NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT[1]

SUBTROPICAL STORM KAREN

(AL112025)

9–10 October 2025

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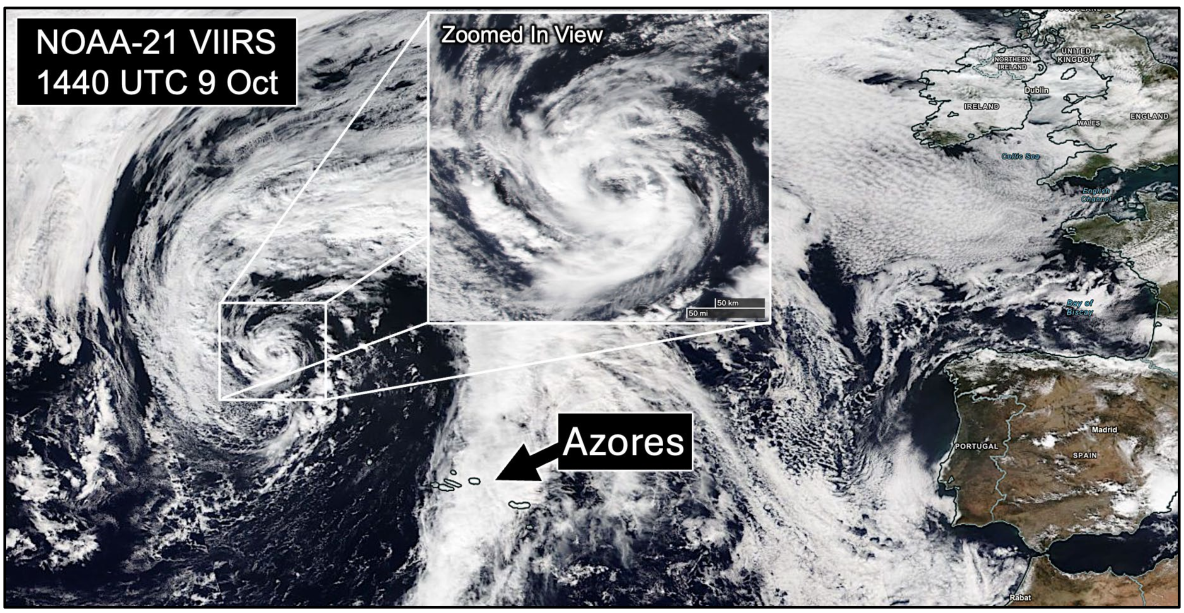
National Hurricane Center
4 December 2025



NOAA-21 VIIRS IMAGERY AT 1440 UTC 9 OCTOBER, SHOWING SUBTROPICAL STORM KAREN (INSET) EMBEDDED IN A LARGE MID-LATITUDE SYSTEM (ZOOMED OUT VIEW) AFTER IT BECAME A SUBTROPICAL STORM. IMAGERY COURTESY OF NASA WORLDVIEW.

Karen was a high-latitude subtropical storm that formed well to the northwest of the Azores. Karen's genesis location was the farthest north that a tropical or subtropical cyclone has formed in NHC records.

[1] This is an abbreviated Tropical Cyclone Report since there were no coastal watches or warnings issued and no direct fatalities reported in association with Karen.

Subtropical Storm Karen

9–10 OCTOBER 2025

BEST TRACK

The "best track[2]" positions and intensities for Subtropical Storm Karen are listed in Table 1. The best track chart of Karens's path is given in Fig. 1, with the wind and pressure histories along with available observations[3] shown in Figs. 2 and 3, respectively.

There were no surface observations of winds of tropical storm force associated with Karen.

Origin

Karen had non-tropical origins from a frontal low pressure system that formed downstream of an amplifying upper-level trough early on 8 October (Fig. 4a). This frontal low quickly became occluded by 1200 UTC that day (Fig. 4b) as the upper-level trough cutoff and became superimposed over the low-level circulation. Over the following day, the occluded low moved slowly northeastward as shallow convection began to develop closer to the center. This change resulted in the associated fronts decaying as the temperature gradient decreased. By early 9 October, a Sentinel-1A Synthetic Aperture Radar (SAR) pass (Fig. 5a), in addition to a scatterometer pass (not shown), indicated that the low was no longer attached to frontal features, was producing 35- to 40-kt winds, and its radius of maximum wind had shrunk to about 15 n mi. During this period, the system was also classified as a subtropical cyclone by TAFB using the Hebert-Poteat technique. Thus, the low is estimated to have become Subtropical Storm Karen with maximum sustained winds of 40 kt by 1200 UTC 9 October, about 300 n mi to the northwest of the northern-most Azores Islands. During and shortly after formation, the system was producing organized convective bands which could be seen on both microwave (Fig. 5b) and geostationary satellite imagery (Fig. 4c), with a distinct clear spot appearing near the center (cover photo).

Karen was unique for developing very far north (43.5°N, 34.8°W) where sea-surface temperatures (SSTs) were cooler (20–22°C) than typically observed for tropical or subtropical cyclogenesis (Fig. 6a). SSTs below 26°C can limit deep organized convection, but in Karen's

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[2] 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.

