NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

UNNAMED SUBTROPICAL STORM

(AL012023)

16–17 January 2023

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National Hurricane Center
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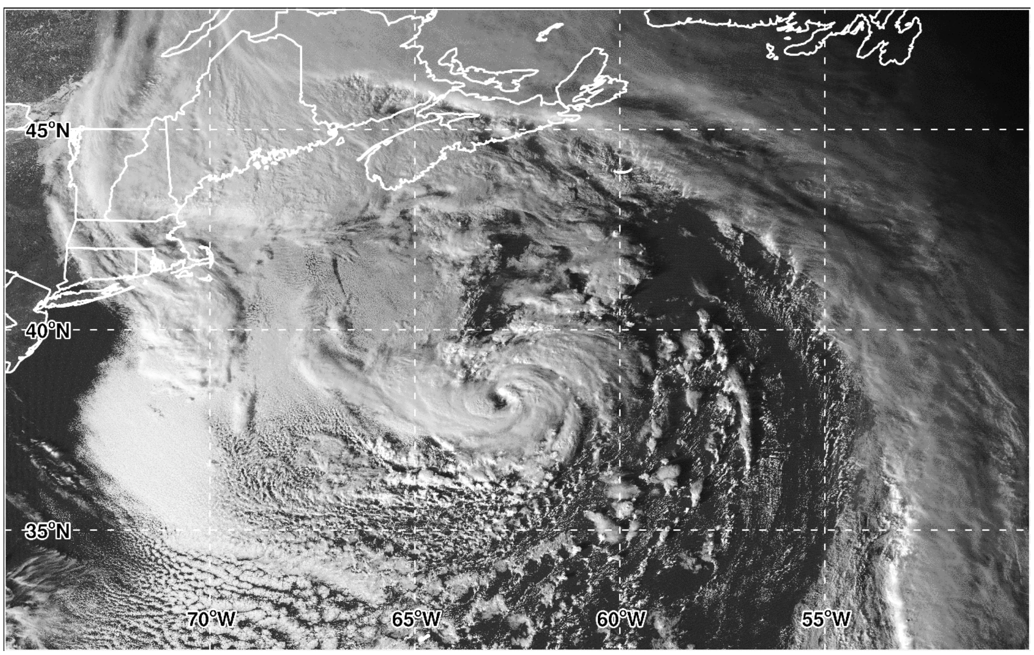

GOES-16 VISIBLE SATELLITE IMAGE AT 2000 UTC 16 JANUARY 2023 OF THE UNNAMED SUBTROPICAL STORM. DATA USED TO CREATE THIS IMAGE COURTESY OF THE NOAA BIG DATA PROJECT.

As part of its routine post-operational review, the National Hurricane Center (NHC) occasionally identifies previously undesignated tropical or subtropical cyclones from new data or meteorological interpretation. The NHC re-analysis has concluded that a low that developed over the Gulf Stream during mid-January became a short-lived subtropical storm. The subtropical storm moved rapidly northeastward, making landfall on the far northeastern coast of Nova Scotia just before the system became a post-tropical low.

Unnamed Subtropical Storm

16–17 JANUARY 2023

SYNOPTIC HISTORY

In the middle part of January, an amplified mid-latitude deep-layer trough emerged off the eastern United States coastline. As this feature moved offshore on 14 January, it became cut off from the larger polar flow to the north and slowed down while it moved over the Gulf Stream just off the eastern United States. Enhanced instability immediately downstream of the upper-level trough axis helped generate shallow convection that spawned a surface trough behind the main frontal boundary (Fig. 1a, white dashed line). The surface trough then underwent “instant occlusion” (Evans et al. 1994), resulting in baroclinic cyclogenesis, which led to the formation of a well-defined but non-tropical area of low pressure at 0000 UTC 15 January, about 215 n mi southeast of Ocean City, Maryland (Fig. 1b). Over the following day, this occluded low began to obtain hybrid characteristics as convection deepened over marginally warm 23–24°C sea-surface temperatures (SSTs, Fig. 2a), and the convective structure became increasingly symmetric about the circulation (Fig. 3a). During this time, the low moved slowly eastward, along the southern portion of the large upper-level trough axis. Scatterometer imagery overnight on 16 January (not shown) indicated that the system had shed the remaining frontal features near its center while it produced surface winds of 45–50 kt. By 1200 UTC 16 January, convective bands with cloud-top temperatures between -50 and -60°C had wrapped around the circulation (Fig. 3b), and this improvement in structure resulted in the formation of a subtropical storm with 50-kt winds about 310 n mi southeast of Nantucket, Massachusetts. The “best track” chart of the cyclone’s path is given in Fig. 4, with the wind and pressure histories shown in Figs. 5 and 6, respectively. The best track positions and intensities are listed in Table 1[1].

After development, the cyclone began accelerating, first to the east and then toward the northeast as it rotated around the southern periphery of the larger upper-level trough. The subtropical storm continued to intensify on 16 January while it moved over the warm Gulf Stream (Fig. 2) and reached a peak intensity of 60 kt at 0000 UTC 17 January, about 300 n mi south-southeast of Halifax, Nova Scotia. Near the time of peak intensity, the subtropical storm was well organized, with convective bands wrapping around a warm spot denoting the center (cover photo, Fig. 3c). However, the system was still embedded within a cold upper-level trough, which inhibited more pronounced upper-level anticyclonic outflow, and limited the vertical depth of the smaller-scale low-level circulation associated with the cyclone.

Early on 17 January, the subtropical storm continued accelerating, now moving nearly due northward. This motion brought the system north of the Gulf Stream and over much cooler waters, and as a result, weakening began as deep convection decayed. This rapid motion also brought

[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.

the subtropical storm quickly towards the northeastern tip of Nova Scotia. The system made landfall as a 45-kt subtropical storm at 1245 UTC 17 January near Louisbourg, Nova Scotia, with the highest winds remaining east over open waters. While some remaining convective bands were observed on radar (Fig. 7) and infrared satellite imagery near landfall (Fig. 3d), the remaining convection dissipated by 1800 UTC that day, and the system became a 40-kt post-tropical low at that time. The low continued moving northward at a slower forward speed, and it dissipated entirely by 1200 UTC 18 January, just inland over far eastern Quebec.

METEOROLOGICAL STATISTICS

Observations in the unnamed subtropical storm (Figs. 5 and 6) include subjective satellite-based Dvorak and Herbert-Poteat subtropical technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB). 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 storm's best track.

After the storm dissipated, a team of forecasters from the NHC and the National Weather Service's Ocean Prediction Center (OPC) came together to evaluate the classification of the system. The post-analysis designation of the low as a subtropical storm was based on several factors. First, the cyclone developed a convective cloud pattern characteristic of a tropical cyclone (TC) on 16–17 January, including convective bands near the center and an eye-like feature (Figs. 3b-c and 8). This development is partly attributable to the system being near or just south of the Gulf Stream during the early portion of its development (Fig. 2a), where SSTs were approximately 3–4°C above average for mid-January (Fig. 2b). These SSTs, in combination with cold environmental temperatures under the upper-level trough, provided sufficient instability to maintain moderate-to-deep convection over the subtropical cyclone. Second, microwave sounder data (Fig. 9) and model analyses (not shown) indicate that the system formed a tropospheric-deep warm core similar to those in TCs, though the tropopause under the upper-level trough was lower than typical in the Tropics. Third, satellite imagery (Fig. 3b-c) and surface analyses (Fig. 10b) suggest that while embedded in the cool environmental air, the system became non-frontal by 16 January, which is supported by scatterometer data early on 16 January (not shown). A sequence of surface observations from Sable Island, Nova Scotia, (not shown) also indicated the system possessed a small inner wind and pressure core similar to that in TCs.

