 | 20.2 |
| HCCA | 7.6 | 9.6 | 10.1 | 9.2 | 8.8 | 17.5 | 8.0 |
| IVDR | 6.4 | 8.4 | 8.6 | 7.4 | 9.8 | 18.2 | 13.0 |
| IVCN | 6.6 | 8.4 | 8.9 | 7.4 | 9.2 | 16.4 | 9.8 |
| ICON | 6.8 | 8.2 | 8.8 | 7.4 | 9.4 | 14.8 | 9.5 |
| LGEM | 6.4 | 7.7 | 9.6 | 9.7 | 13.2 | 16.2 | 5.2 |
| DSHP | 6.8 | 8.3 | 10.4 | 8.1 | 10.3 | 11.1 | 8.0 |
| Forecasts | 20 | 18 | 16 | 14 | 12 | 8 | 4 |

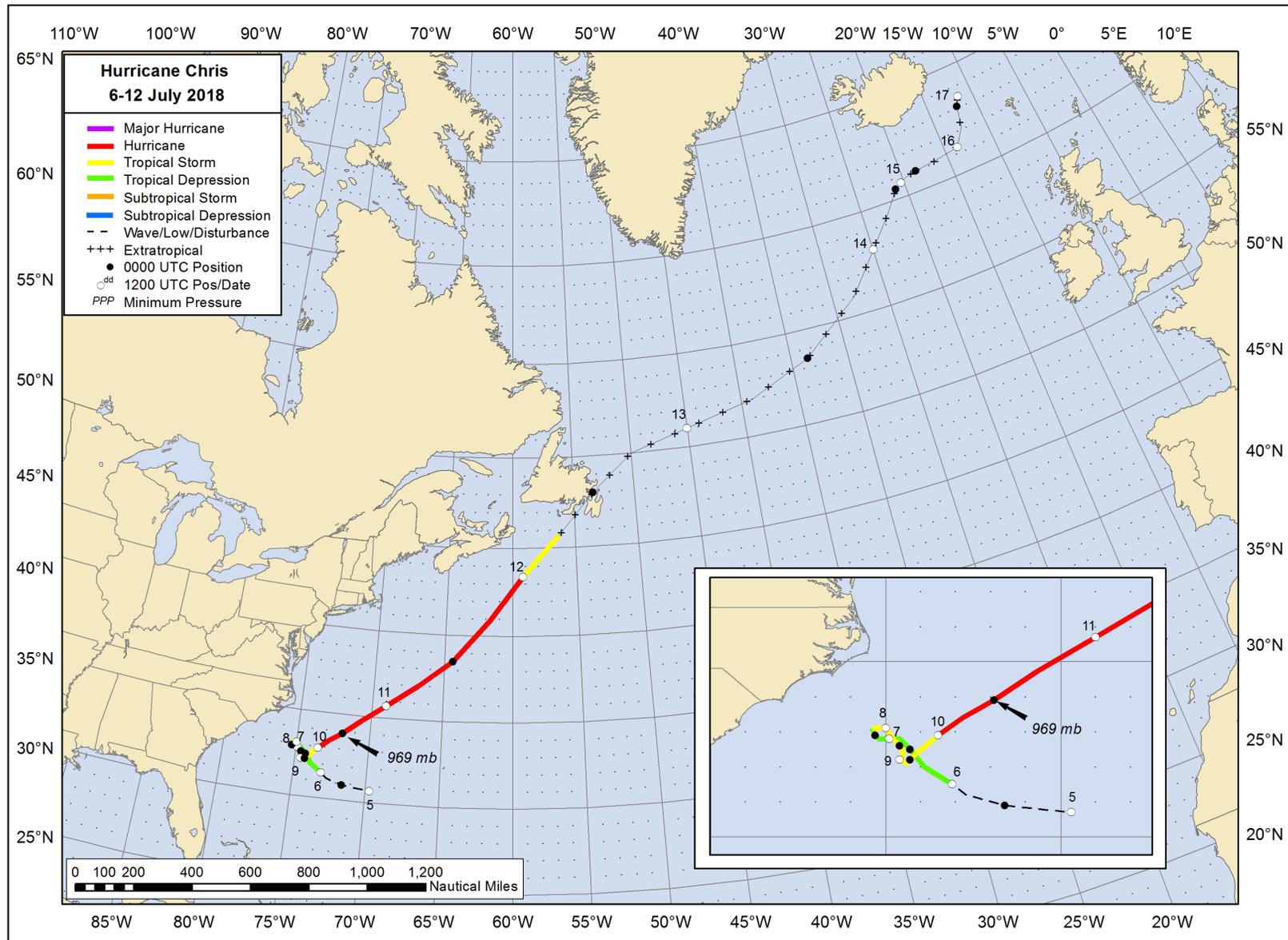


Figure 1. Best track positions for Hurricane Chris, 6–12 July 2018. Extratropical positions are based primarily on analyses from the NOAA Ocean Prediction Center.