[3] Observations include subjective satellite-based Dvorak and Herbert-Poteat subtropical technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. 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), the Defense Meteorological Satellite Program (DMSP) satellites, and the Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS) satellites, among others, were also useful in constructing the best track of Karen.

case, upper-level temperatures were also colder than usual in part due to its formation under a suppressed tropopause (Fig. 7). For cyclones that undergo tropical transition within a baroclinic environment, a helpful index developed to determine if sufficient tropospheric instability exists is called the Coupling Index (Bosart and Lackman 1995). This index is calculated as the difference between the potential temperature at the tropopause and the 850-mb equivalent potential temperature (Fig. 6b). A maximum threshold of 22.5°C has been proposed in literature (McTaggart-Cowan et al. 2015) as a better variable than using SSTs alone for these tropical transitioning cases. The Coupling Index has also been used in compositing studies of subtropical cyclones that form in the presence of a large cutoff upper-level cyclone, as in Karen's case (Bentley et al. 2017, see their Fig. 10). Despite Karen's development over cool SSTs, a large region of instability existed (Coupling Index values below 22.5°C) over the system while it was in a low-shear environment (Fig. 6b) which aided the system's transition into a subtropical storm.

While Karen is notable for developing into a subtropical storm at such a high latitude, other non-tropical-originating systems have tracked even farther north, including Hurricane Pablo (2019), which became a 70-kt hurricane farther north and west (44.1°N, 17.3°W) over cooler SSTs than where Karen first became a subtropical storm.

Peak Intensity and Minimum Pressure

Karen's peak intensity of 40 kt as a subtropical storm is based on scatterometer data of 37 kt near 1133 UTC 9 October, assuming some undersampling of the peak wind speed from this instrument. This peak intensity of 40 kt is also roughly in between the highest subjective intensity estimates provided by TAFB (ST 2.5/35–40 kt), and SAB (T3.0/45 kt) between 0000–0600 UTC 10 October.

The estimated minimum central pressure of 998 mb is based on a combination of surface analyses from the NWS Unified Surface Analyses and a blend of subjective and objective pressure estimates.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Karen.

FORECAST AND WARNING VERIFICATION

Table 2 provides the number of hours in advance of formation with the first NHC Tropical Weather Outlook (TWO) forecast in each likelihood category. Karen's genesis was poorly predicted. The extratropical low that transitioned into Subtropical Storm Karen was first introduced into the TWO only 12 h prior to transition, and the outlook failed to reach the medium or high categories in the TWO prior to the post-analyzed formation of Karen. These transitions require the associated fronts to dissipate, deep convection to develop near the center, and for the radius of maximum wind to contract. In particular, the global models often struggle to simulate these changes in characteristics, especially in producing sufficiently deep convection, which limited the predictability of this subtropical cyclone. The location of Karen's genesis was well predicted in the three genesis areas that were issued before and during Karen's formation (Fig. 8).

Only two NHC official forecasts verified at 12 h due to the cyclone's short existence. Those 12-h forecasts had a track error of 7.2 n mi and an intensity error of 2.5 kt, which are both below the mean official errors for the previous 5-yr period. A homogeneous comparison of the official track and intensity errors with selected guidance models is not shown due to the small sample size of forecasts.

There were no coastal watches or warnings issued for Karen.

REFERENCES

Bentley, A. M., L. F. Bosart, and D. Keyser, 2017: Upper-Tropospheric Precursors to the Formation of Subtropical Cyclones that Undergo Tropical Transition in the North Atlantic Basin. *Mon. Wea. Rev.*, **145**, 503–520, https://doi.org/10.1175/MWR-D-16-0263.1.

Bosart, L. F., and G. M. Lackmann, 1995: Postlandfall Tropical Cyclone Reintensification in a Weakly Baroclinic Environment: A Case Study of Hurricane David (September 1979). *Mon. Wea. Rev.*, **123**, 3268–3291, https://doi.org/10.1175/1520-0493(1995)123<3268:PTCRIA>2.0.CO;2.

McTaggart-Cowan, R., E. L. Davies, J. G. Fairman, T. J. Galarneau, and D. M. Schultz, 2015: Revisiting the 26.5°C Sea Surface Temperature Threshold for Tropical Cyclone Development. *Bull. Amer. Meteor. Soc.*, **96**, 1929–1943, https://doi.org/10.1175/BAMS-D-13-00254.1.

ACKNOWLEDGEMENTS

Special thanks to the NOAA Ocean Prediction Center for coordination that was conducted prior to and after the formation of Subtropical Storm Karen. Additional thanks to Dr. Alicia Bentley (NOAA/EMC) who provided the code to compute the Coupling Index used in Fig. 6b of this report.

Table 1. Best track for Subtropical Storm Karen, 9–10 October 2025.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
08 / 0000	38.0	35.9	1014	45	extratropical
08 / 0600	39.9	36.0	1006	45	"
08 / 1200	41.2	36.7	1000	50	"
08 / 1800	41.4	36.9	996	50	"
09 / 0000	41.9	35.7	997	45	"
09 / 0600	42.8	35.1	997	45	"
09 / 1200	43.5	34.8	998	40	subtropical storm
09 / 1800	43.9	34.2	998	40	"
10 / 0000	44.4	33.5	998	40	"
10 / 0600	45.0	32.6	998	40	"
10 / 1200	45.7	31.5	998	40	"
10 / 1800	46.8	30.6	1000	35	"
11 / 0000	48.0	29.7	1003	35	low
11 / 0600	49.4	28.7	1005	30	"
11 / 1200	51.3	28.0	1005	30	"
11 / 1800					dissipated
09 / 1200	43.5	34.8	998	40	Maximum winds and minimum pressure

Table 2. Number of hours in advance of formation 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	**168-Hour Outlook**
Low (<40%)	12	12
Medium (40%-60%)	-	-
High (>60%)	-	-