However, it is not fully conclusive that the system transitioned into a TC, with enough uncertainty to preclude its classification as a TC. While not a necessary requirement, the system lacked a well-defined warm anticyclone at the upper levels, likely due to its position being well-embedded in a large upper-level cyclonic circulation. Also, since the cyclone was embedded in a polar or modified polar air mass, it shares some similarities with polar lows (Emanuel and Rotunno 1989), which occur at higher latitudes but derive some energy from the ocean surface, and Medicanes (Lagouvardos et al. 2022), which are surface cyclones that develop subtropical characteristics in the Mediterranean Sea under upper-level troughs. These observations and similarities set it apart from other cyclones that completed tropical transition to a TC, where the upper-level trough overhead weakens, as the surface cyclone moves into a more tropical airmass or becomes entrained in the warm air sector of other baroclinic cyclones. The main factor that argues for this system's classification as a subtropical cyclone is the robust intensity of the large upper-level trough that remained over the system through its lifespan (Fig. 11a-b). It is worth emphasizing that the definition of a subtropical cyclone possesses ambiguity that straddles the boundary between a low-pressure system that possesses fully tropical characteristics versus non-tropical characteristics, and the current evidence argues for this system's best classification as a subtropical cyclone.

A handful of land-based surface observations of tropical-storm-force winds helped to construct the best track of the subtropical storm. As the system passed by Sable Island early on 17 January, a sustained wind of 48 kt and a gust to 59 kt were reported on the island at 0918 UTC. The same station also reported a minimum pressure of 980 mb at 0901 UTC 17 January while still reporting tropical-storm-force winds, and the subtropical storm is estimated to have had a minimum pressure around 3–4 mb lower than that observed in Sable Island (976 mb) at 0000 UTC 17 January. The peak intensity of 60 kt at that same time is based primarily on a TAFB Hebert-Poteat subtropical classification of 55–65 kt at 0000 UTC 17 January, consistent with the peak satellite structure on infrared and microwave satellite imagery (Fig. 3c, 8). The landfall intensity of 45 kt is supported by a scatterometer pass that occurred afterwards at 1455 UTC 17 January that had a peak wind retrieval of 43 kt offshore of Nova Scotia, to the east of the center.

In Nova Scotia, the highest known surface wind observation was a citizen station at Waddens Cove (elevation 13 m) with sustained winds of 33 kt, gusting to 46 kt at 1330 UTC 17 January. The lowest minimum pressure observed in Nova Scotia was 983 mb at Louisbourg at 1300 UTC 17 January.

On 15 January, before the system became a subtropical storm, a NASA P-3 research flight flew into the center of the non-tropical low, with dropsonde data at 1729 UTC measuring a surface pressure of 983 mb with 4-kt surface winds. This observation was helpful in determining the minimum pressure of the cyclone before it attained subtropical characteristics.

CASUALTY AND DAMAGE STATISTICS

While the unnamed subtropical storm made landfall in Nova Scotia, there were no reports of damage or casualties associated with the system, likely due to the highest winds remaining offshore.

FORECAST AND WARNING CRITIQUE

There were no forecasts issued by NHC, and only one Special Tropical Weather Outlook was issued on the morning of 16 January with a near zero percent chance of genesis for the cyclone. This outlook was issued directing users to marine warnings and products issued by OPC. There was extensive coordination on that day and the following days between NHC and OPC to focus on the associated hazards that were already ongoing. National Weather Service policy (through NWS Instruction 10-607, Section 1) allows for marginal subtropical systems to be handled in real-time as non-tropical gale or storm events in the NWS High Seas Forecast products. At the time of the issuance of the Special Tropical Weather Outlook, OPC had issued a Storm Warning and indicated winds in the system as high as 50 kt and seas building up to 24 ft in their High Seas Forecasts. OPC provided significant lead time for these hazards as seen in their 48-hour surface forecast product valid at 0600 UTC 15 January (Fig 10a). The verifying surface analysis at 0000 UTC 17 January (Fig. 10b) also highlights the low producing an area of storm-force winds that was separate from the broader scale frontal features.

Coordination also occurred with Environment and Climate Change Canada during the system's evolution, and that agency issued a short-fused wind warning early on 17 January for a small portion of Cape Breton Island in far northeastern Nova Scotia.

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ACKNOWLEGEMENTS

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Table 1. Best track for Unnamed Subtropical Storm 16–17 January 2023.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
15 / 0000	36.4	71.3	989	45	extratropical
15 / 0600	36.8	70.6	986	45	"
15 / 1200	37.2	69.7	986	45	"
15 / 1800	37.4	68.8	983	45	"
16 / 0000	37.5	68.3	983	45	"
16 / 0600	37.3	67.6	982	50	"
16 / 1200	37.1	66.1	982	50	subtropical storm
16 / 1800	37.6	63.6	980	55	"
17 / 0000	39.8	61.6	976	60	"
17 / 0600	42.4	60.6	977	55	"
17 / 1200	45.5	60.0	981	45	"
17 / 1245	45.9	60.0	983	45	"
17 / 1800	48.4	60.2	988	40	low
18 / 0000	50.4	60.2	991	35	"
18 / 0600	51.4	60.2	994	30	"
18 / 1200					dissipated
17 / 0000	39.8	61.6	976	60	Maximum wind and minimum pressure
17/ 1245	45.9	60.0	983	45	Landfall in Louisbourg, Nova Scotia, Canada