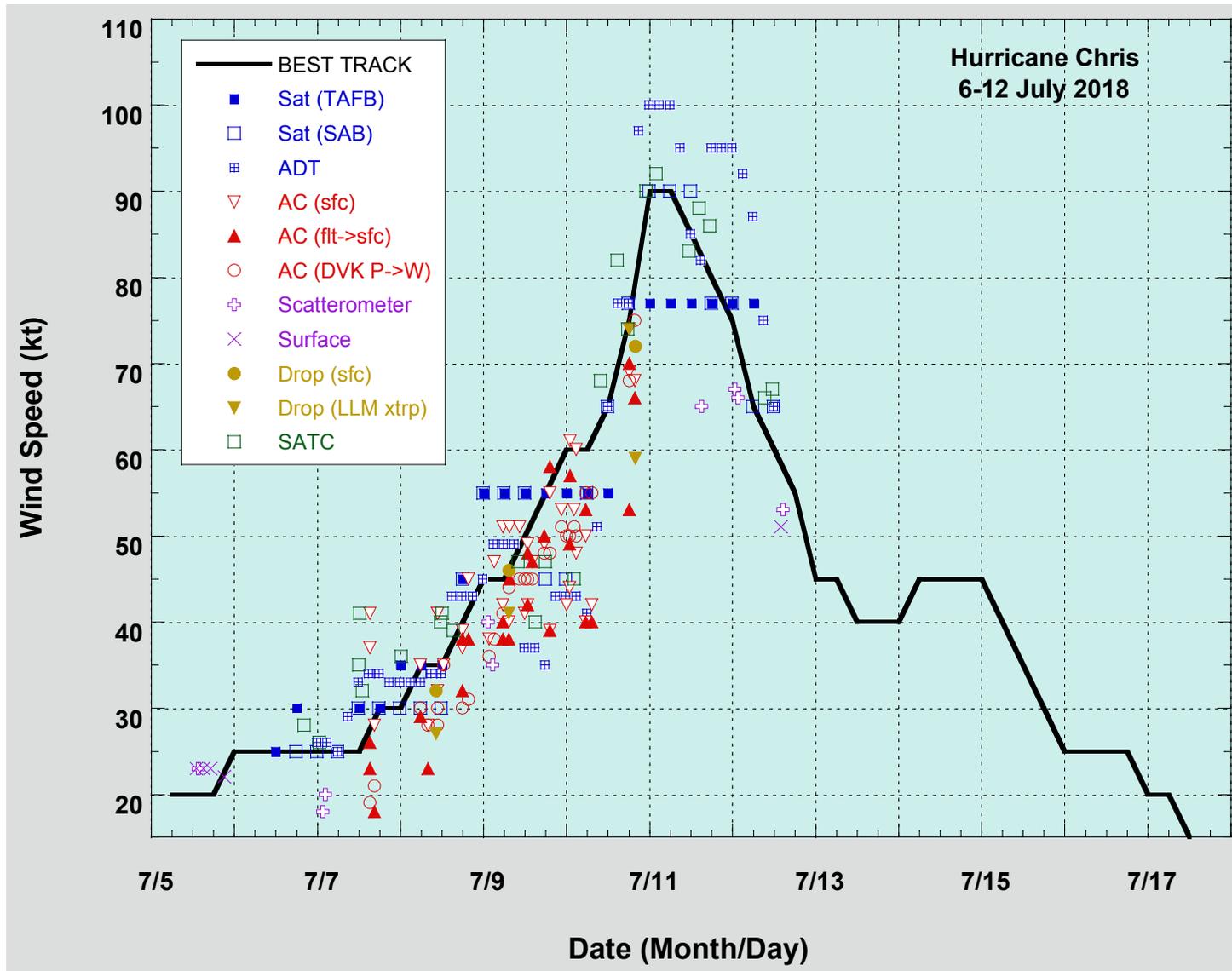


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Chris. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATC intensity estimates are the satellite consensus estimates from the Cooperative Institute for Meteorological Satellite Studies.