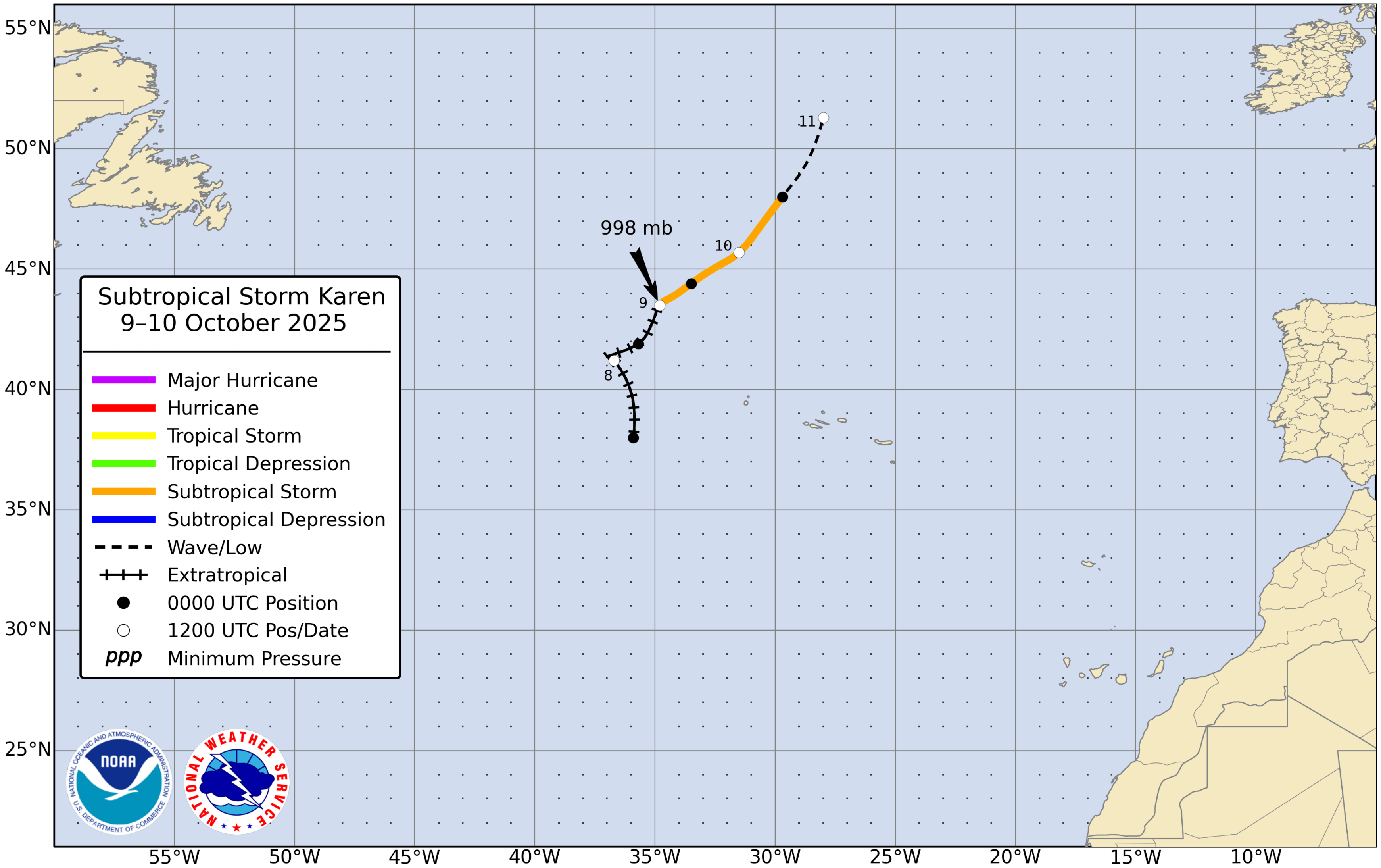

Figure 1. Best track positions for Subtropical Storm Karen, 9–10 October 2025. Tracks during the extratropical stage are partially based on unified surface analyses from the NWS Unified Surface Analyses.