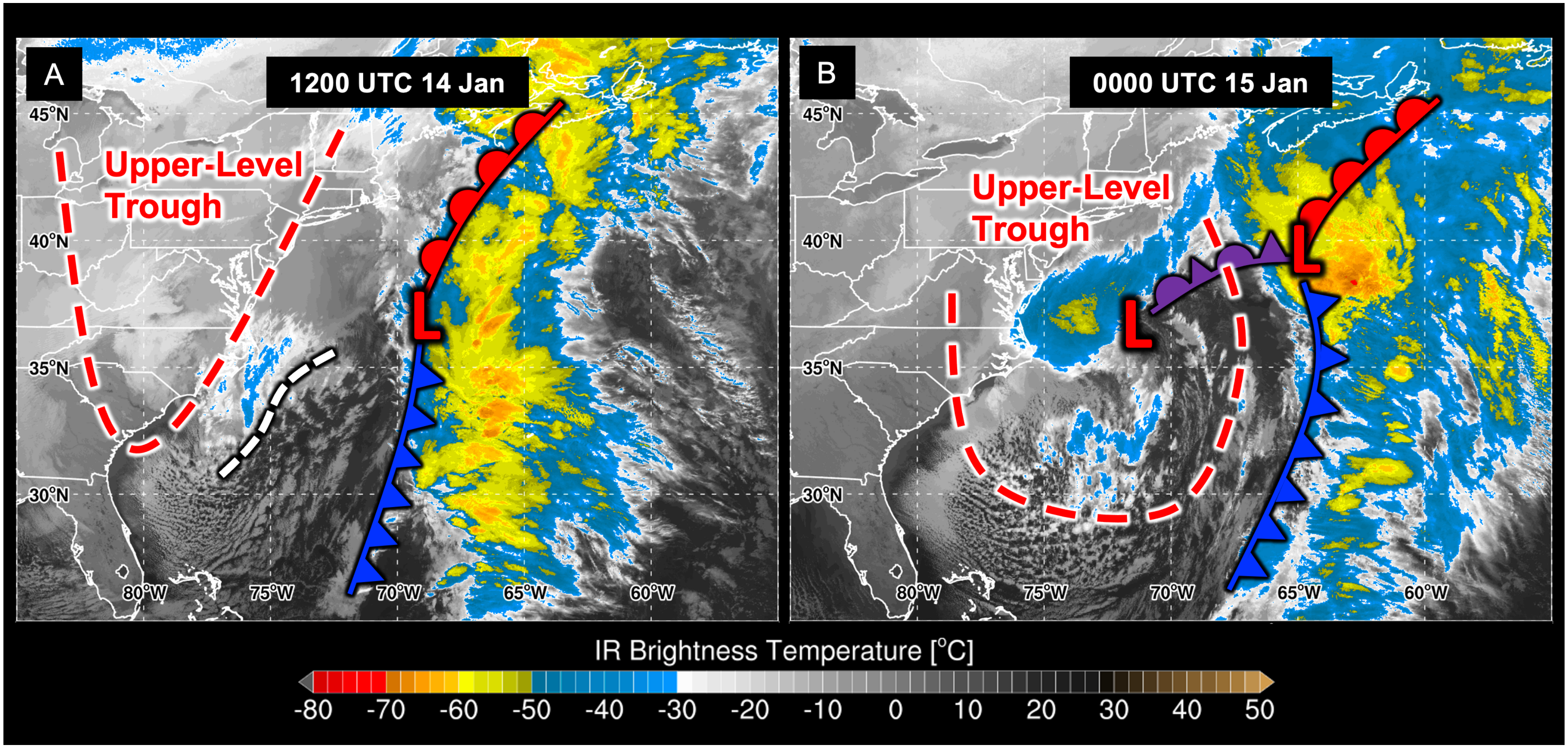

Figure 1. GOES-16 satellite imagery during the pre-development stage of the Unnamed Subtropical Cyclone at 1200 UTC 14 January (panel a) and 0000 UTC 15 January (panel b). Relevant surface and upper-level meteorological features are annotated over the imagery with the surface features adapted from the NWS Unified Surface Analysis available at both times.

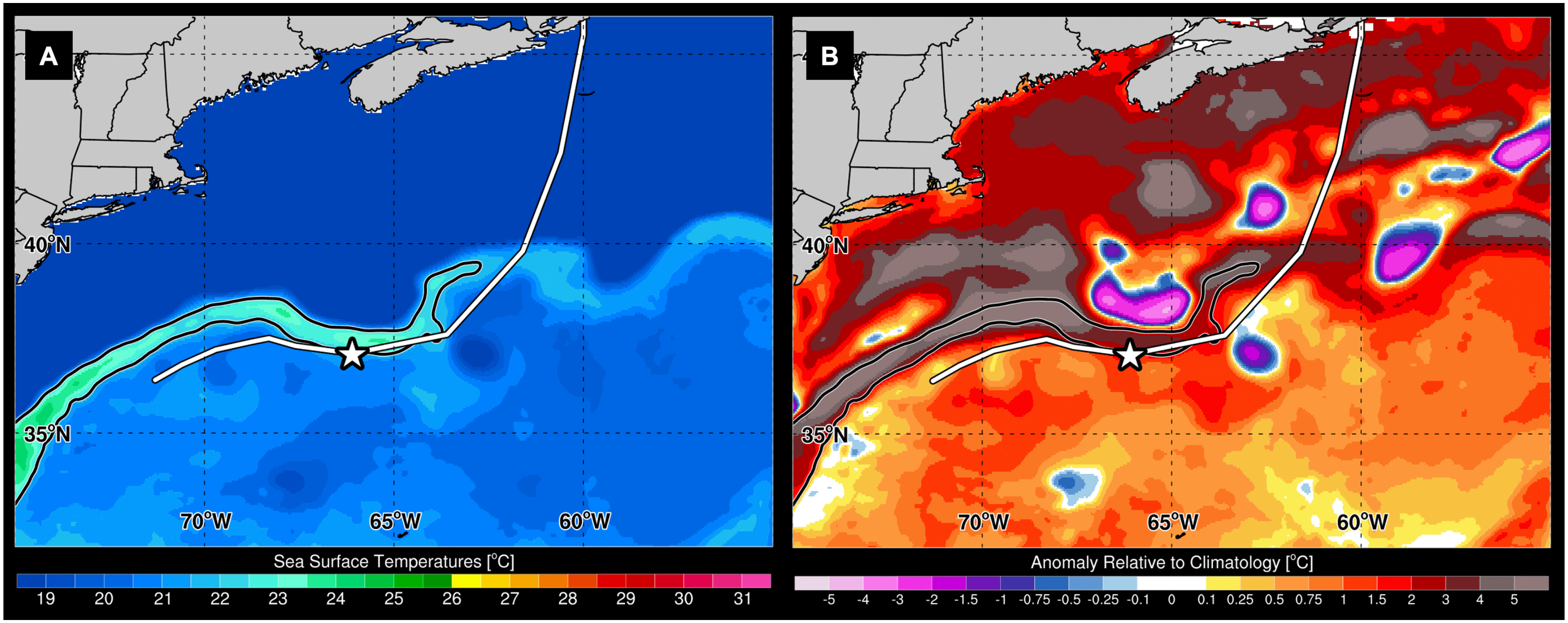

Figure. 2 Sea surface temperatures (°C, panel a) and sea surface temperature anomalies relative to a daily climatology (°C, panel b) on 18 January, after the formation and passage of the Unnamed Subtropical Storm. The 23°C sea surface temperature isotherm is highlighted as a black contour, while the track and location of the Subtropical Storm when it was designated are shown as a white line and star, respectively. Data from NOAA's Coral Reef Watch, accessible at https://coralreefwatch.noaa.gov/.

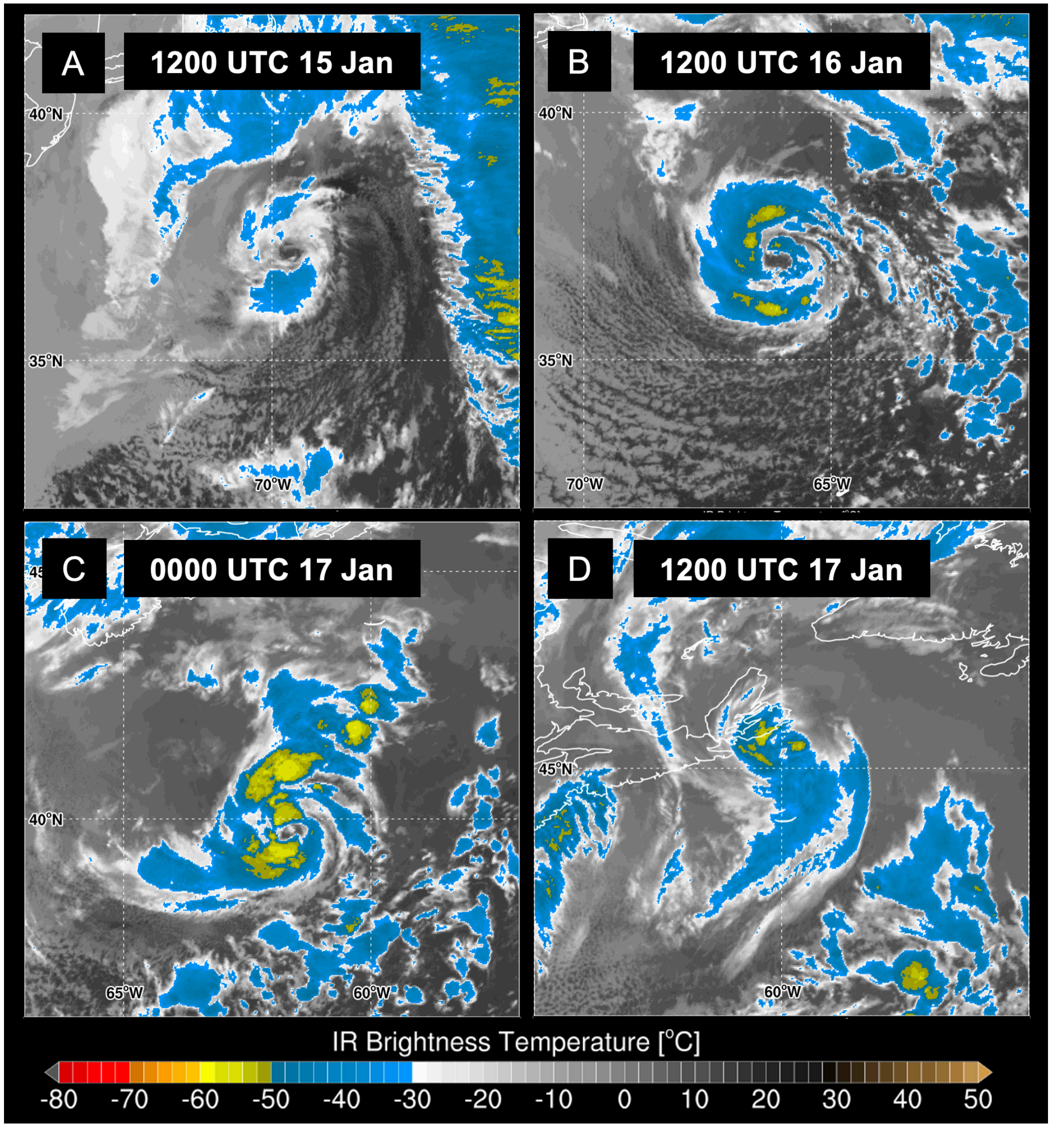

Figure 3. GOES-16 satellite imagery documenting the lifecycle of the Unnamed Subtropical Cyclone at a) 1200 UTC 15 January when the system was an occluded non-tropical low, b) 1200 UTC 16 January, when the system was first designated a subtropical storm, c) 0000 UTC 17 January, near the system's peak intensity, and d) 1200 UTC 17 January, shortly before landfall as a weakening subtropical storm.

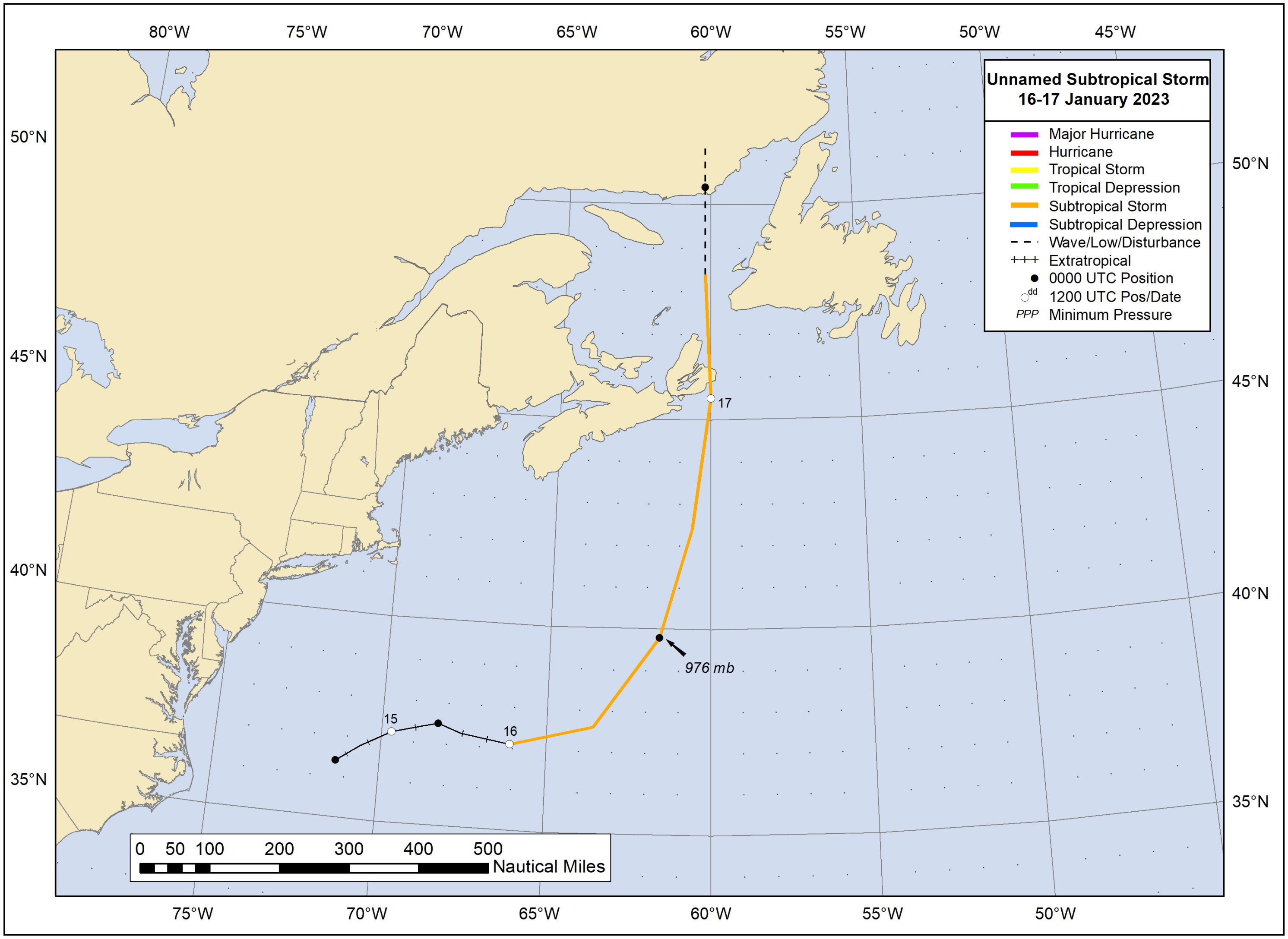

Figure 4. Best track positions for the Unnamed Subtropical Storm, 16–17 January 2023. Tracks during the extratropical stage and low stage are partially based on analyses from the NOAA Weather Prediction Center and the NOAA Ocean Prediction Center.

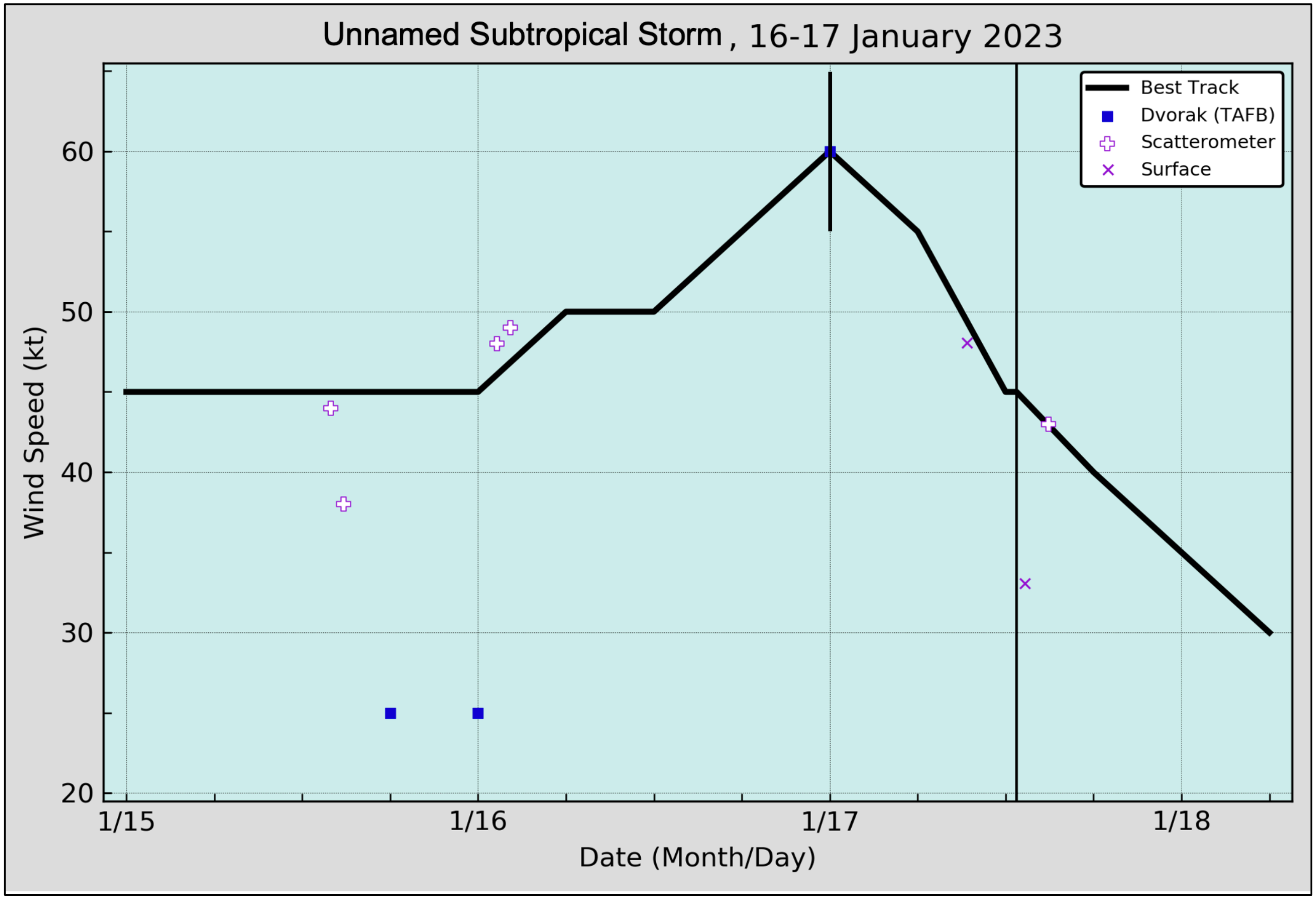

Figure 5. Selected wind observations and best track maximum sustained surface wind speed curve for Unnamed Subtropical Storm, 16–17 January 2023. Dashed vertical lines correspond to 0000 UTC, and the long solid vertical line corresponds to landfall. The short solid vertical line depicts the intensity range associated with Hebert-Poteat subtropical satellite classifications.

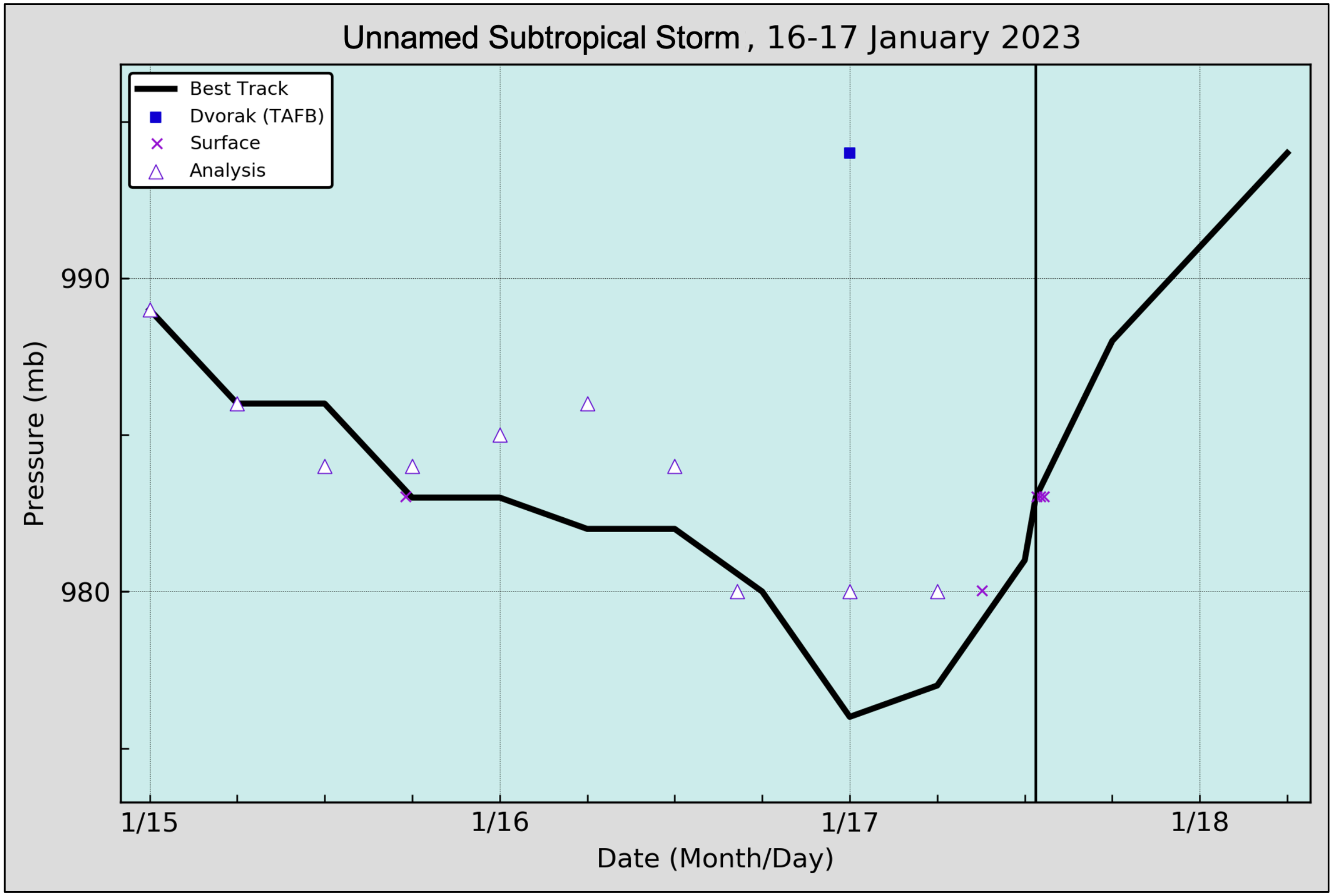

Figure 6. Selected pressure observations and best track minimum central pressure curve for Unnamed Subtropical Storm, 16–17 January 2023. Dashed vertical lines correspond to 0000 UTC, and the solid vertical line corresponds to landfall.

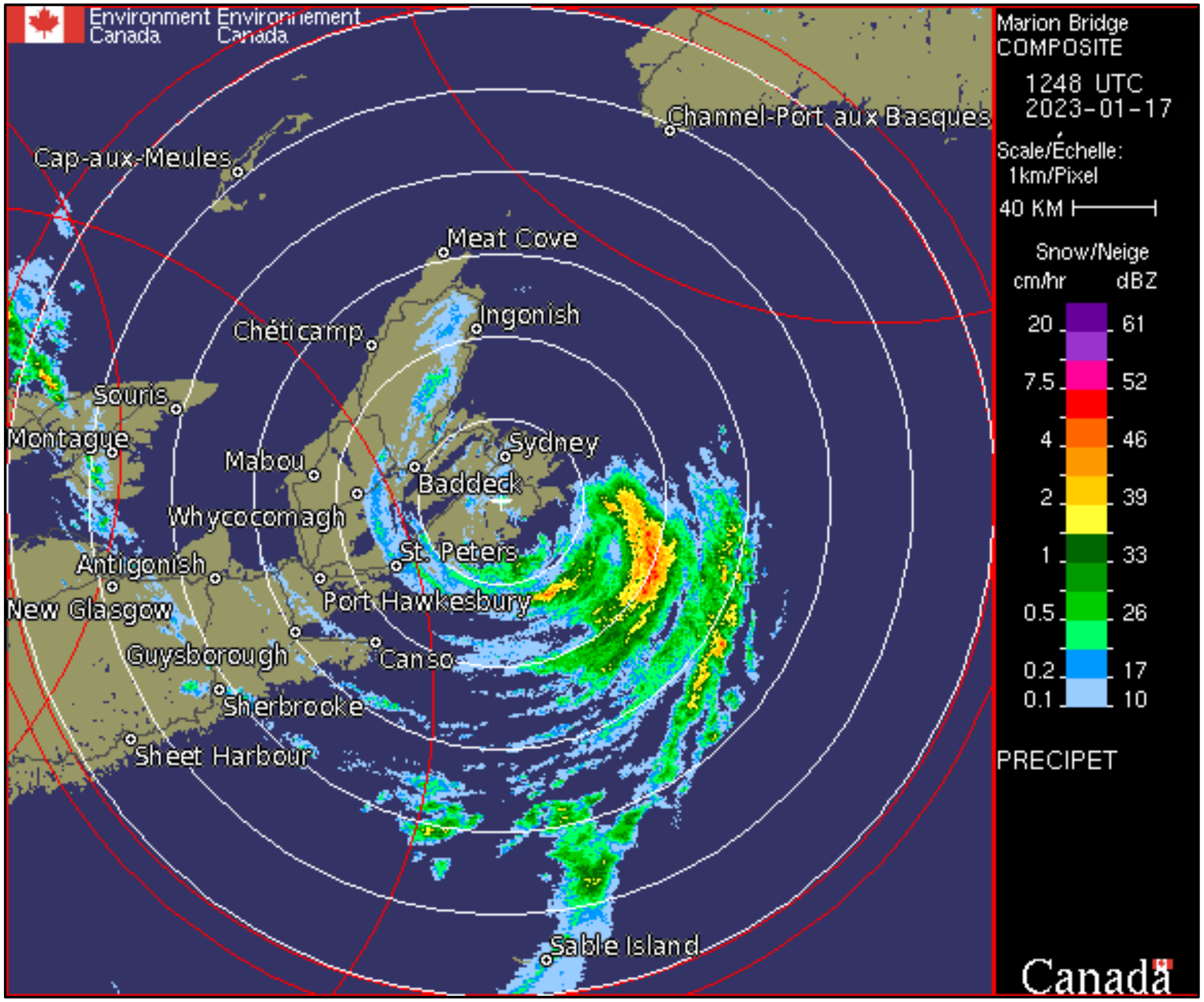

Figure 7. Radar reflectivity of the Unnamed Subtropical Storm at 1248 UTC 17 January 2023, near the time of landfall. Radar imagery courtesy of Environment and Climate Change Canada.

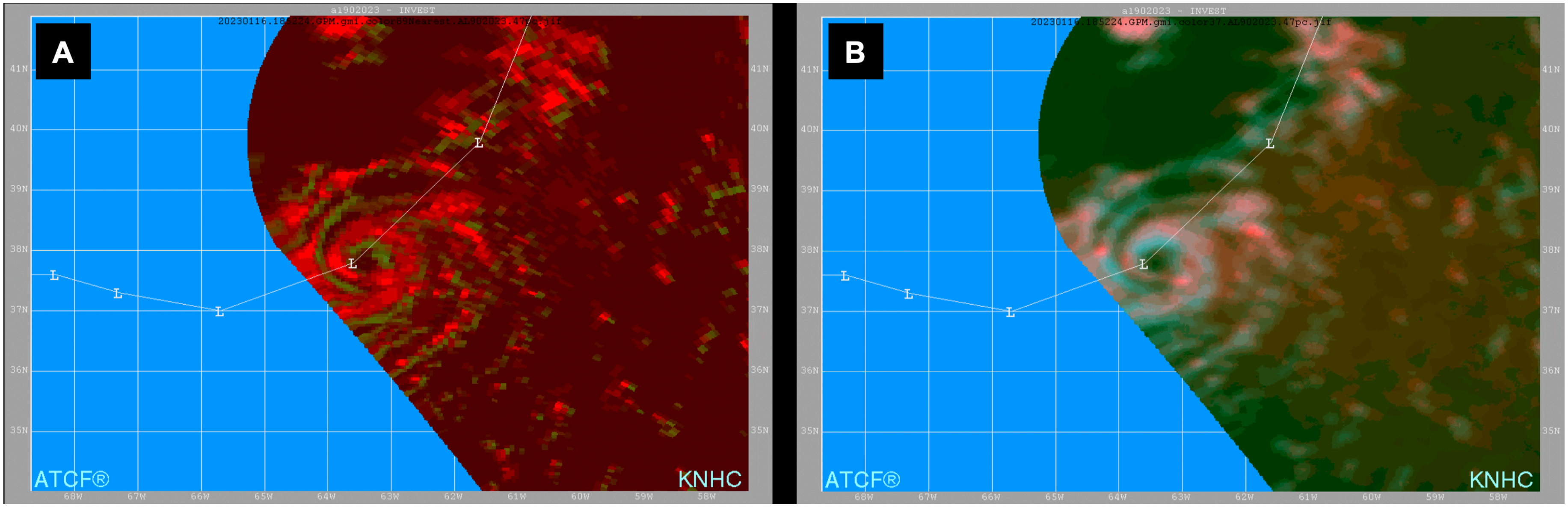

Figure 8. GMI 89-GHz color composite (panel a) and 37-GHz color composite (panel b) microwave imagery of the Unnamed Subtropical Storm valid at 1852 UTC 16 January 2023.

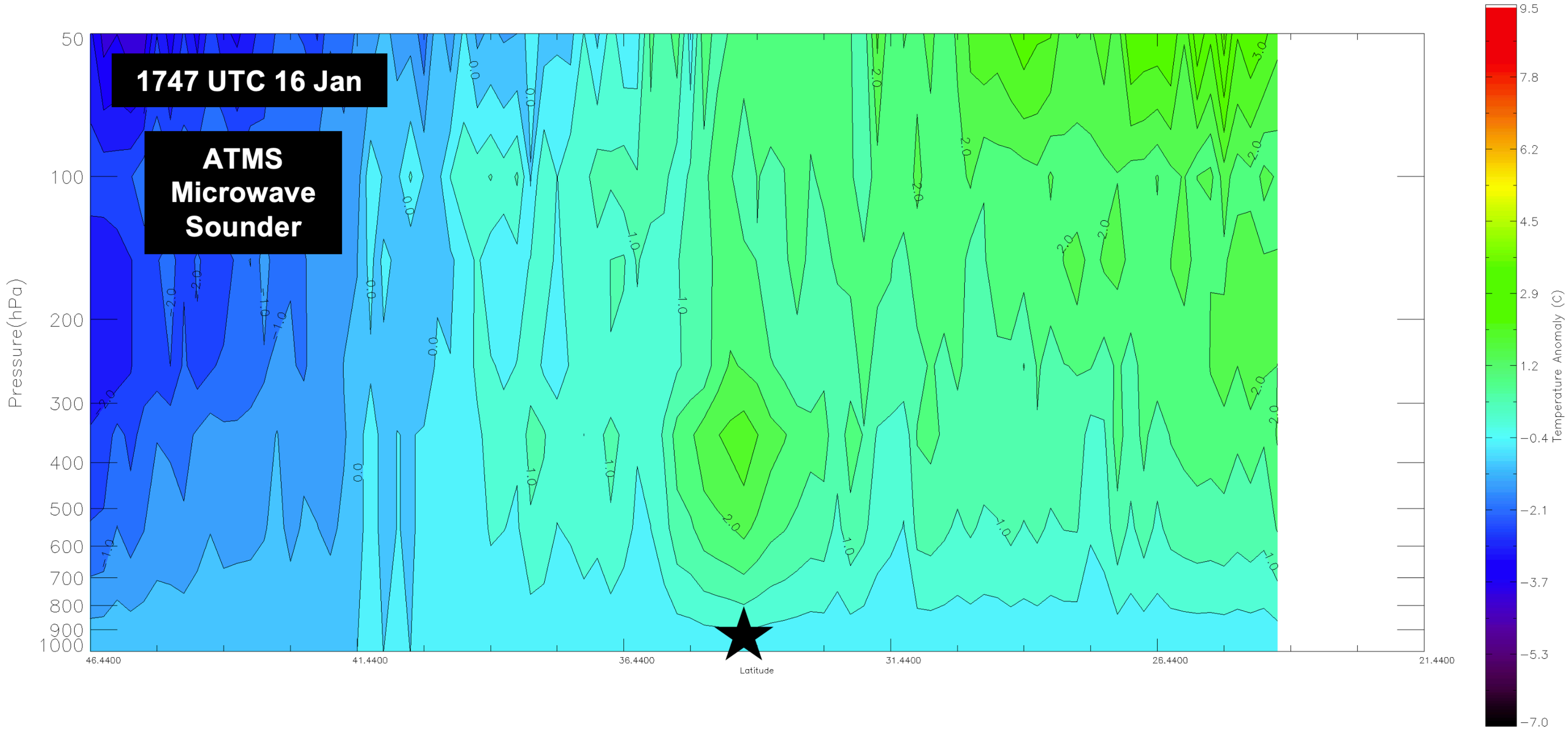

Figure 9. Advanced Microwave Sounder Unit temperature anomaly north (left) – south (right) cross section at 1747 UTC 16 January 2023. The black star denotes the center of the Unnamed Subtropical Storm at the time the cross-section was available. Adapted image courtesy of the Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin.