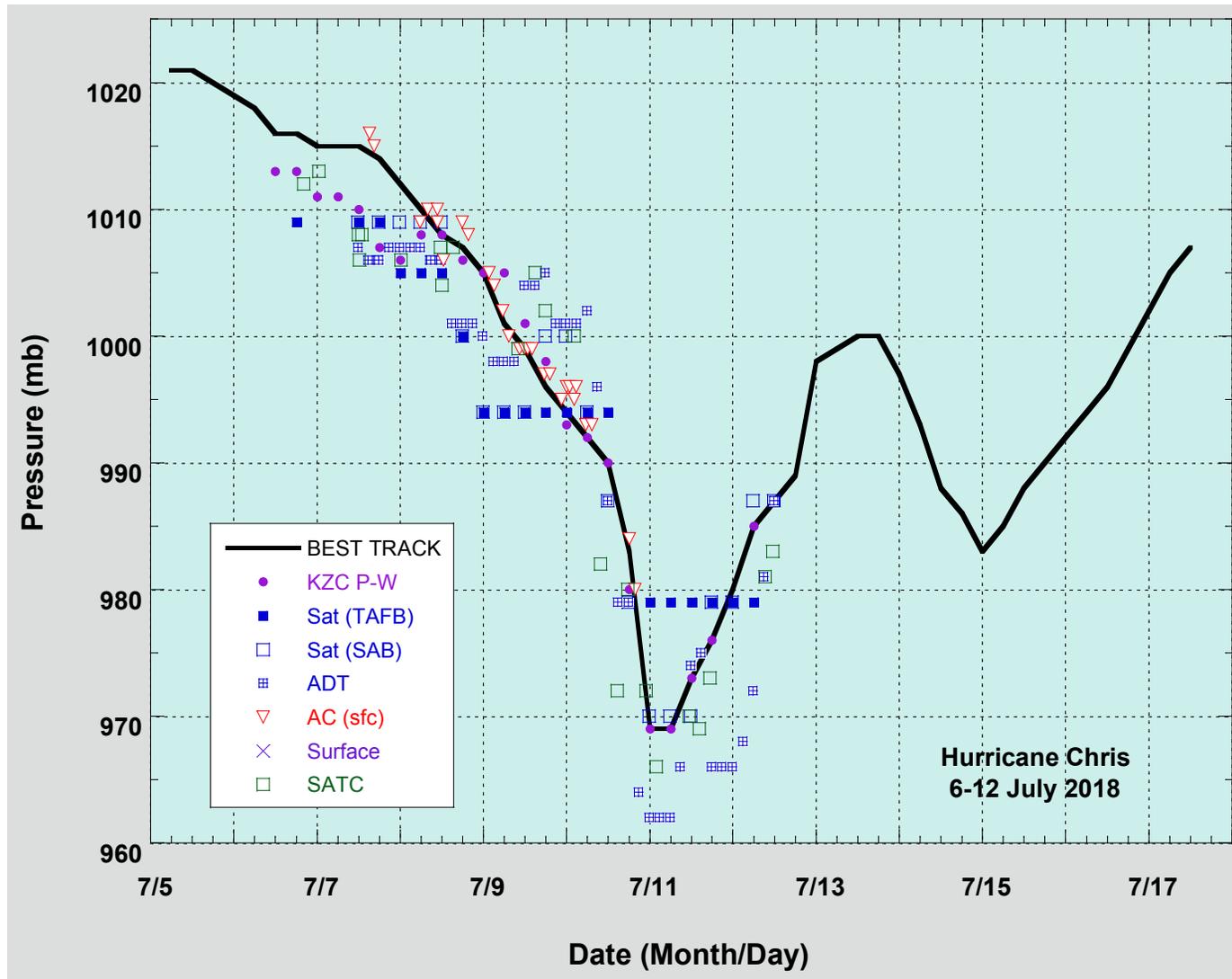


Figure 3. Selected pressure observations and best track minimum central pressure curve for Chris. Advanced Dvorak Technique estimates represent the pressure from the Current Intensity at the nominal observation time. SATC pressures estimates are the satellite consensus estimates from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship.