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The Joint Typhoon Warning Center Tropical Cyclone Best Tracks, 1945-2025

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14. ABSTRACT

This report provides an overview of the current Joint Typhoon Warning Center (JTWC) tropical cyclone "best-track" review process and a qualitative assessment of the reliability and accuracy of individual elements of the JTWC best-track data record, which spans the 80-year period from 1945 to 2025. The JTWC database consists of historical tropical cyclone records for the following basins: western North Pacific, North Indian Ocean, and Southern Hemisphere. The authors consider the two of the quality-controlled elements, position and intensity, to be reliable from 2000 through 2025, but advise cautious use of older data. The other three quality-controlled elements are the 34-, 50-, and 64-kt wind radii. The 34-kt wind radii have been quality-controlled since 2016, and the accuracy likely improves gradually through 2025. The 50-kt and 64-kt wind radii were regressed from 34-kt wind radii from 2016 through 2019, then quality-controlled with observations from 2020 through 2025. The remaining elements are not quality-controlled and are of varying accuracy. The best-track data are posted on the JTWC Tropical Cyclone Best Track Data website: https://www.metoc.navy.mil/jtwc/jtwc.html?best-tracks.

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EXECUTIVE SUMMARY

This report provides an overview of the current Joint Typhoon Warning Center (JTWC) review process to determine the best tracks of tropical cyclones and a qualitative assessment of the reliability and accuracy of individual elements of the JTWC best-track data record, which spans the 80-year period from 1945 to 2025. The JTWC database consists of historical records of tropical cyclones for the following basins: western North Pacific, North Indian Ocean, and Southern Hemisphere. The authors consider two quality-controlled elements, position and intensity, to be reliable from 2000 through 2025, but advise caution when using older data. The other three quality-controlled elements are the 34-, 50-, and 64-kt wind radii. The 34-kt wind radii have been quality controlled since 2016, and accuracy likely improves gradually through 2025. The 50-kt and 64-kt wind radii were determined by regression from the 34-kt wind radii from 2016 through 2019, then were quality controlled with observations from 2020 through 2025. The remaining elements are not quality controlled and are of varying accuracy. The best-track data are posted on the JTWC Tropical Cyclone Best Track Data website: https://www.metoc.navy.mil/jtwc/jtwc.html?best-tracks.

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THE JOINT TYPHOON WARNING CENTER TROPICAL CYCLONE BEST TRACKS, 1945-2025

1. INTRODUCTION

The Joint Typhoon Warning Center (JTWC, see Appendix B for a list of acronyms used in this work) area of responsibility (AOR) has evolved over the years to meet the changing requirements of the US Department of Defense (DoD). When JTWC was established in 1959, the DoD tropical cyclone (TC) forecast region included only the western Pacific (Machado 2016). JTWC's AOR subsequently expanded to include the Bay of Bengal in 1971, the northern Arabian Sea in 1974, and both the South Indian Ocean and the South Pacific Ocean in 1985 (Chu et al. 2002). Currently, the JTWC produces TC analyses and forecasts for US Government interests in the western North Pacific, North Indian Ocean, and Southern Hemisphere basins, illustrated by the blue shading in Fig. 1. Table 1 shows the single-character DoD basin identifiers and JTWC archive designators.

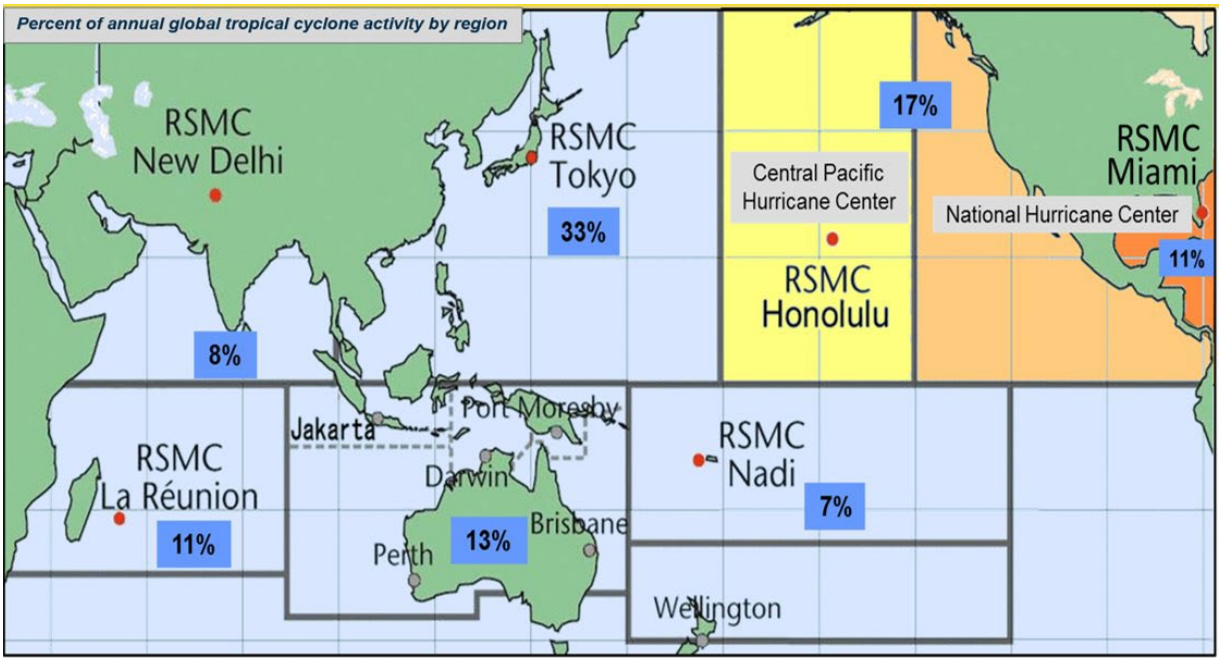


Fig. 1—Regional Specialized Meteorological Centers (RSMCs)/Tropical Cyclone Warning Centers (TCWCs) and their AORs.

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Table 1—Basin and Sub-Basin Designators Used by the DoD and the RSMCs Responsible for Each Basin as Designated by the World Meteorological Organization (WMO)

DoD single letter basin designator	Two-letter basin designator	Other basin monikers	Responsible RSMC(s)/TCWC(s)
A (North Arabian Sea)	IO (North Indian Ocean)	NIO	IMD New Delhi
B (Bay of Bengal)	IO (North Indian Ocean)	NIO	IMD New Delhi
C (Central North Pacific)	CP	CNP, CPAC, CENTPAC	CPHC Honolulu
E (Eastern North Pacific)	EP	NEP, EPAC, EASTPAC	NHC Miami
P (South Pacific)	SH (Southern Hemisphere)	SHEM, SWP, SPAC	FMS Nadi/*BOM Australia*/*NZMS Wellington*/*PNGNWS Port Moresby*
S (South Indian Ocean)	SH (Southern Hemisphere)	SHEM, SWI, SIO	MeteoFrance LaR/*BOM Aus*/*BMKG Jakarta*
W (Western North Pacific)	WP	NWP, WPAC, WESTPAC	JMA Tokyo

Red letters indicate basins within the current JTWC AOR. Italics text indicates a TCWC. For more information concerning the WMO TC Program, see (https://community.wmo.int/en/tropical-cyclone-regional-bodies)

In accordance with mission requirements, JTWC maintains an archive database of TC analysis parameters, commonly referred to as "best tracks," or "bdecks." The word "best" is an acknowledgment of the uncertainty inherent in any estimate of TC position, intensity, and other parameters. Best-track (BT) data represent the best subjective assessment of these parameters given the available tools and datasets and multiple levels of review by operational forecasting professionals. The purpose of this database is threefold:

- to create an official historical record of each TC across the JTWC's AOR,
- to enable worldwide TC research and development and scientific analysis based on an accurate, long-term TC record, and
- to provide a resource for forecaster training and support production of poststorm reviews and reports.

While JTWC is not a member of the World Meteorological Organization (WMO), the center provides TC analysis and forecast support for US Government interests in accordance with both DoD instructions and the US National Hurricane Operations Plan (NHOP) (NHOP, 2024). Together, the National Hurricane Center (NHC), the Central Pacific Hurricane Center (CPHC), and the JTWC provide global TC analysis and forecast support for US Government interests. The NHC and CPHC are further charged with fulfilling WMO obligations as designated WMO Regional Specialized Meteorological Centers (RSMCs). The JTWC AOR overlaps with five WMO RSMC AORs and two Tropical Cyclone Warning Center (TCWC) AORs, each of which has its own TC-reporting criteria, wind speed averaging technique (10-min, 3-min or 1-min averaging), forecast components, and BT review methodology. The disparate nature of the BT data provided by different TC-forecasting centers at times can present challenges, particularly for researchers studying long-term trends and TC meteorology (Schreck et al. 2014). The JTWC BT database provides a reliable, consistent, long-term source of quality-controlled (QC'd) BT data spanning nearly eight decades

and three quarters of the globe and is often combined with data from CPHC and NHC to construct a consistent global database.

The JTWC BT database extends back to 1945 across the center's AOR thanks to an extensive reanalysis and cross-validation effort in 2000 (Chu et al. 2002). The period of availability of official JTWC documentation and data varies by basin, beginning in 1945 for western North Pacific TCs, in 1971 for Bay of Bengal TCs, in 1974 for North Arabian Sea TCs, and in 1985 for Southern Hemisphere TCs. Data from RSMCs and TCWCs, the National Center for Environmental Information (formerly the National Climatic Data Center), the Fleet Numerical Meteorology and Oceanography Center, and sources compiled by researchers were used to reconstruct the historical record prior to the starting point of JTWC official data (Chu et al. 2002). Data from reconstructed early periods, for which documentation is sparse or nonexistent, are rated as low confidence and should be used with caution. Additionally, an unknown number of TCs may have been analyzed incorrectly or entirely undetected prior to the era of routine space-based satellite monitoring.

2. BEST-TRACK DATABASE COMPONENTS

At the present time, each entry within the BT database consists of up to 24 individual analyzed elements, though not all 24 elements are QC'd nor are they included throughout the entire archive. Figure 2 shows which elements are included across the entirety of the BT archive (shaded green), those that were added in the past few years (shaded yellow), and those that were not included in the archive at any point (shaded red). Of the 24 total elements, only 5 undergo retrospective QC at JTWC: position (latitude and longitude), intensity or maximum wind velocity (VMAX), and 34-, 50-, and 64-kt wind radii in the compass quadrants (NE, SE, SW, NW). However, the time history of additional BT elements, including mean sea level pressure, radius of maximum wind, and radius and pressure of the outermost closed isobar, also undergo a cursory review to identify and smooth out errant inconsistencies temporally. More details on the BT review process are available in Section 3 of this report.

All JTWC BTs comprise of entries at synoptic times of 00, 06, 12 and 18 UTC and occasionally contain additional "intermediate" points, typically inserted at 3-hour intervals to capture significant events such as peak intensity, landfall, or sharp shifts in track direction. The final BT data posted to the JTWC archive are QC'd in a comprehensive, multistage process (see Section 3) well after the real-time tracking of each TC has ended. Final BT data can and frequently do differ significantly from the real-time BT data.

In contrast to real-time BT analysis conducted under time constraints, poststorm analyses are more deliberate, with access to additional raw data and a complete storm history to inform decision-making and to enable refinement of data for the JTWC BT archive. The quality of data in the JTWC BT archive and associated supporting documentation are less reliable for older storms than for more recent ones. As mentioned in the previous section, much of the earliest data in the JTWC BT archive is either poorly documented or undocumented. Previous efforts (Chu et al. 2002) conducted a cursory inspection of the undocumented best tracks but could not perform rigorous QC because of the lack of documentation.

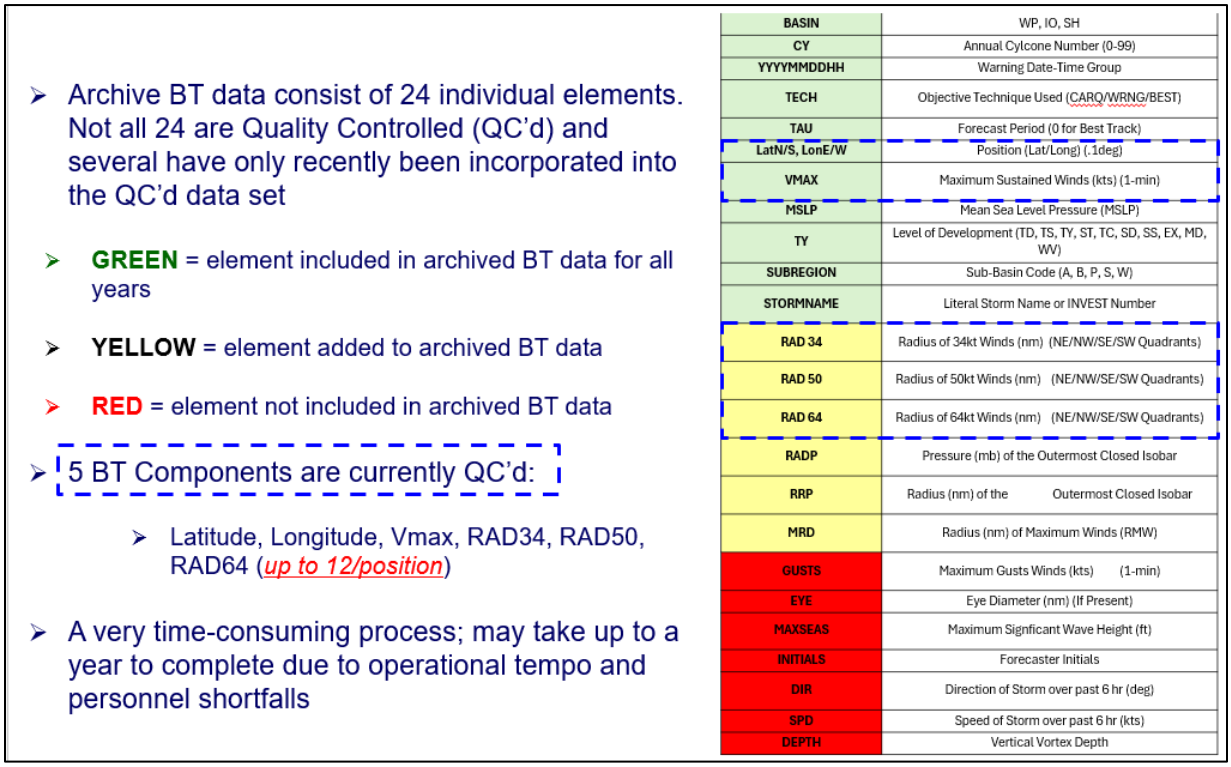


Fig. 2—Elements included in the BT archive for which green, yellow, or red indicate that best tracks existed for the element for all years, recent years, or not at all, respectively. See Appendix B for acronyms. The element "TECH" is always defined as "BEST" for best tracks.