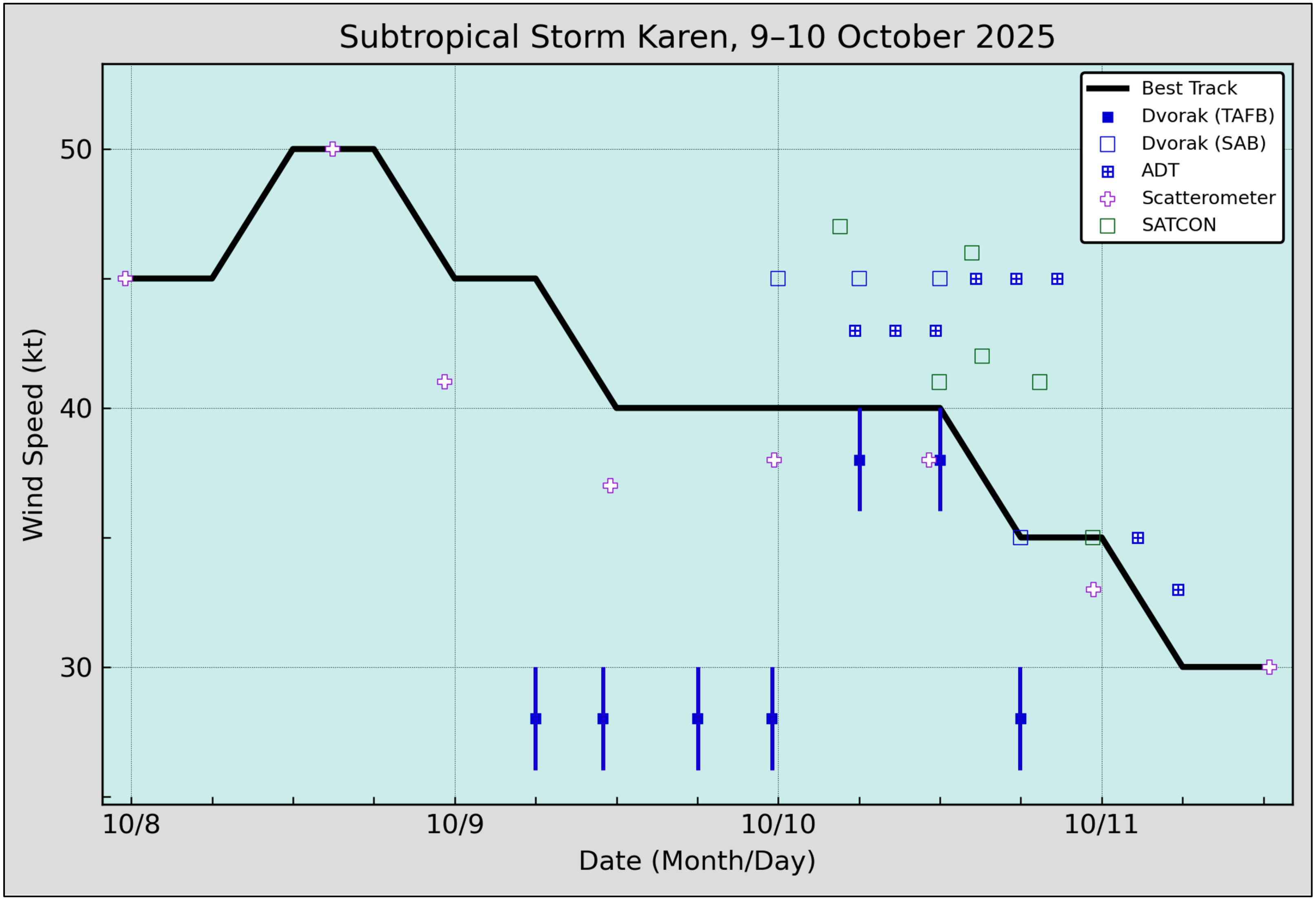

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Subtropical Storm Karen, 9–10 October 2025. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC.

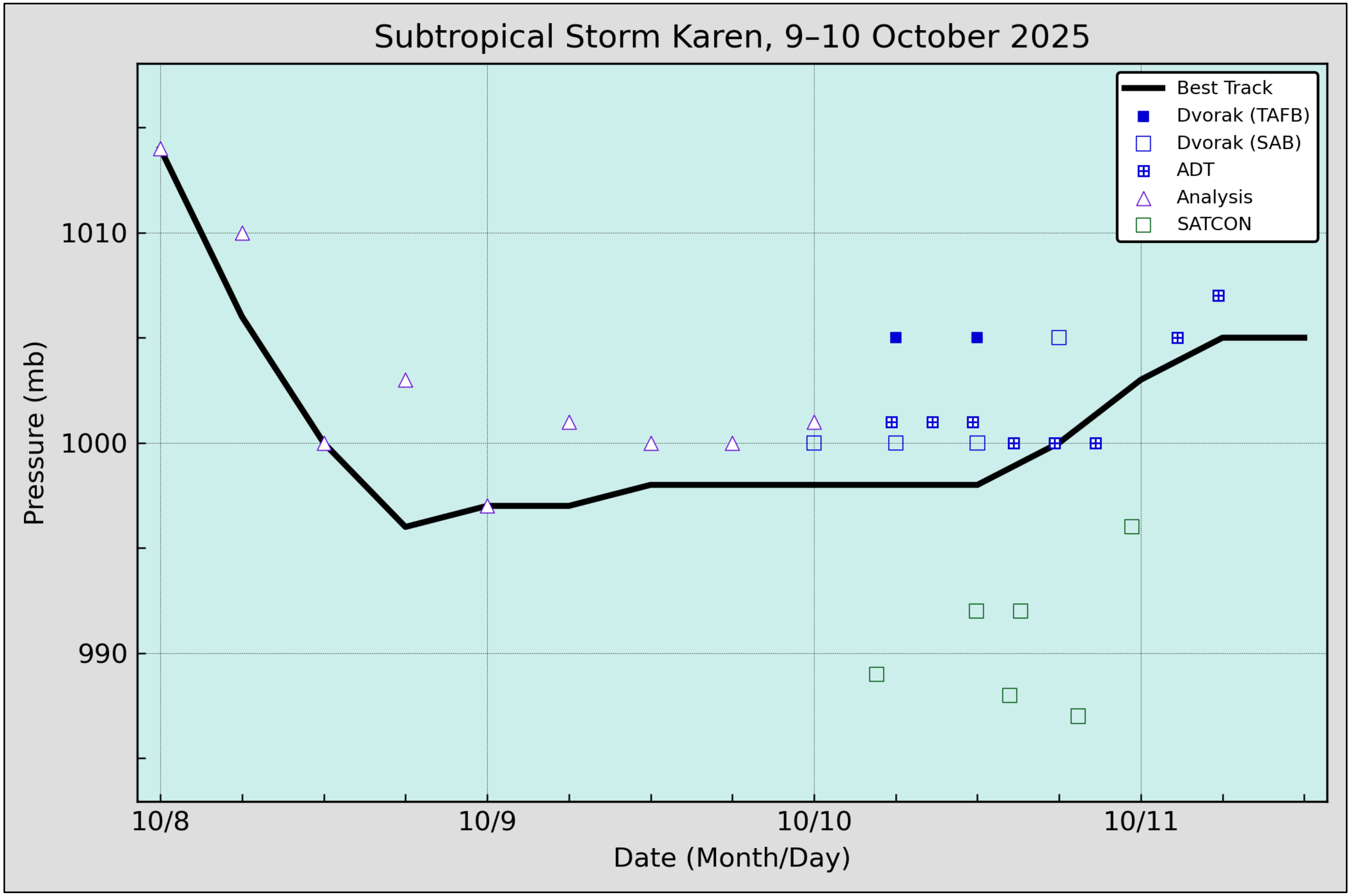

Figure 3. Selected pressure observations and best track minimum central pressure curve for Subtropical Storm Karen, 9–10 October 2025. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

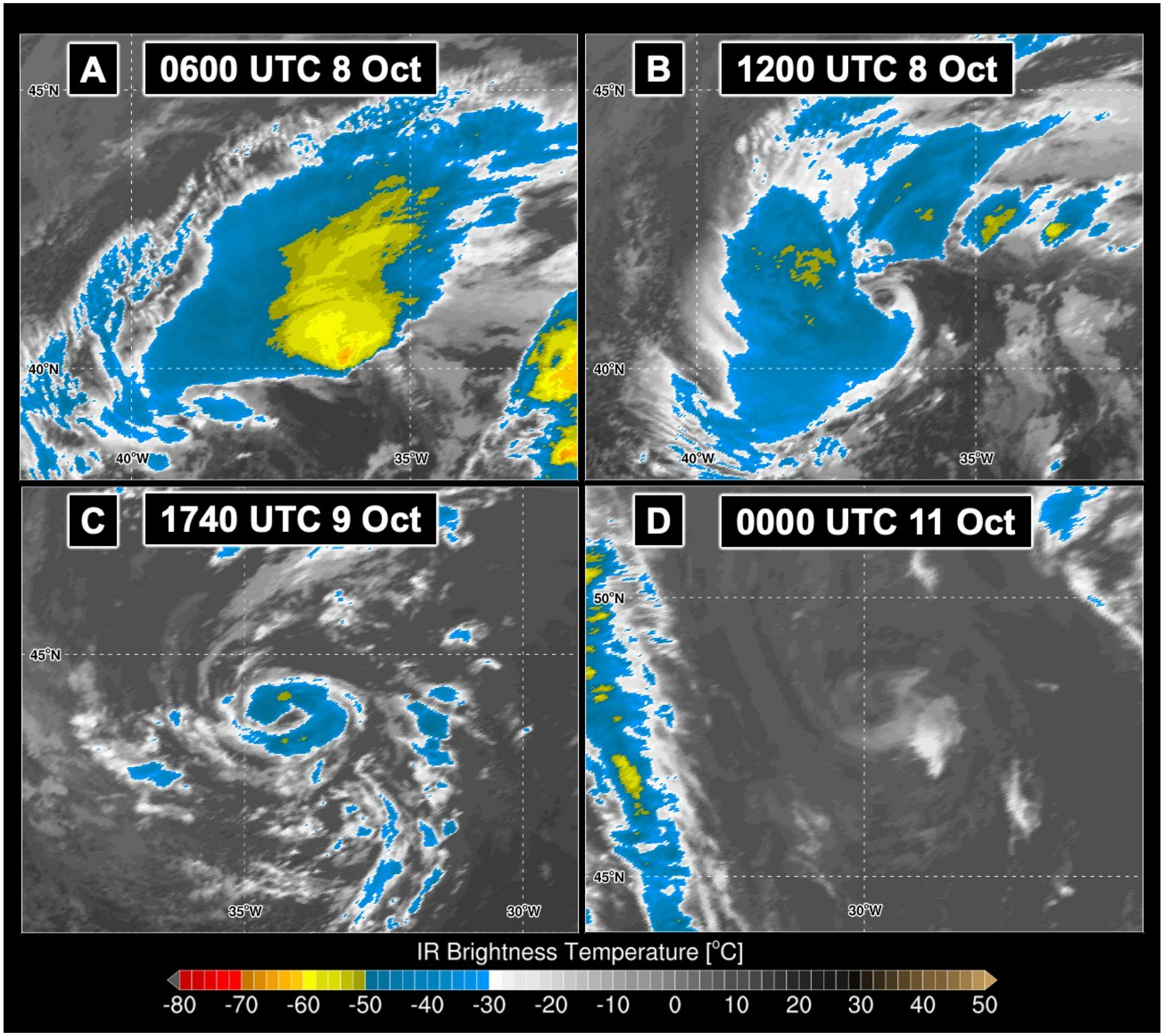

Figure 4. GOES-19 infrared images documenting the evolution of Karen at a) 0600 UTC 8 October when the system was a frontal low, b) 1200 UTC 8 October when the low became occluded, c) 1740 UTC 9 October after the system had shed its frontal features and had become a subtropical storm, and d) 0000 UTC 11 October when Karen became a post-tropical remnant low.

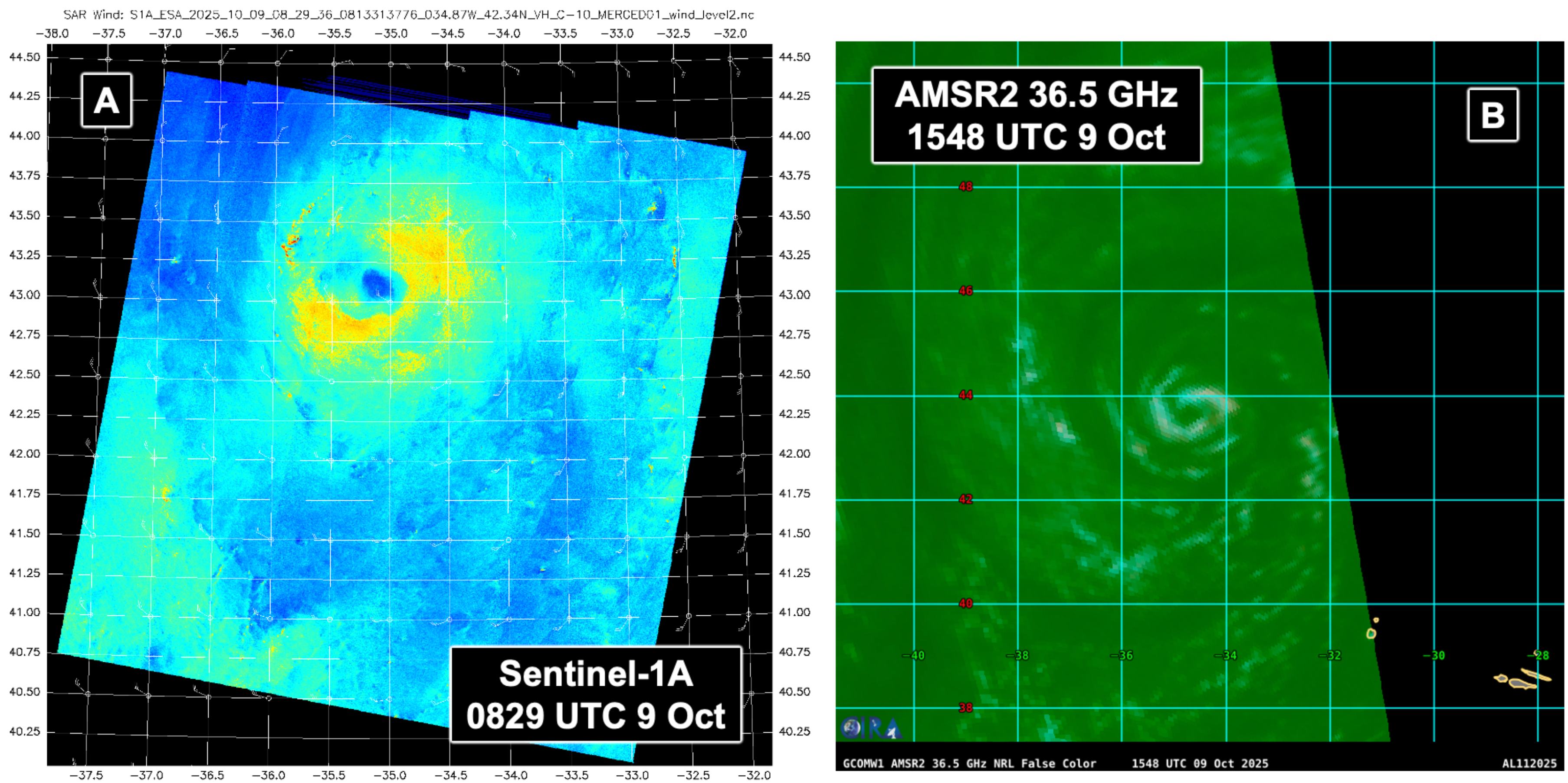

Figure 5. Polar orbiting imagery of Karen shortly before and after it became a subtropical storm, where (a) is a Sentinel-1A Synthetic Aperture Radar pass at 0829 UTC 9 October which showed the low had shed its remaining frontal boundaries and (b) a 1548 UTC 9 October AMSR2 36.5 GHz microwave pass showing organized curved bands associated with Karen. Note that the calibration of wind estimates from SAR are still being examined, and the data were only used qualitatively when estimating Karen's peak intensity.

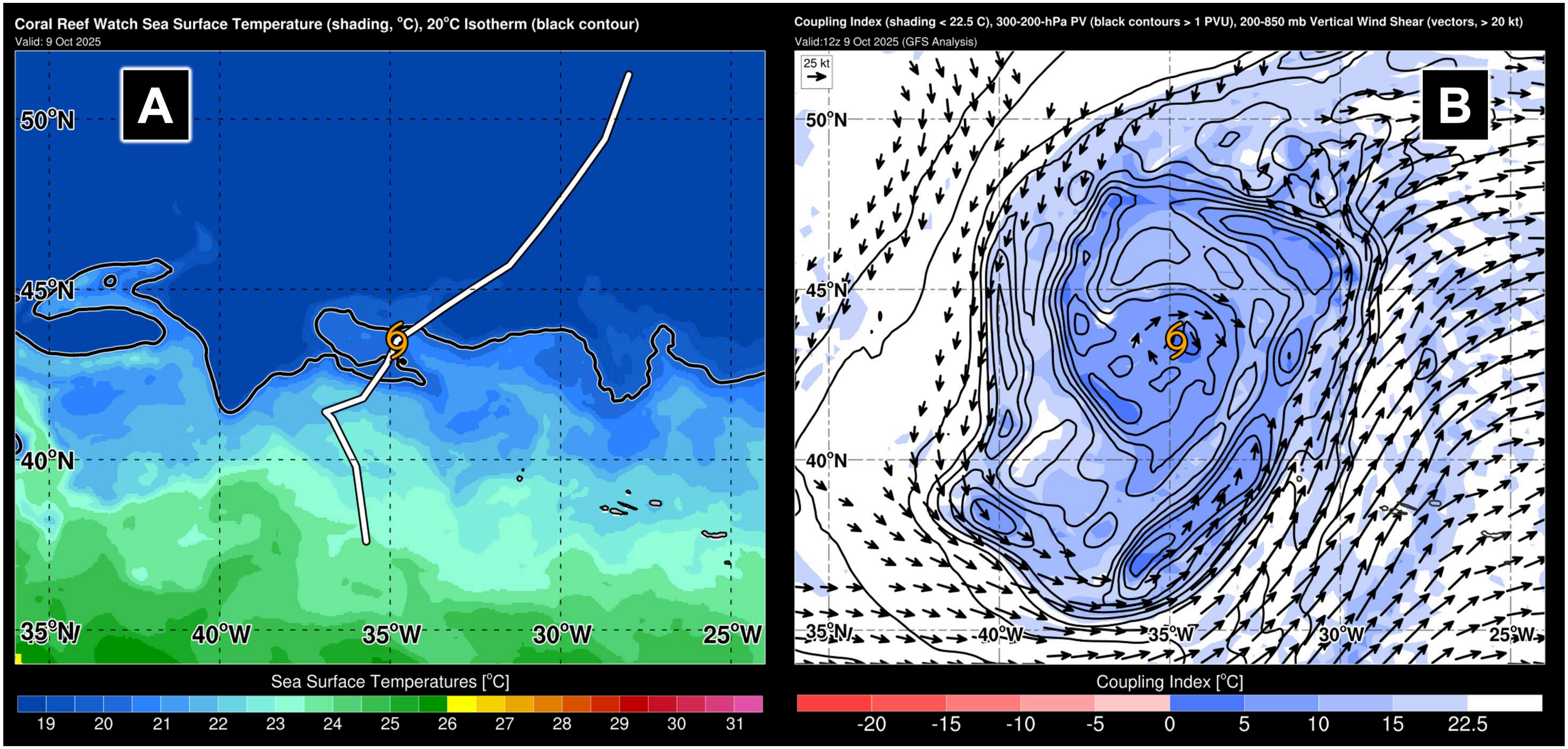

Figure 6. Thermodynamic variables related to Karen's development into a subtropical storm. Panel (a) depicts sea surface temperatures (shading, °C) on 9 October. The 20°C sea surface temperature isotherm is highlighted as a black contour, while the track and location of the subtropical storm when it was designated are shown as a white line and orange cyclone symbol, respectively. Panel (b) depicts the 1200 UTC 9 October GFS analysis of coupling index (shaded, °C), 300–200 mb layer mean potential vorticity (black contours, > 1 PVU), and 200–850 mb Vertical Wind Shear (vectors, >20 kt, 25 kt reference vector provided in top left). Data from NOAA's Coral Reef Watch, accessible at https://coralreefwatch.noaa.gov/ and the GFS archive at UCAR, accessible at https://gdex.ucar.edu/datasets/d084001/.