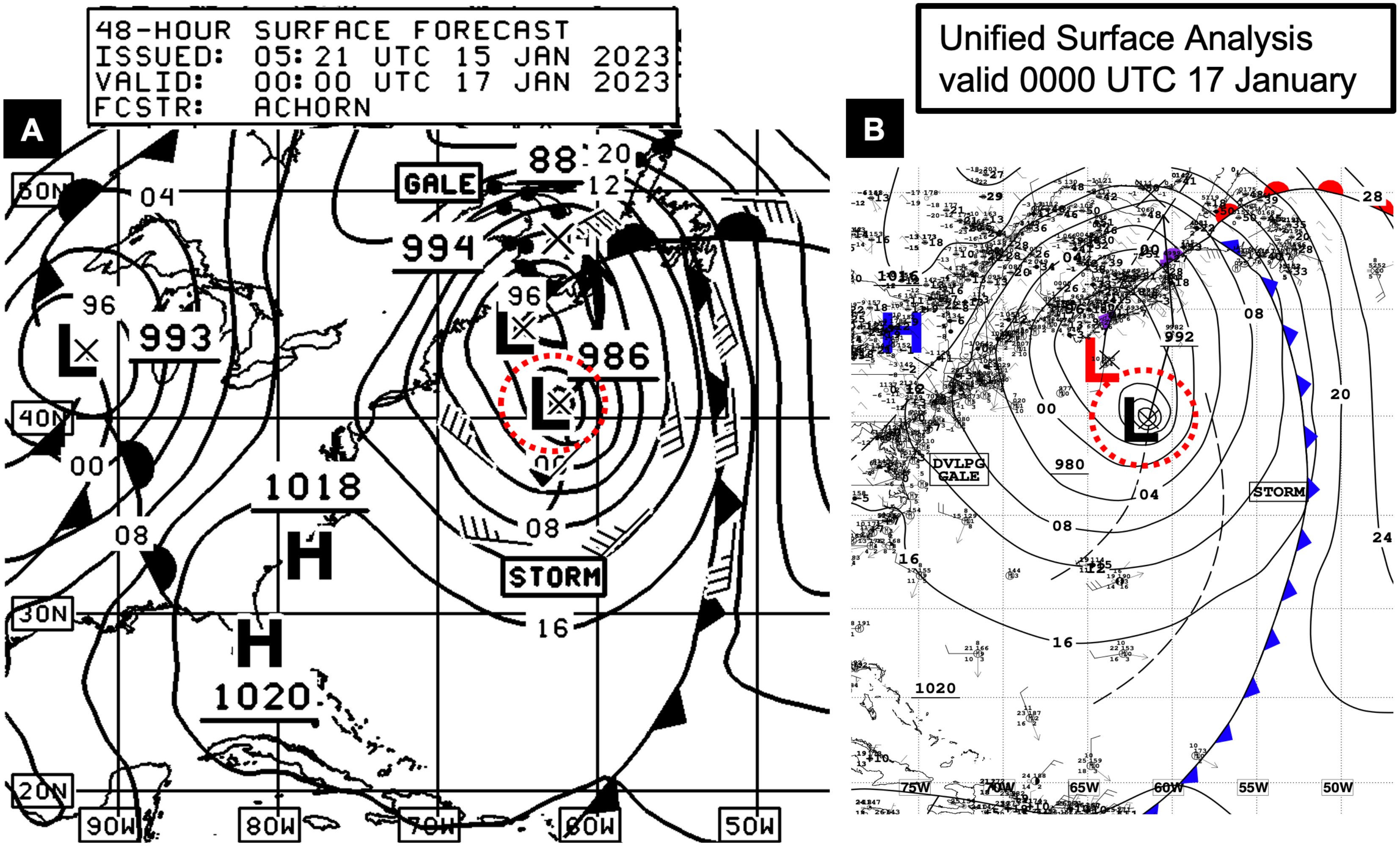

Figure 10. A 48-h surface forecast of the North Atlantic basin issued at 0521 UTC 15 January from the Ocean Prediction Center, valid at 0000 UTC 17 January (panel a). The verifying NWS Unified Surface Analysis is depicted to the right (panel b). Highlighted by the red dotted circle is the storm-force low pressure area forecasted by OPC that went on to become the Unnamed Subtropical Storm by that forecast time.

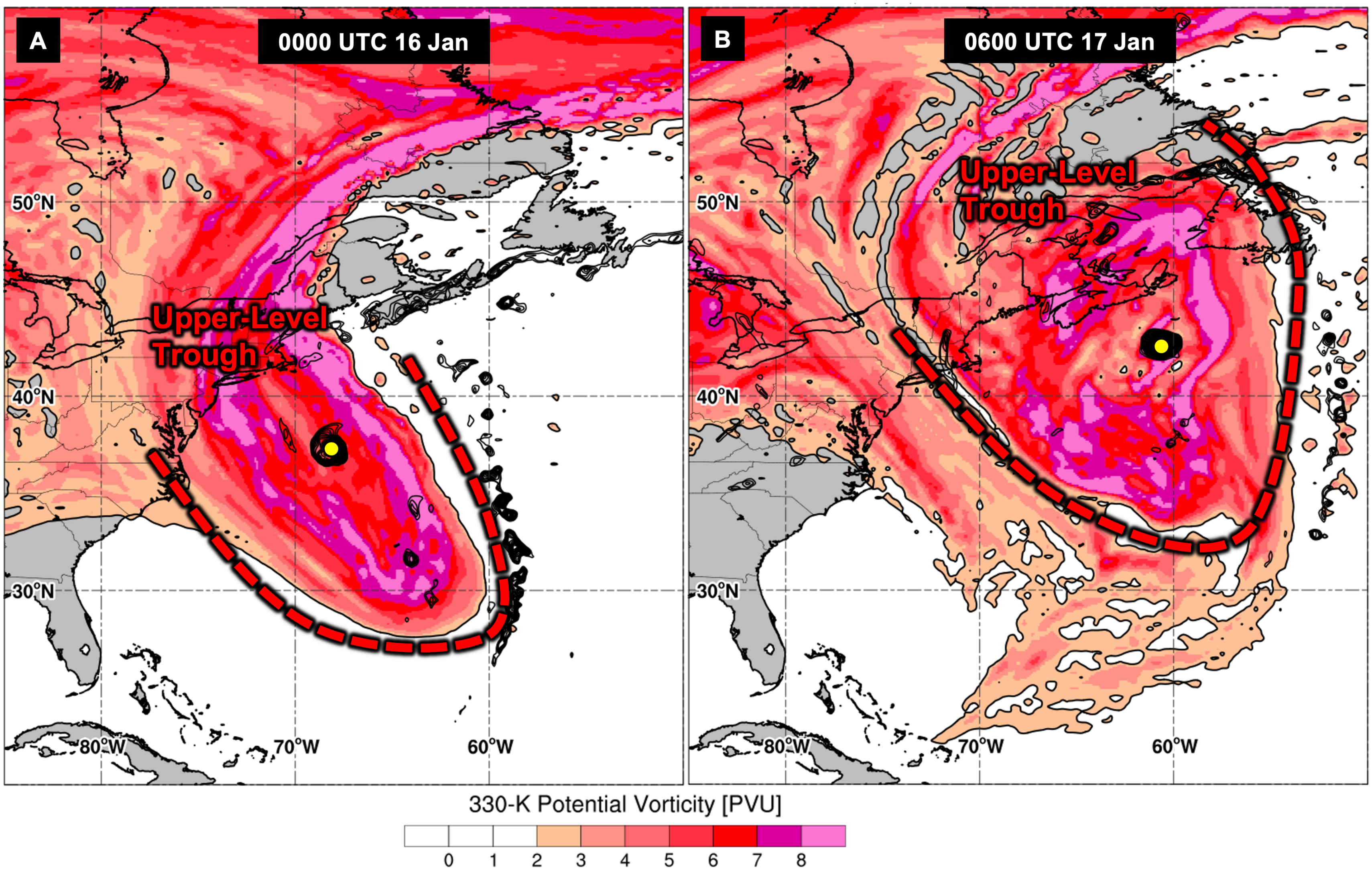

Figure 11. GFS analysis at select times, depicting a robust upper-level trough that remained overhead during the subtropical storm's lifespan. Plotted are Potential Vorticity on the 330-K isentropic surface (shaded, > 2 PVU), and 850-hPa relative vorticity (black contours, $>10\times10^{-5}$ s^{-1}). The red dotted line denotes the broad base of cyclonic flow associated with the upper-level trough, and the yellow dot depicts the location of the subtropical cyclone just prior to its transition (a) and shortly after its peak intensity (b).