3. BEST-TRACK PROCESS

As discussed above, the JTWC BT archive consists of up to 24 individual elements for TCs that developed across the JTWC AOR from 1945 to the present. Currently, qualified typhoon duty officers (TDOs) and senior leaders at JTWC follow a labor-intensive, four-step, best-track data-review process to prepare BT data associated with each cyclone for public release. The steps in the process are:

Level 1 — working BT
Level 2 — poststorm BT
Level 3 — poststorm BT review
Level 4 — marquee storm review

The Level 1 process is conducted in real time, at least once every 6 hours, by the on-shift TDO. The TDO collates and analyzes multiple sources of data, including geostationary visible and infrared satellite imagery, polar-orbiting microwave imagery, and satellite-derived ocean-surface vector-wind data (see Appendix A for a full listing) to determine all 24 elements of the BT. These elements are then entered into the Automated Tropical Cyclone Forecast System (ATCF) (Sampson and Schrader 2000). The TDO also records the data and reasoning that were applied to determine the BT in ATCF "storm logs" for individual TCs. Each BT point is subsequently scrutinized during a "turnover review" conducted by the subsequent TDO, who is responsible for reviewing at least the previous two BT points (representing the past 12 hours of storm activity), using all available data at that time, and making necessary adjustments. During real-time operations, the BT is essentially a living dataset, subject to frequent and sometimes significant changes to

all elements as new data becomes available. Varying perspectives and levels of experience among qualified forecasters can result in accuracy, quality, and consistency issues in the working BT data set.

Level 2 review is the first phase of the poststorm BT process. To begin Level 2 reanalysis, an assigned satellite analyst reviews all available PGTW fixes, which are individual estimates of storm position, intensity, and other structure parameters based on single data sources such as a satellite image. This process ensures that all fixes, including Dvorak-based (Dvorak 1975), microwave, scatterometer, radar, and analysis fixes, are QC'd and available within the ATCF for forecaster review. Following the fix review, a TDO examines all available data within the ATCF as well as archived data provided by external organizations such as the Cooperative Institute for Meteorological Satellite Studies (CIMSS), the Cooperative Institute for Research in the Atmosphere (CIRA), the Naval Research Laboratory (NRL), the National Environmental Satellite, Data and Information Service (NESDIS), and commercial radar archive sites, some of which may not have been available in real time. This allows for in-depth review and reassessment of the position, intensity, and 34-, 50- and 64-kt wind radii (RAD34, RAD50 and RAD64, respectively) associated with each BT position for the lifetime of the TC. All changes are annotated within the ATCF storm log. The quality and consistency of BT data following Level 2 review still depend on the interpretation and experience of individual reviewers. The assigned reviewer notifies the best track officer (BTO) when the poststorm BT is ready for the next phase in the review process.

To achieve consistency across all annual records, the BTO, a full-time senior TDO, conducts a Level 3 review to evaluate each entry. By this point in the process, little to no new data are available. Hence, the BTO focuses on the QC of all available data rather than data discovery. Much of the effort is spent verifying accuracy and consistency — particularly of the position, intensity, and wind radii, as well as completeness of the storm logs. The BTO also conducts a consistency check of the radius of maximum wind (RMW) and minimum sea level pressure (MSLP) through time. Additionally, the BTO constructs TC "storyboards" (Fig. 3) to identify irregularities in key BT elements to target for reconciliation. Finally, the BTO annotates significant events within the life cycle of each TC, such as TC genesis time, time of first warning, time of maximum intensity, and landfall times and intensities (as applicable), in both the TC storm log and the storyboard. For most cases, once the BTO has completed Level 3 review, the BT is finalized.