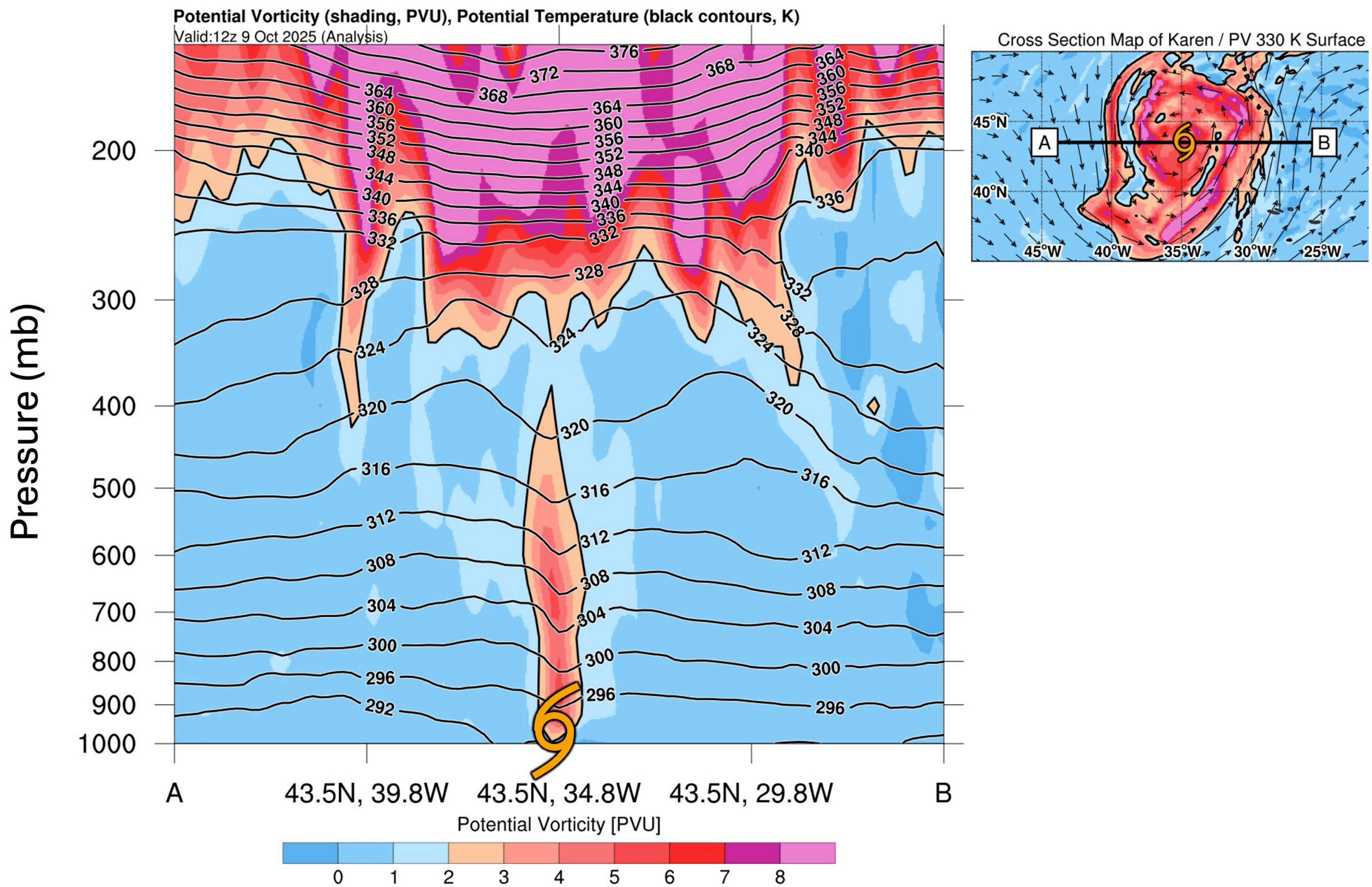

Figure 7. Cross-section of Karen and the upper-level cutoff low at the time of designation as a subtropical storm at 1200 UTC 9 October. Cross-section depicts potential vorticity (shading, PVU) and potential temperature (black contours, every 4 K). Map inset shows PV on the 330-K surface (shading, PVU), and winds on the 330-K surface (vectors). Note the location of Karen is denoted by the orange cyclone symbol. Data from GFS archive from UCAR, accessible at https://gdex.ucar.edu/datasets/d084001/.

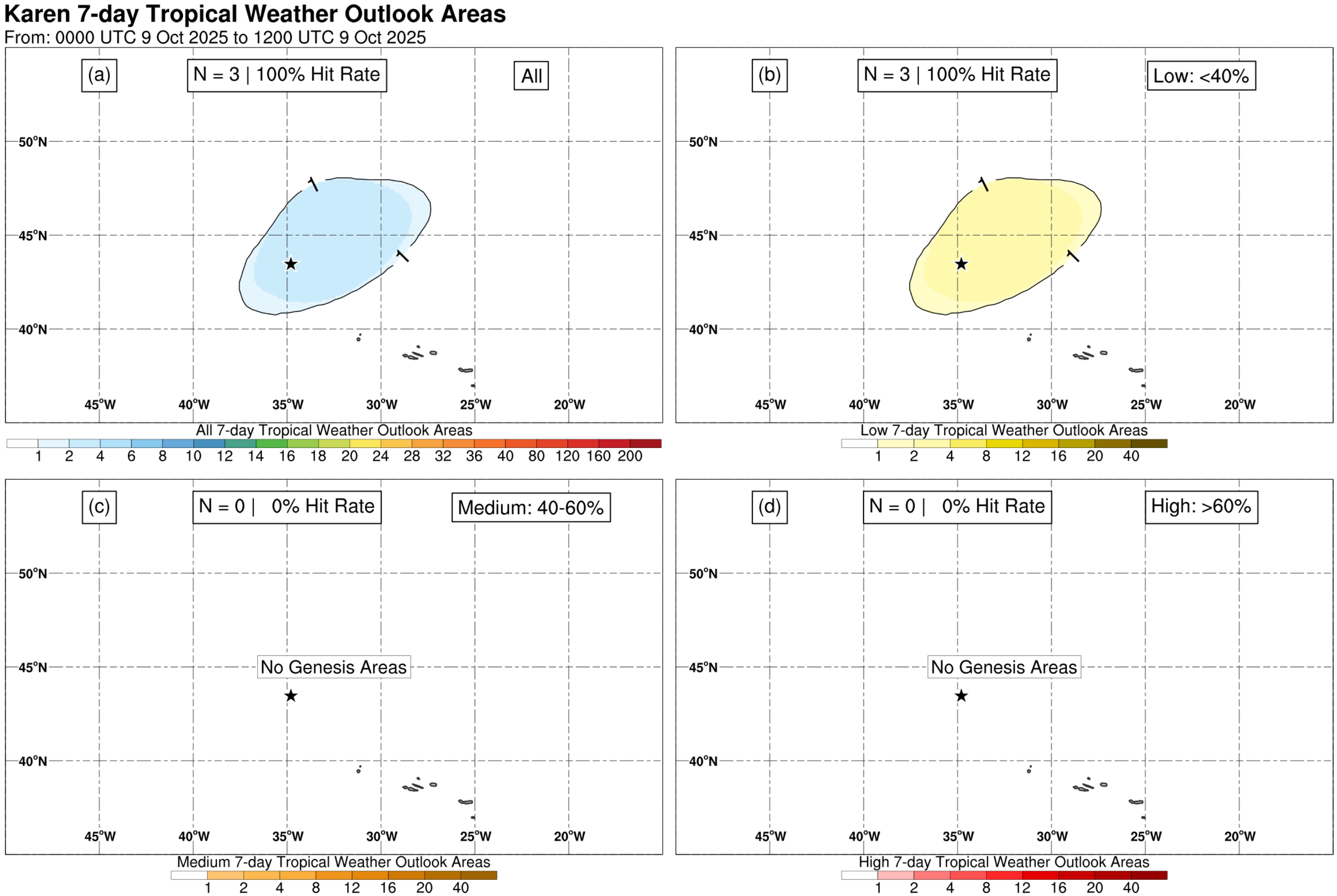

Figure 8. Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks prior to and at the formation of Karen for (a) all probabilistic genesis categories, (b) the low (<40%) category, (c) medium (40–60%) category, and (d) high (>60%) category. The location of genesis is indicated by the black star.