The Joint Typhoon Warning Center Tropical Cyclone Best Track Review Process

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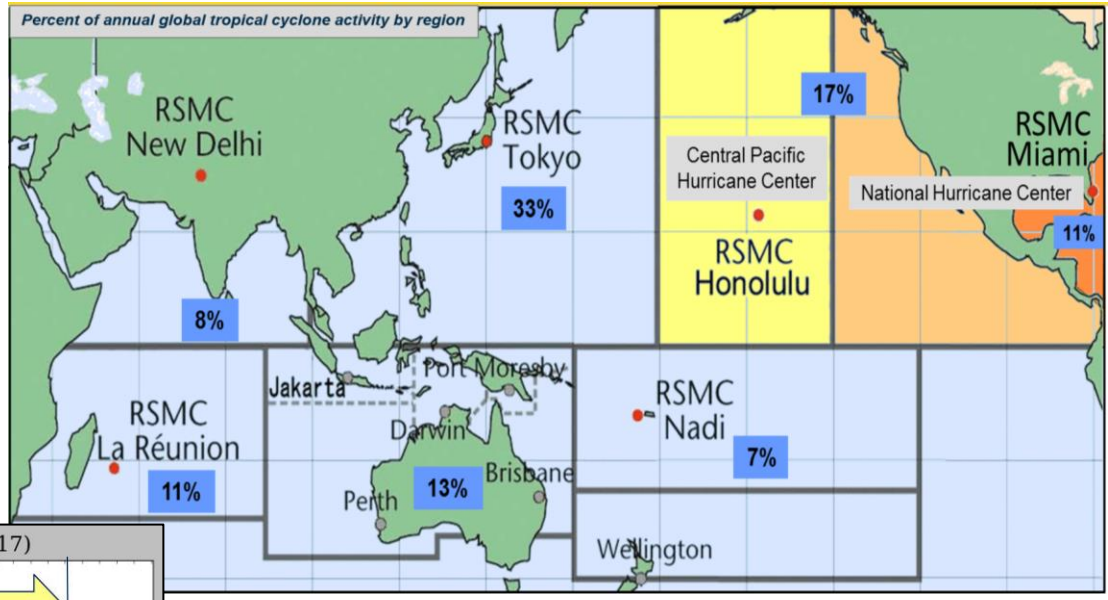
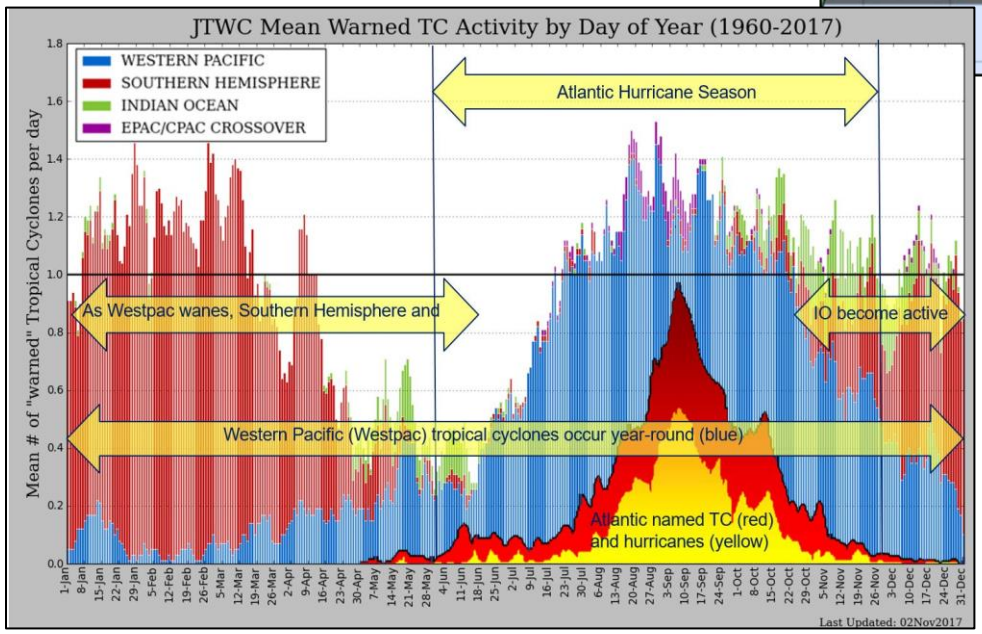
Joint Typhoon Warning Center

Mission and Area of Responsibility

Mission: Provide analysis, forecast and decision support to enable DoD and other decision makers to plan, prepare and protect against the threat of tropical cyclones, tsunamis and other weather impacts.





- ***Monitoring & forecasting TC's across an AOR covering over 65-million square miles of tropical oceans, comprising over 85% of the world's tropical cyclone (TC) activity***

JTWC averages:

~ 60 TCs / year in NWPAC + SPAC + IO

~ 1000+ TC warnings / year

~ 8000+ TC position-intensity fixes / year

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JTWC Best Tracks

An Overview

- **The Best Track (BT) process conducted by the JTWC serves three purposes:**

  1. To CREATE an *official* historical record of each TC across the JTWC AOR
  2. To SERVE *worldwide* TC/Climate research, development and scientific efforts
  3. To provide a RESOURCE for forecaster training and support production of the Annual Tropical Cyclone Report (ATCR) and TC post-storm reviews

- **The term "Best Track" encapsulates the entire four-step process:**

  - *Working BT*: "Real-Time" BT, conducted by on-shift forecasters
  - *Post-Storm BT*: 2nd/3rd level reviews conducted by forecasters / full-time BTO
  - *Final-BT*: 4th level review of ~10% of total + significant TCs → Published data
  - *BT Archive*: Historical data base available online

- **JTWC BT Database dates back to 1945:**

  - *1945-1970's*: Low quality, primarily based on ship/aircraft reports
  - *1970's-early 2000's*: Quality increased due to advent of global geo sat data
  - *2000's-today*: Incorporation of additional datasets + more and better sensors + process improvements = higher quality BT's, particularly after 2019

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JTWC Best Track

Components of the Best Track Archive

BASIN	CY	YYYYMMDDHH	TECH	TAU	LatN/S	LonE/W	VMAX	MSLP	TY	RAD	WINDCODE	RAD NE	RAD NW	RAD SE	RAD SW	RADP	RRP	MRD	GUSTS	EYE	SUBREGION	MAXSEAS	INITIALS	DIR	SPEED	STORMNAME	DEPTH
WP	4	2022070200	BEST	0	206N	1117E	75	969	TY	34	NEQ	145	140	100	125	999	215	30	0	0	w	0		0	0	CHABA	D

- Archive BT data consist of 28 individual elements. Not all 28 are Quality Controlled (QC'd) and several have only recently been incorporated into the QC'd data set
  - **GREEN** = element included in archived BT data for all years
  - **YELLOW** = element added to archived BT data
  - **RED** = element not included in archived BT data
- 10 BT Components are currently QC'd:
  - Latitude, Longitude, Vmax, MSLP, [R34, R50, R64](*up to 16/position*), RADP, RRP, MRD
- A very time-consuming process; may take up to a year to complete due to operational tempo and personnel shortfalls

BASIN	WP, IO, SH
CY	Annual Cylcone Number (0-99)
YYYYMMDDHH	Warning Date-Time Group
TECH	Objective Technique Used (CARQ/WRNG/BEST)
TAU	Forecast Period (0 for Best Track)
LatN/S, LonE/W	Position (Lat/Long) (.1deg)
VMAX	Maximum Sustained Winds (kts) (1-min)
MSLP	Mean Sea Level Pressure (MSLP)
TY	Level of Development (TD, TS, TY, ST, TC, SD, SS, EX, MD, WV)
RAD 34	Radius of 34kt Winds (nm) (NE/NW/SE/SW Quadrants)
RAD 50	Radius of 50kt Winds (nm) (NE/NW/SE/SW Quadrants)
RAD 64	Radius of 64kt Winds (nm) (NE/NW/SE/SW Quadrants)
RADP	Pressure (mb) of the Outermost Closed Isobar
RRP	Radius (nm) of the Outermost Closed Isobar
MRD	Radius (nm) of Maximum Winds (RMW)
SUBREGION	Sub-Basin Code (A, B, P, S, W)
STORMNAME	Literal Storm Name or INVEST Number

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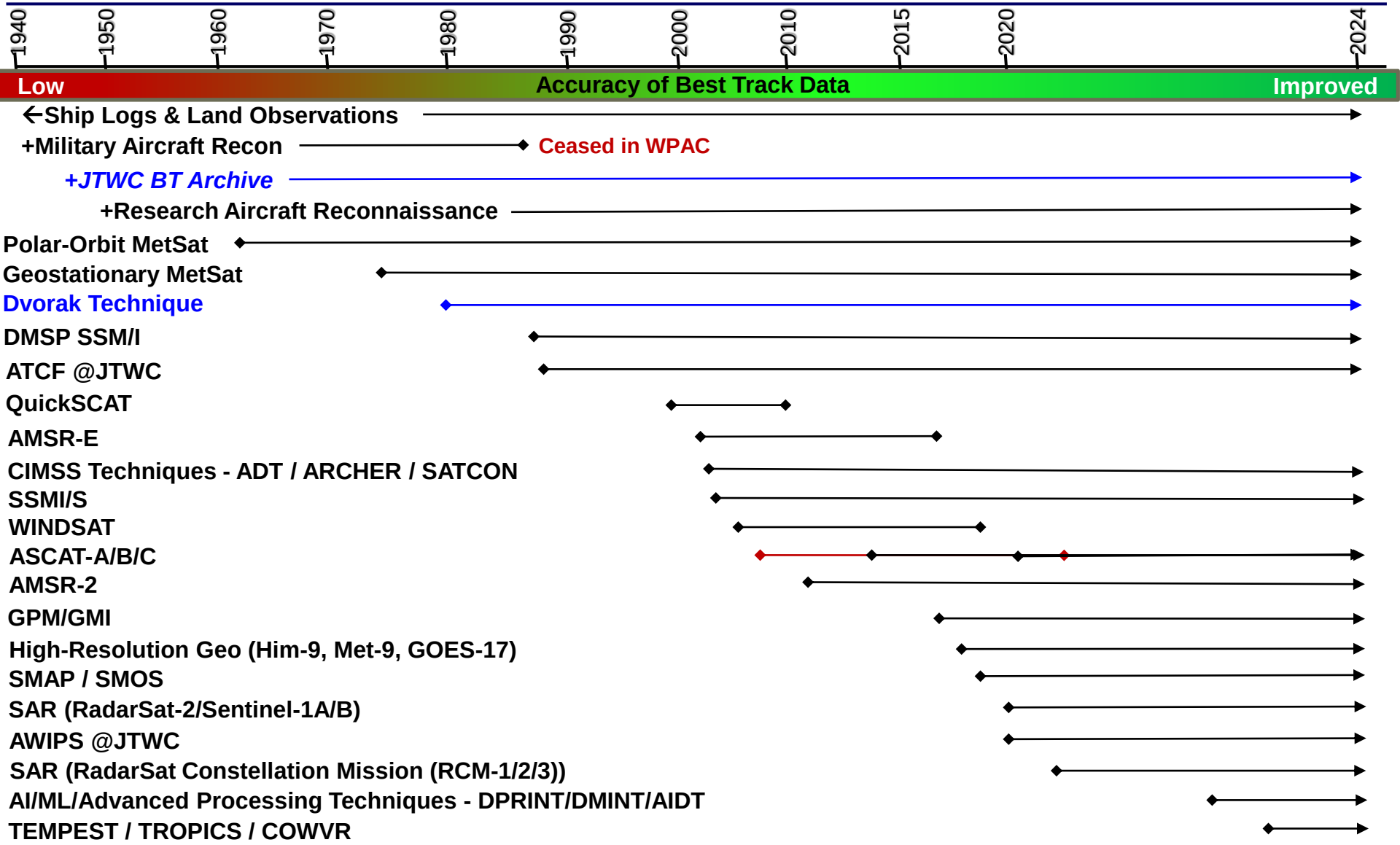
Tropical Cyclone Analysis

Data Sources/Techniques/Applications



JTWC Best Tracking Process

Detailed Overview / "The LOG"

- ***The foundational tactic of the JTWC BT process is to increase accuracy through redundancy and putting multiple eyes-on***

- *Summary*: Best Track analysis is conducted every six hours (all 10 elements); data are reviewed, at a minimum, four (potentially five) times:

  - During the shift ("**A**"), the next shift ("**1**"), post-storm TDO re-analysis ("**B**"), post-storm Best Track Officer (BTO) re-analysis ("**C**") and…

  - For "marquee" storms, a review committee ("**D**") takes a final look

07/27-00Z. DEVELOPMENT TYPE: TY MSLP (if not ATCF default):
A. 19.6N 120.6E, 75 knots. PBO animated proxy vis, eye is now completely filled. IBO combination of PGTW T4.0/4.5, RCTP T4.5/4.5, RJTD T4.0/5.0, KNES T4.0/4.5, DEMS T4.0/5.0 21Z along with objective fixes ADT 72 knots, SATCON72 knots, D-PRINT 70 knots, D-MINT 68 knots. CRM
1.(TURNOVER REVIEW): 20.8N 119.8E, 80kts. PBO CWB radar position of very small eye at 20.8N 119.8E. IBO PGTW/KNES 4.0/4.5, RJTD 4.0/5.0, RCTP 4.5, ADT 4.3(2.8), AIDT 65kts, DPRINT 70kts, DMINT @2250Z 68kts, SC 78kts. SC looks to be right in line with two coincident SAR passes at 220156Z SEN-1, and 220251Z RCM-3 showing the same thing, 79kts in the NE quadrant with a center a bit east of the BT, looks like some wobbling based on later radar data. **NOTE: Looks like the 37ghz center is significantly "off" based on the SAR at the same time, much too far to the southwest. Something to look into later. 021629.metopb.ascat.windspeed provided clarity to adjust the WR, particularly on the west side, significantly smaller than previously assessed. BCH
B. 20.7N 119.9E (80 knots IBO 4.5 CIs). PBO radar position cited in paragraph A. and 224900.F17.ssmis.color89Nearest image, revealing defined LLCC. SJB
C. 20.8N 119.7E, 80kts. Used 1kVis IRBD and PGTW fix to place just southeast of deepest convection, 270019Z AMSU 89V supports. IBO earlier SAR and then pulled it down 5kts b/o ADT and SATCON and PGTW 4.0/4.5. AAH
D. *Final review committee, when required.

Example TC Log

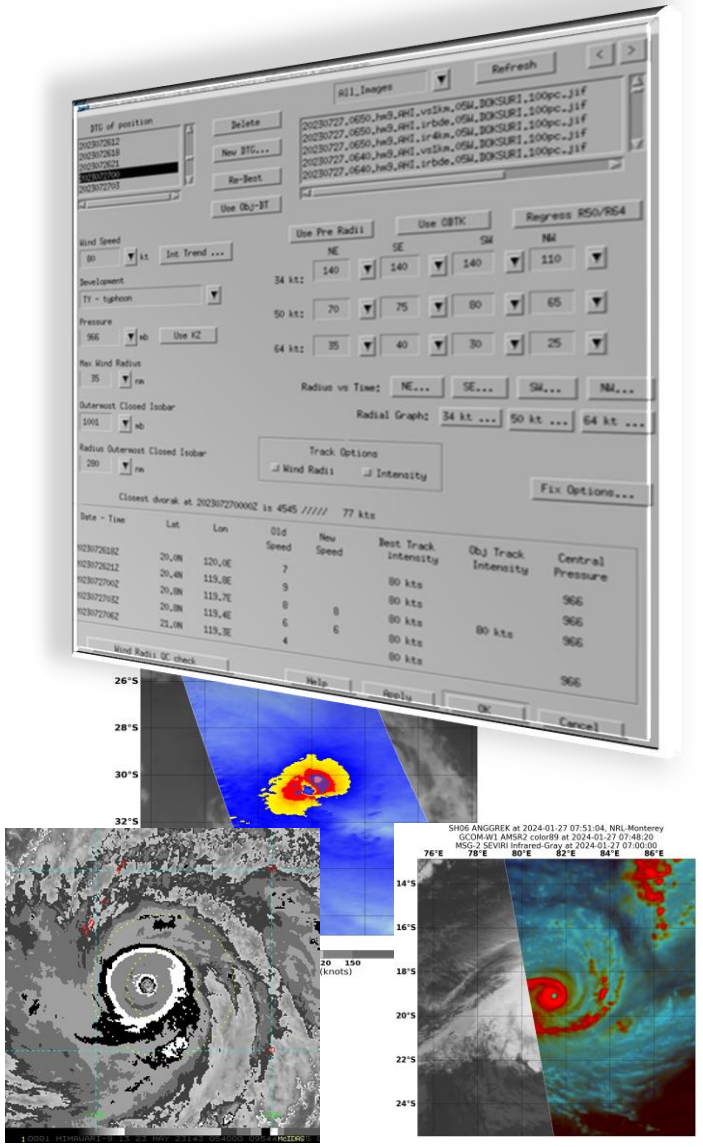
JTWC Best Track Process

Level-1 Real-Time Best Tracking

- ***Level-1, "Real-Time" BT***
  - Conducted six-hourly by the on-shift TDO
  - Utilizes ATCF "re-best" dialog + "storm log"
  - Includes all 10 BT components
  - Leverages all available data

- ***Includes a "Turnover Review" by the relieving shift***
  - Reanalyze data for previous two BT times (12-hour period)
  - Incorporates data that were not available during initial best tracking

- ***At this point, the BT is a <u>living document</u>***
  - All BT elements subject to frequent, *sometimes significant*, changes
  - Differences in TDO experience or perspectives can lead to accuracy/quality differences



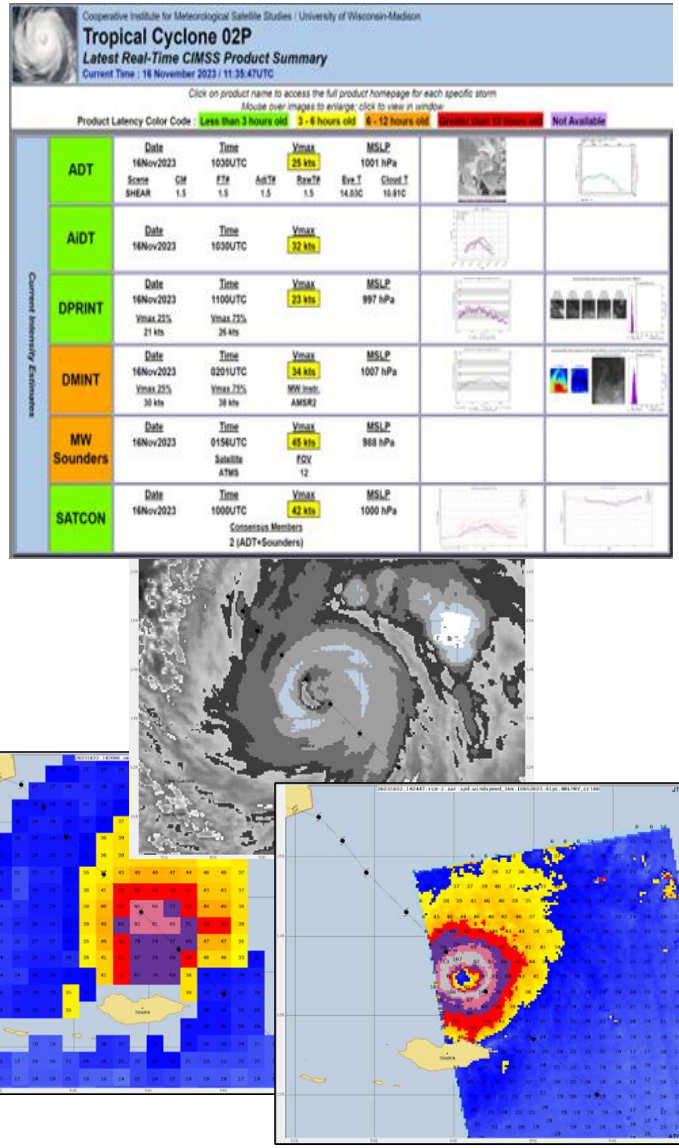
JTWC Best Track Process

Level-2 Post Storm Best Track

- ***Level-2, "Post-Storm BT"***
  - Fix-deck check by Satellite Analyst: ensures all available fixes are in ATCF
  - Assigned to qualified TDO w/in 4wks
  - TDO gets 2wks to complete (frequently ++)
  - Incorporates additional time-late data + CIRA/CIMSS/NRL TCWeb/NESDIS, etc.

- ***2nd Set of Eyes on the TC***
  - Reanalyze *Position, Intensity, WR* at each position for the lifetime of the TC
  - Generally, not the same TDO as Level-1
  - Reviewer documents all changes

- ***Still a living document but not quite as fluid***
  - All BT elements potentially subject to adjustment, but usually less than real-time
  - Still sensitive to TDO experience or perspectives



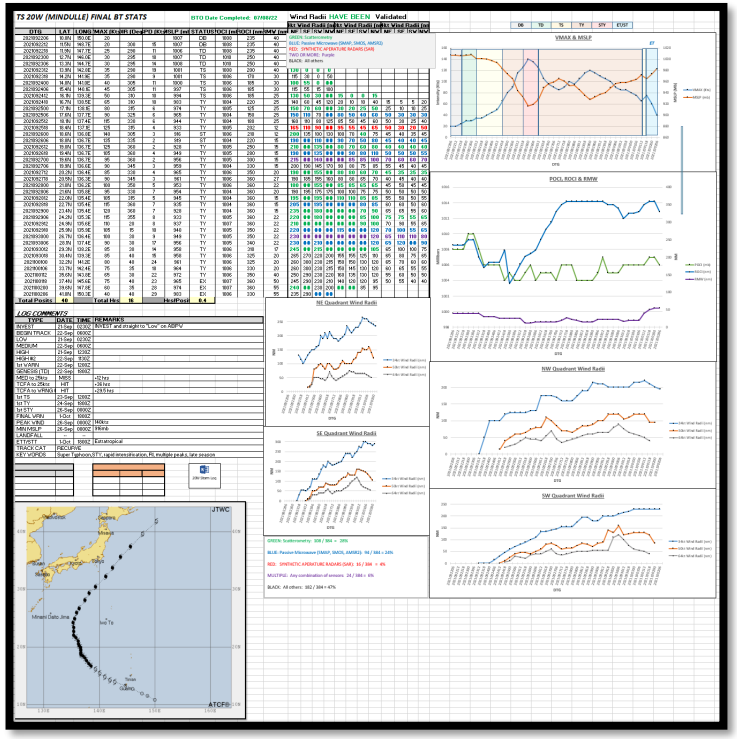
JTWC Best Track Process

Level-3 Post Storm Best Track

- ***Level-3, "Expert Level Review"***
  - Conducted by full-time Best Track Officer (BTO); highly-experienced forecaster
  - Reanalyzes all TC BT data points
  - Limited "new" data, generally a final check

- ***3rd Set of Eyes on the TC***
  - QC of Position, Intensity, WR; *sanity check* of RMW, MSLP, ROCI, POCI
  - Smooths data to eliminate unrealistic / unsupported jumpiness
  - Documents landfall times, max intensity, etc.

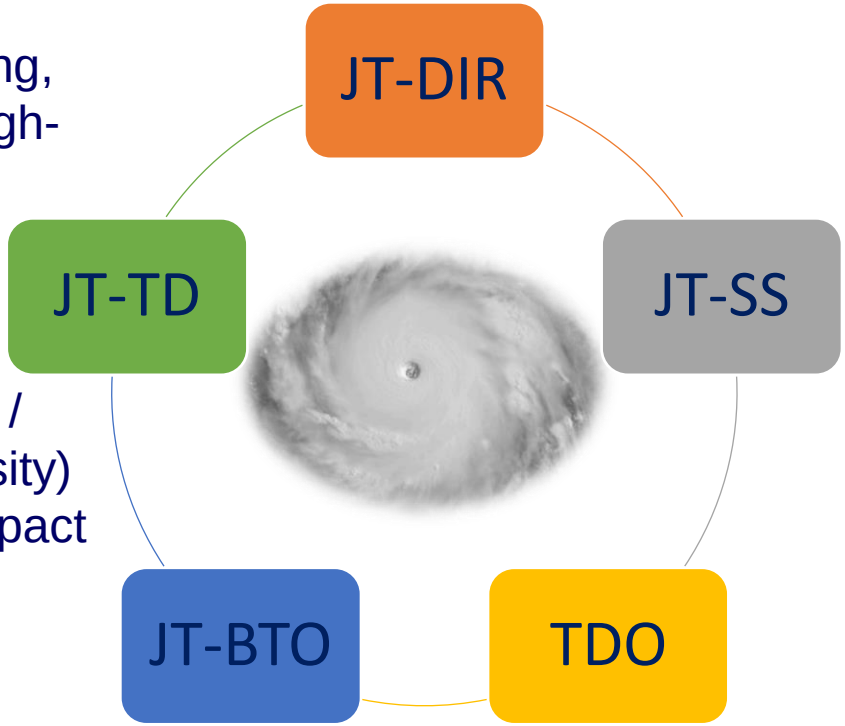
- ***In most cases, the process stops here***
  - For most BT datasets, the Level-3 review is the final step before public release
  - A few marquee TCs undergo a final Level-4 review



JTWC Best Track Process

Level-4 Post Storm Best Track

- ***Level-4, "Marquee TC Review"***
  - Conducted by committee of most senior and experienced personnel at JTWC
  - Final review of select TCs (record setting, crossed TC cat (e.g. TS to TY/STY), high-interest (e.g. STY MAWAR), etc.
  - + 10% of the total for spot check
- ***Last set of eyes on the TC***
  - Highly focused review→ discrete times / components of the BT (e.g. peak intensity)
  - Clear understanding of the potential impact of record-setting TC's
- ***The buck stops here***
  - Ensures accuracy for record-setting TC's
  - Final decisions are fed back to the BTO
  - The BT database is updated and packaged
  - Best Tracks are released to the public



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JTWC Best Track Archive

BT Component Quality Assessment

BASIN	CY	YYYYMMDDHH	TECH	TAU	LatN/S	LonE/W	VMAX	MSLP	TY	RAD	WINDCODE	RAD NE	RAD NW	RAD SE	RAD SW	RADP	RRP	MRD	GUSTS	EYE	SUBREGION	MAXSEAS	INITIALS	DIR	SPEED	STORMNAME	DEPTH
WP	4	2022070200	BEST	0	206N	1117E	75	969	TY	34	NEQ	145	140	100	125	999	215	30	0	0	w	0		0	0	CHABA	D

Best Track Archive Name	Best Track Component	Data Used to Generate	QC'd Data Date Range	Data Quality Assessment
BASIN	WP, IO, SH	TC Database / ATCF	1945-Present	
CY	Annual Cylcone Number (0-99)	TC Database / ATCF	1945-Present	
YYYYMMDDHH	Warning Date-Time Group	ATCF	1945-Present	
TECH	Objective Technique Used (CARQ/WRNG/BEST)	ATCF	1945-Present	
TAU	Forecast Period (0 for Best Track)	ATCF	1945-Present	
LatN/S, LonE/W	Position (Lat/Long) (.1deg)	SBEM (IR/Vis, PMW, Scat, SAR) Ship/Sfc Obs, Radar, Recon	1945-Present	
VMAX	Maximum Sustained Winds (kts) (1-min)	SBEM (Dvorak, Obj/Subj Est., Scat/UHR, SAR, SMAP/SMOS/AMSR2), Recon	1945-Present	
MSLP	Mean Sea Level Pressure (MSLP)	Wind Pressure Relationship (WPR) algorithms, Recon, Ship/Sfc Obs	1945Present	
TY	Level of Development (TD, TS, TY, ST, TC, SD, SS, EX, MD, WV)	See Vmax. Added non-TC categories after 20XX	1945-Present	
RAD 34	Radius of 34kt Winds (nm)	SBEM (Scat/UHR, SAR, SMAP/SMOS/AMSR2)	2019-Present	
RAD 50	Radius of 50kt Winds (nm)	SBEM (Scat/UHR, SAR, SMAP/SMOS/AMSR2)	2022-Present	Regression only (2022)
RAD 64	Radius of 64kt Winds (nm)	SBEM (Scat/UHR, SAR, SMAP/SMOS/AMSR2)	2022-Present	Regression only (2022)
RADP	Pressure (mb) of the Outermost Closed Isobar	Global Model Fields (MSLP) (GFS, NAVGEM, ECMWF, JGSM, CMC)	*Not QC'd*	Smoothed
RRP	Radius (nm) of the Outermost Closed Isobar	Global Model Fields (MSLP) (GFS, NAVGEM, ECMWF, JGSM, CMC)	*Not QC'd*	Smoothed
MRD	Radius (nm) of Maximum Winds (RMW)	SBEM (Scat/UHR, SAR, SMAP/SMOS/AMSR2), Eye Diameter from IR/Vis/PMW	*Not QC'd*	Smoothed
SUBREGION	Sub-Basin Code (A, B, P, S, W)	TC Database / ATCF	1945-Present	
STORMNAME	Literal Storm Name or INVEST Number	RSMC Naming Convention or JTWC Invest Database	1945-Present	

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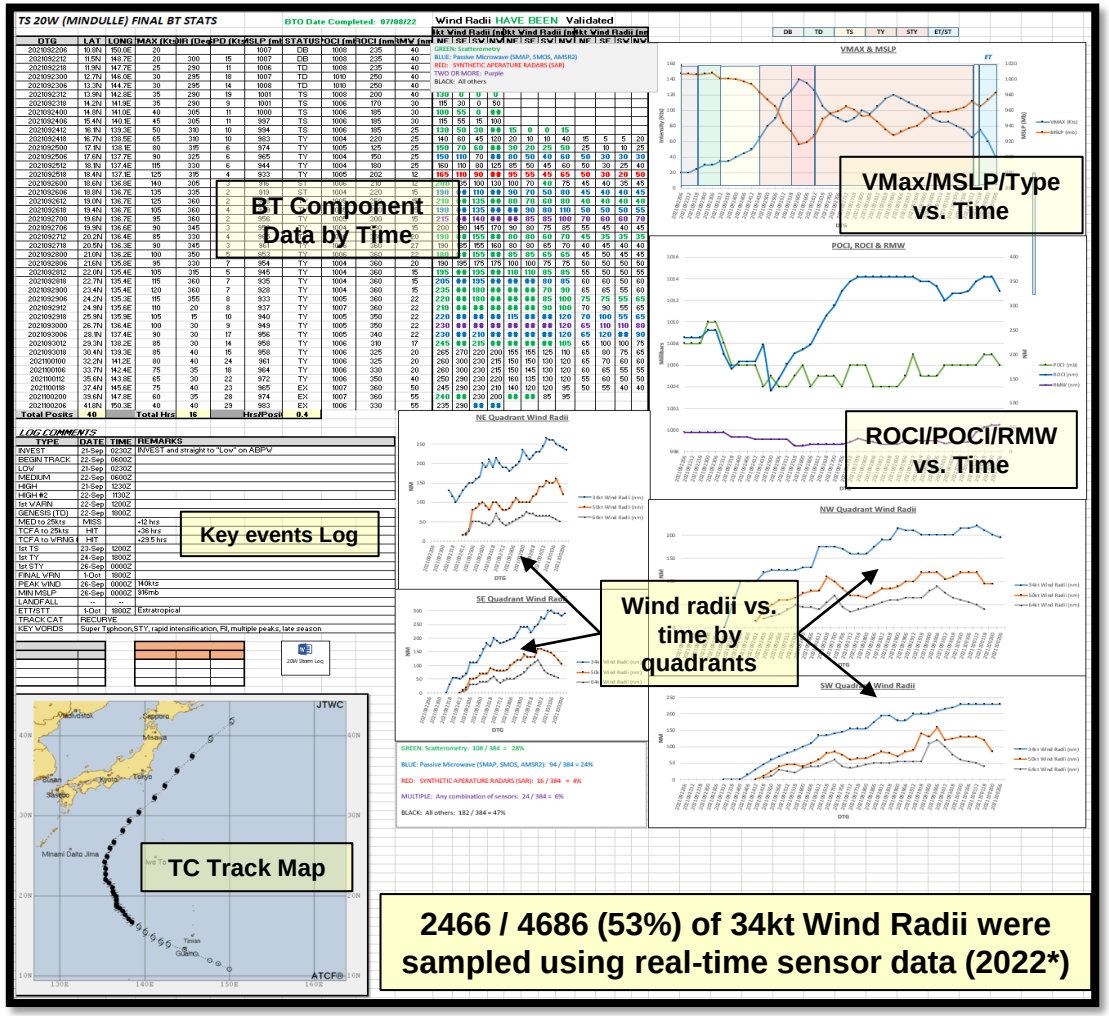
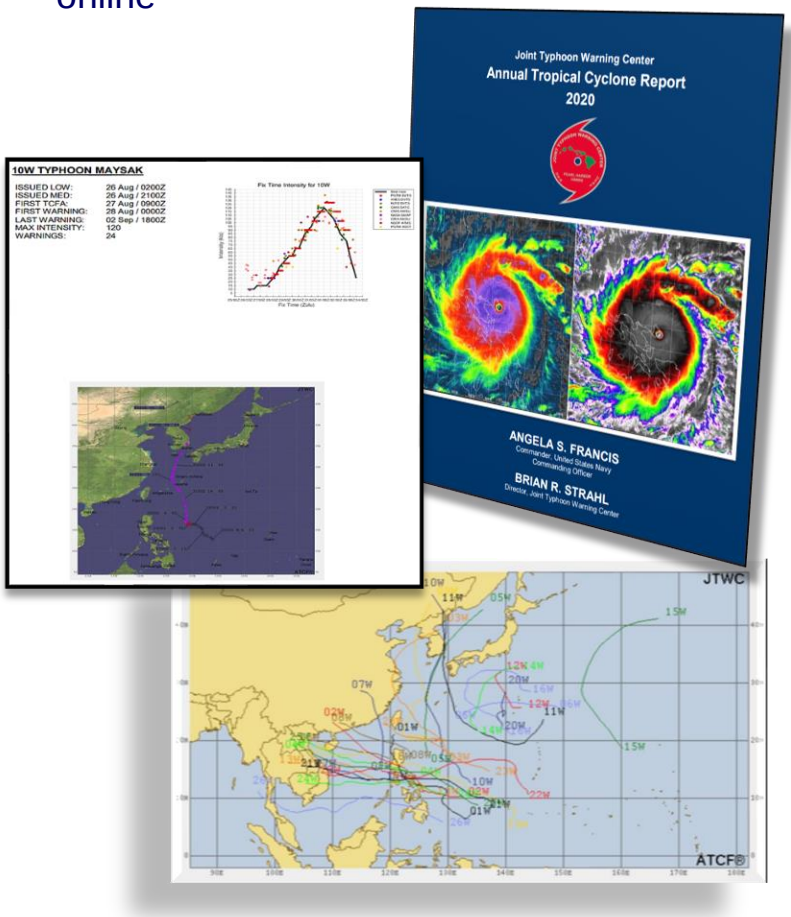
Other Best Track Products

TC Storyboards & ATCR



- ATCR provides a summary of TC activity in the JTWC AOR for a given storm year
- Detailed review for selected TCs
- Internally produced since 1959; available online

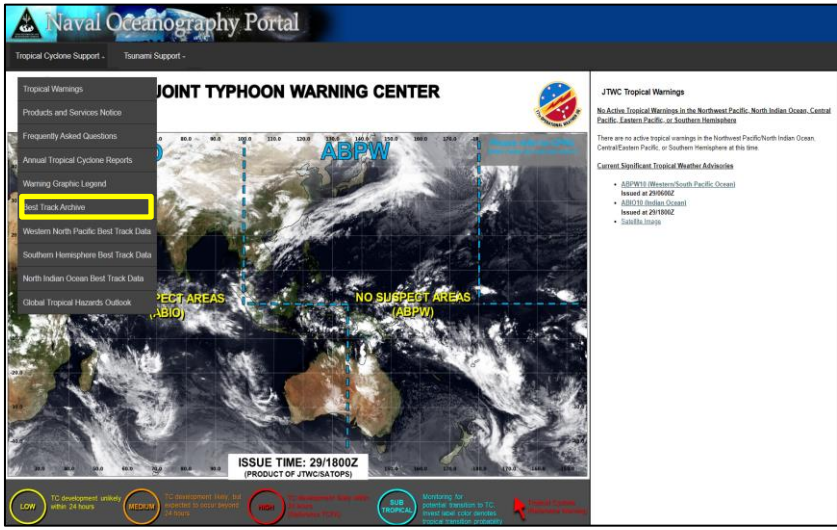


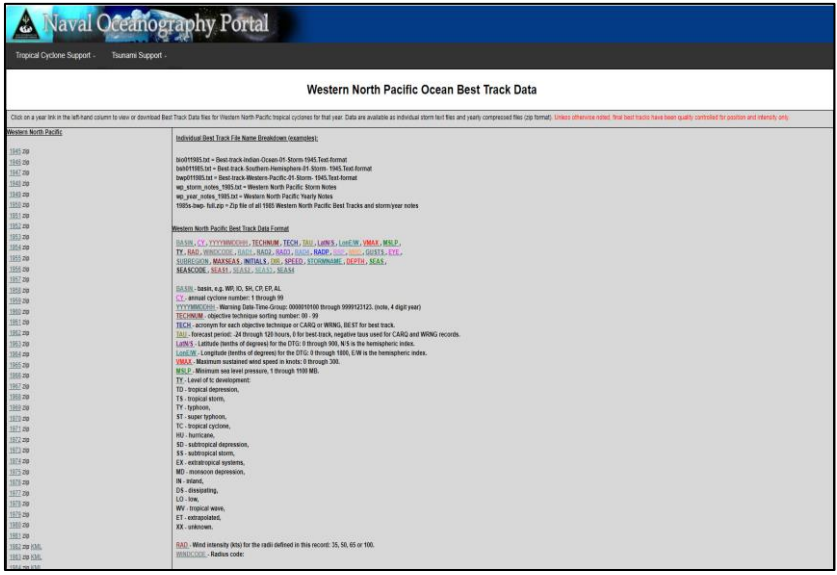
- Storyboards started in 2019; Internal JTWC product
- Enhanced visualization of data trends → enables smoothing between sensed data points, reduced "jumpiness" in data

JTWC Best Track Process

Published Data Availability

- Fully QC'd, "Final" Best Track data are published as soon as the BT process is completed (usually w/in 1year)
- BTs provided as .ZIP files (zipped .dat files) for 1945-1981 and both .ZIP and .KML files from 1982-Present
- Data distributed via multiple websites
  - JTWC Public website: https://www.metoc.navy.mil/jtwc/jtwc.html?best-tracks
  - JTWC Collaboration (Password Access) Website: https://pzal.metoc.navy.mil/php/rds/login.php
- Public release also announced via message to "*Tropical-Storms*" email group





Questions and Comments