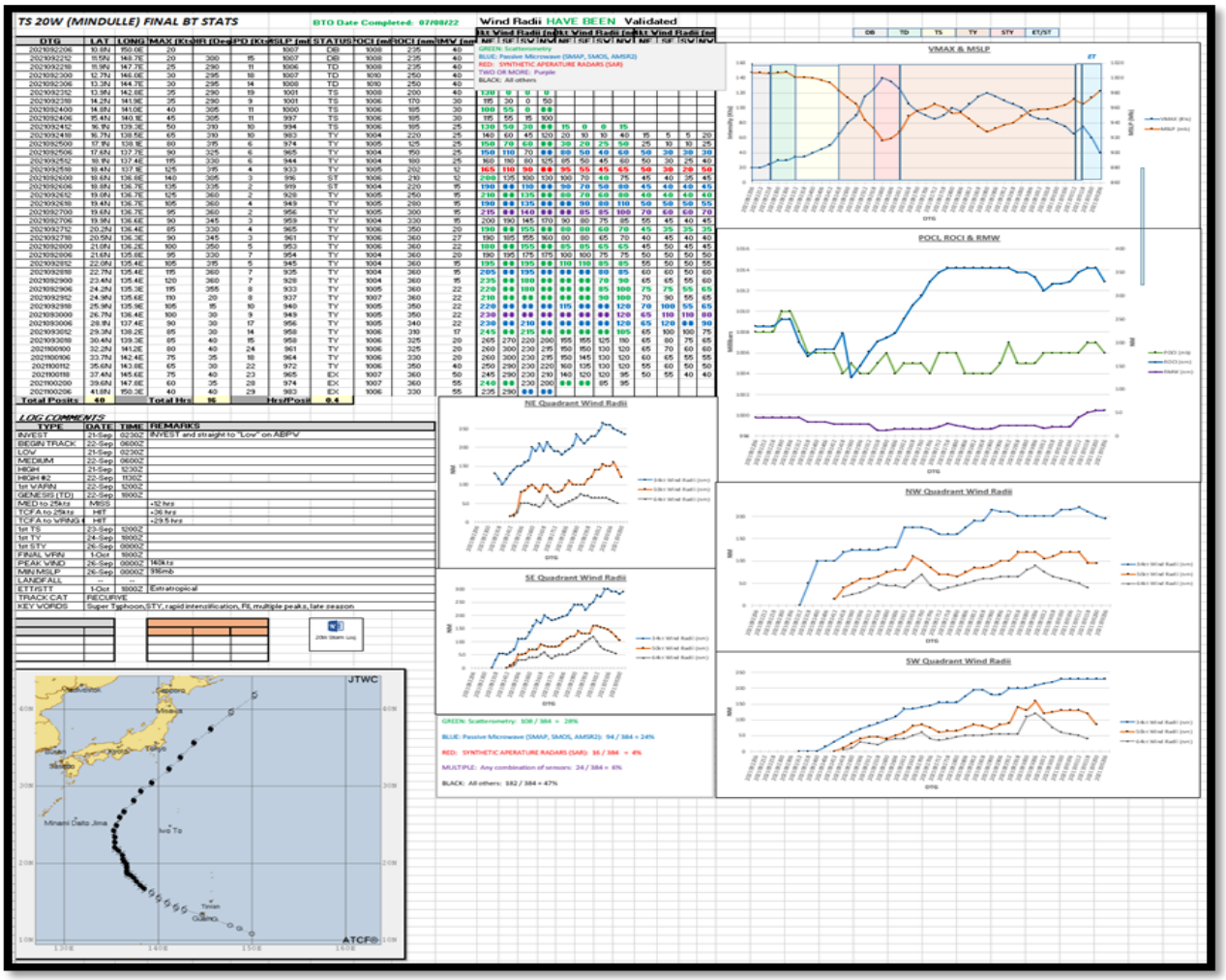


Fig. 3—A TC storyboard for Mindulle (TS 20W, the 20th TC in the western North Pacific 2021 season). The storyboard includes all the best-track data, a track image, log comments, and a time series of best-track parameters.

A fourth-level review is conducted by a panel consisting of the most senior and experienced personnel at JTWC, including the JTWC director, the JTWC senior scientist, the JTWC technical services team chief, the BTO, and usually at least one senior TDO. A Level 4 review is typically considered for the following reasons:

- to confirm the ordering of strongest TCs of the season,
- to determine whether any TCs whose peak intensity was within 5 kt of TY/STY thresholds should be adjusted,
- to review TCs that are considered historically significant (record-breaking intensity, intensification trend, longevity, etc.),
- to assess significant TC landfall events,
- to review TCs that featured particularly high uncertainty in the intensity assessment at some point in their lifecycles.

The BT data associated with roughly 10% of total TCs in a given storm year are subjected to Level 4 review, which focuses on discrete points and elements of individual TC BT datasets. The BTO consolidates outcomes of this review, updates the final BT database as necessary, and forwards the packaged and completed BT data to the JTWC senior scientist for generation of Keyhole Markup Language (KML)-formatted files and public release. Following public release, BT data generally remain unchanged unless a major issue, such as incorrectly formatted data, is discovered.

4. BEST-TRACK QUALITY ASSESSMENT

As noted in Section 2 of this report, not all elements of the publicly available JTWC BT database have been fully reviewed during the poststorm QC review process. Some elements have been incorporated into the QC process only within the past few years. The advent and steady improvement of space-based environmental monitoring (SBEM) technologies and improved analysis techniques (Ricciardulli et al. 2023) have enabled expansion of the QC'd components of the BT database and steady improvements to the quality of and our confidence in individual elements. A list of sensors, techniques, and observational tools referenced by JTWC to generate the BT is included in Appendix A. Figure 4 highlights elements of the BT database that are QC'd, lists their period of record, and provides subjective data-quality assessments. Nonmeteorological elements such as TC names, dates, and basins have been included since 1945 and are provided with high confidence. Some meteorological elements, including position, intensity, MSLP, and development level (TD/TS/TY/STY/SD/SS/MD) also have been included in the database since 1945, but were historically of low confidence due to the scarcity of reliable data to support generation of the BT (there is a higher uncertainty associated with categorization of non-TC systems and during TC transition events). As more reliable and extensive data sets have become available, confidence in these elements has increased steadily. Position, intensity, and development level are now provided with overall high confidence across all basins. Confidence in MSLP is moderate due to a lack of ground truth in situ data, primarily driven by the lack of airborne reconnaissance in the JTWC AOR since the discontinuation of western North Pacific aircraft reconnaissance in 1987 and sparse surface observations. In lieu of in situ observational data, JTWC employs wind-pressure relationships (WPRs) as the basis for MSLP estimation of TCs. Historically, JTWC used the Atkinson-Holliday (Atkinson and Holliday 1977) and Knaff-Zehr (Knaff and Zehr 2007) WPRs developed in the late 1970s and early 2000s, respectively. Since 2010, JTWC has utilized the Courtney and Knaff (2009) WPR. For weaker systems and disturbances (VMAX < 34 kts), for which WPRs are less applicable or accurate, JTWC utilizes global model analyses and surface observations to support MSLP estimation.

Beginning in 2019, 34-kt wind radii (RAD34) QC has become a routine step in the BT process, with increasing confidence in ocean surface wind data derived from SBEM assets including the Advanced Scatterometer (ASCAT) (Stoffelen et al. 2017; Polverari et al. 2022), the Soil Moisture Active Passive satellite (SMAP) (Meissner et al. 2017), the Soil Moisture Operational Sensor (SMOS) (Reul et al. 2017) and synthetic aperture radar (SAR) (Jackson et al. 2021). These data, when available, enable assessments of the outer wind field structure of most TCs to within approximately 20% on average (see Sampson et al. 2017). Additionally, ongoing SBEM wind-retrieval research-and-development efforts have enabled estimation of the inner core wind structure (RAD50, RAD64, and RMW) for even the most intense and compact TCs (Knaff et al. 2021; Jackson et al. 2021; Howell et al. 2022). From 2016 to 2019, RAD50 and RAD64 were calculated using a statistical regression (see Appendix B in Sampson et al. 2025) based on the higher-confidence RAD34 values. However, JTWC began to calculate QC'd RAD50 and RAD64 using data from SBEM sensors and other situation-dependent data sources in 2022. MRD (RMW) remains a non-QC'd element and is smoothed for temporal consistency only, but a recent tenfold increase in SAR data collections and the advent of ultrahigh-resolution (UHR) ASCAT data (e.g., Lindsley et al. 2016) could enable direct QC of this element in the future. The final two elements in the BT database that are not fully

QC'd but are smoothed during Level 3 review are the radius and pressure of the outermost closed isobar (RRP and RADP, respectively). At the time of this report, there are no plans to QC these elements fully because of a lack of consistent, reliable measurements within the JTWC AOR.

Best Track Component	Data Used to Generate	*QC'd Data* Date Range	Data Quality Assessment
WP, IO, SH	TC Database / ATCF	1945-Present	
Annual Cylcone Number (0-99)	TC Database / ATCF	1945-Present	
Warning Date-Time Group	ATCF	1945-Present	
Objective Technique Used (CARQ/WRNG/BEST)	ATCF	1945-Present	
Forecast Period (0 for Best Track)	ATCF	1945-Present	
Position (Lat/Long) (.1deg)	SBEM (IR/Vis, PMW, Scat, SAR) Ship/Sfc Obs, Radar, Recon	1945-Present	
Maximum Sustained Winds (kts) (1-min)	SBEM (Dvorak, Obj/Subj Est., Scat/UHR, SAR, SMAP/SMOS/AMSR2), Recon	1945-Present	
Mean Sea Level Pressure (MSLP)	Wind Pressure Relationship (WPR) algorithms, Recon, Ship/Sfc Obs	1945Present	
Level of Development (TD, TS, TY, ST, TC, SD, SS, EX, MD, WV)	See VMAX	1945-Present	
Radius of 34kt Winds (nm)	SBEM (Scat/UHR, SAR, SMAP/SMOS/AMSR2)	2016-Pres (WP) 2020-Pres (SH,IO)	
Radius of 50kt Winds (nm)	SBEM (Scat/UHR, SAR, SMAP/SMOS/AMSR2)	2020-Present	Regression only (2019)
Radius of 64kt Winds (nm)	SBEM (Scat/UHR, SAR, SMAP/SMOS/AMSR2)	2020-Present	Regression only (2019)
Pressure (mb) of the Outermost Closed Isobar	Global Model Fields (MSLP) (GFS, NAVGEM, ECMWF, JGSM, CMC)	*Not QC'd*	Smoothed
Radius (nm) of the Outermost Closed Isobar	Global Model Fields (MSLP) (GFS, NAVGEM, ECMWF, JGSM, CMC)	*Not QC'd*	Smoothed
Radius (nm) of Maximum Winds (RMW)	SBEM (Scat/UHR, SAR, SMAP/SMOS/AMSR2), Eye Diameter from IR/Vis/PMW	*Not QC'd*	Smoothed
Sub-Basin Code (A, B, P, S, W)	TC Database / ATCF	1945-Present	
Literal Storm Name or INVEST Number	RSMC Naming Convention or JTWC Invest Database	1945-Present	

Fig. 4—Individual components of the JTWC BT database, their supporting datasets, time frames during which they were quality controlled, and subjective assessments of their quality over time (red represents questionable quality, yellow represents fair quality, green represents high quality). See Appendix B for acronyms.

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APPENDIX A — SIGNIFICANT DATA SOURCES CONTRIBUTING TO JTWC HISTORICAL BEST TRACKS

Systematic TC observation has always intermittent or insufficient, especially before routine satellite imagery was made available to forecasters in the early 1960s. Figure A1 provides an overview of the significant data sources and tools that have supported JTWC BT data analysis in the western North Pacific, the North Indian Ocean, and the Southern Hemisphere. The instruments, observing network, and tools that observe and support analysis of TCs have improved dramatically in the past 40 years in some cases. Additionally, the frequency of TC observations has increased from once per day to several per hour. However, continued investments and transition of research and development to operational capabilities are required as sensors reach end of life. Diamonds indicate the start and end years (when applicable) of time frames within which the data source was utilized. Arrows indicate that the data source is still in use. See Appendix B for a list of acronyms used in this table.

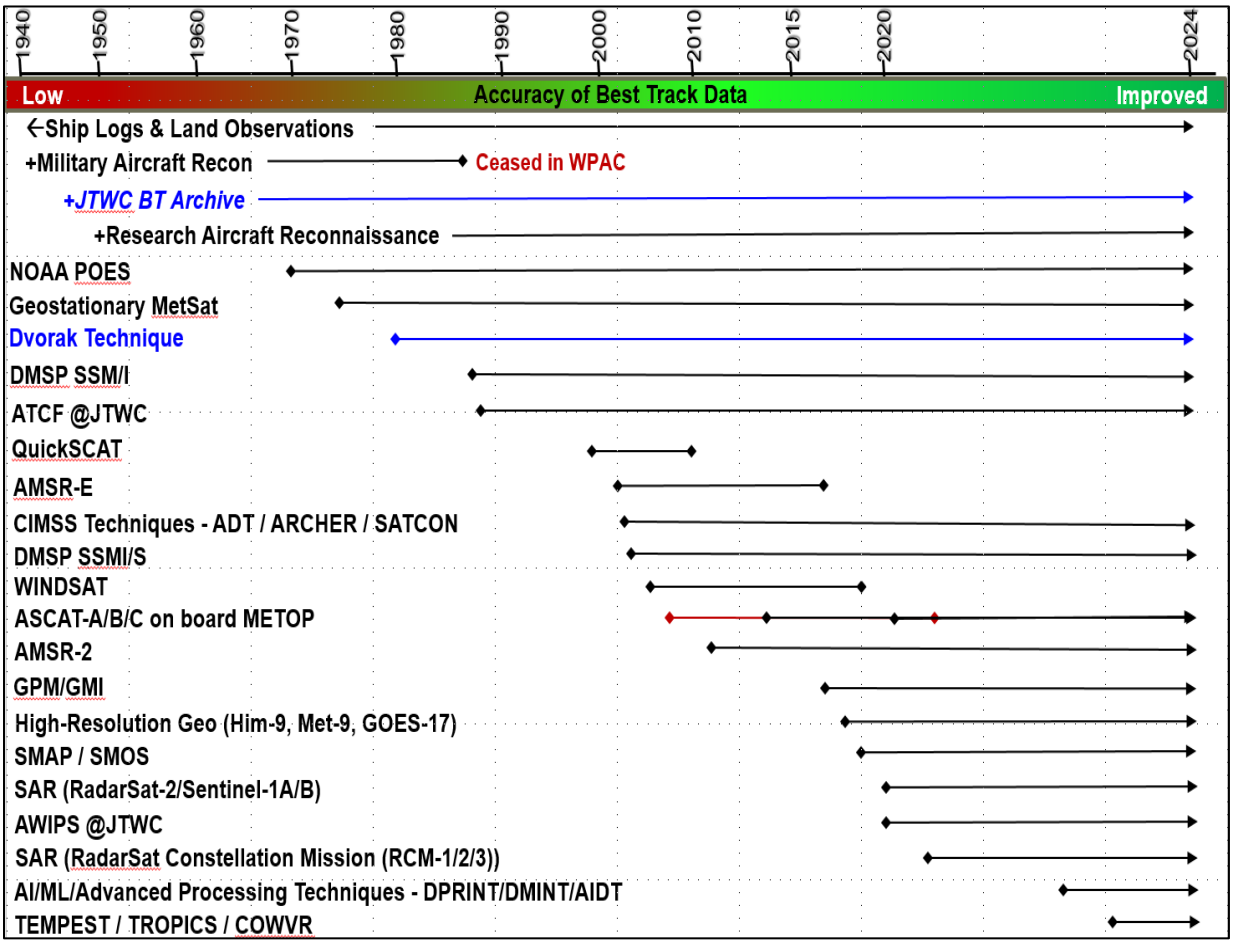


Fig A1—Sensor and data sources that contribute to the JTWC best track database. Acronyms are defined in Appendix B.

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APPENDIX B — LIST OF ACRONYMS

ADT — advanced Dvorak technique
AI — artificial intelligence
AIDT — artificial intelligence augmented ADT
AMSR2/AMSR-2 — Advanced Microwave Scanning Radiometer-2
ARCHER — Automated Rotational Center Hurricane Eye Retrieval
ASCAT — Advanced Scatterometer
ATCF — Automated Tropical Cyclone Forecast system
ATCR — Annual Tropical Cyclone Report
AWIPS — Advanced Weather Interactive Prediction System
BMKG — Indonesia Meteorology, Climatology and Geophysics Agency
BOM — Australia Bureau of Meteorology
BT — best track
CIMSS — Cooperative Institute for Meteorological Satellite Studies
CIRA — Cooperative Institute for Research in the Atmosphere
COWVR — Compact Ocean Wind Vector Radiometer
CP/CPAC/CNP/CENTPAC — Central North Pacific
CPHC — Central Pacific Hurricane Center
CY — calendar year
DMSP — Defense Meteorological Satellite Program
DMINT — Deep Multispectral Intensity of TCs
DPRINT — Deep IR Intensity of TCs
EP/EPAC/EASTPAC — Eastern North Pacific
FMS — Fiji Meteorological Service
GMI — GPM Microwave Imager
GPM — Global Precipitation Monitoring satellite
HIM-9 — Himwari-9 satellite
IMD — Indian Meteorological Department
IO — Indian Ocean
JMA — Japan Meteorological Agency
JT-BTO — JTWC best track officer
JTWC — Joint Typhoon Warning Center
KML — Keyhole Markup Language
LAT — latitude (north/south)
LON — longitude (east/west)
Met-9 — Meteosat-9 satellite
METOP — Meteorological Operational Satellite Program of Europe
MetSat — Meteorological Satellite
MeteoFrance LaR — RSMC La Reunion
MRD — radius of maximum winds
MSLP — mean sea level pressure
NASA — National Aeronautics and Space Administration
NESDIS — National Environmental Satellite, Data and Information Service
NOAA — National Oceanic and Atmospheric Administration

NEP — Northeast Pacific
NHC Miami — National Hurricane Center
NIO — North Indian Ocean
NRL — Naval Research Laboratory
NZMS — New Zealand Met Service
NWP — Northwestern Pacific
PNGNWS — Papua New Guinea National Weather Service
POES — Polar Operational Environmental Satellites
QuikScat — NASA polar orbiting scatterometer
QC — quality control
RAD34/50/64 — Radius of 34-, 50- or 64-kt winds
RADP — pressure of the outermost closed isobar
RRP — radius of the outermost closed isobar
RSMC — Regional Specialized Meteorological Center
SAR — synthetic aperture radar
SATCON — Satellite Consensus
SBEM — space-based environmental modeling
SH/SHEM — Southern Hemisphere
SIO — Southern Indian Ocean
SMAP — Soil Moisture Active Passive satellite
SMOS — Soil Moisture and Ocean Salinity satellite
SPAC — South Pacific Ocean
SSM/I — Special Sensor Microwave/Imager
SSMI/S — Special Sensor Microwave Imager/Sounder
SWP — Southwest Pacific
TAU — forecast period
TC — tropical cyclone
TCWC — Tropical Cyclone Warning Center
TDO — typhoon duty officer
TECH — technique
TEMPEST — Temporal Experiment for Storms and Tropical Systems - Demonstrator
TROPICS — Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats
TY — level of TC development
UHR — ultrahigh resolution (ASCAT)
VMAX — maximum wind velocity or intensity
WMO — World Meteorological Organization
WindSat — A polar orbiting microwave sensor aboard Coriolis Satellite
WP/WPAC/WESTPAC — Western North Pacific
WR — wind radii