P2A.12 National Climatic Data Center Global Tropical Cyclone Stewardship

Michael C. Kruk*
STG Incorporated, National Climatic Data Center, Asheville, North Carolina

Kenneth Knapp, David Levinson
NOAA National Climatic Data Center, Asheville, North Carolina

Jim Kossin
Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison, Madison, Wisconsin

1. INTRODUCTION

To the authors' knowledge, there is no official "one-stop shop" where a tropical cyclone (TC) best track (BT) data set can be readily downloaded and analyzed for the *entire* globe. The term "best track" specifically refers to the best estimates of location, intensity and other parameters on a 6-hr basis during the storm's lifetime. Instead, those interested in global tropical cyclone statistics must seek and merge available data in the creation of an "in-house" global best track data set. This is traditionally done by identifying storms which are repeated in multiple basins, performing quality control and making recommended adjustments. This process is prone to errors and depends largely on the completeness of the methods of the researcher.

For example, while many TC data centers exist, research generally references data from two centers: the Joint Typhoon Warning Center (JTWC), and the National Oceanic Atmospheric Administration (NOAA) National Hurricane Center (NHC) (Chu et al. 2002; Jarvinen et al. 1984). While gathering and merging data from two centers is straightforward, numerous other TC centers exist and provide best track data. The instantaneous availability of a comprehensive, up-to-date, accurate, and peer-recognized global best track data set, though attempted by some (e.g., Neumann 1987b, 1999), remains elusive and difficult to obtain.

In an attempt to standardize the creation and modification of a global best track data set the NOAA National Climatic Data Center (NCDC), through its data stewardship efforts, has produced a NCDC Global Tropical Cyclone Stewardship (NGTCS) project. The goal is to perform a merge of all global BT data sets creating a single global BT data set. When complete, this data set will be made publically available and routine updates and quality control will continually be performed, thereby reducing, if not altogether eliminating the need for "in-house" data development at various institutions. NOAA's NCDC is in a unique position to accomplish this because of its ability to store mass quantities of data in a variety of formats, and the ease with which it can make such a data set publically available.

One criticism of this approach is that it combines all readily available tropical cyclone best track data, some of which may be potentially unreliable and suffering from a lack of objective quality control measures. We recognize that merging data from numerous sources may question the reliability of a new data set; however, through a unique user-to-NCDC web interface (discussed further in section 5), suggestions for improvement in and resolving data quality issues are encouraged and will be archived. In addition, and in support of a new expansive global data set, those seeking global tropical cyclone counts will welcome the addition of numerous, overlapping resources, making certain that no storm has gone unnoticed.

To that end, five principles have emerged which characterize our efforts: global, open, provenance, ongoing, and accessibility.

Global – Tropical cyclone best track data already exist as individual storm tracks at other centers. The unique aspect of the NGTCS is the target of merging individual data sets for the creation of a worldwide TC data base.

Open - The methods used in merging and maintaining the data will be open such that all data quality revisions and additions will be recorded and open for review. Any findings regarding the integrity or quality of a storm track will also be provided back to the center(s) providing the track data.

Provenance - Changes to any data will be recorded. Versions of all data will be maintained and data provenance will be recorded to preserve traceability and to easily determine the source of all data. Reasoning behind changes and algorithms that merge and adjust the datasets will be recorded such that the data can be well understood for years to come.

Ongoing - The data set production will be ongoing, updated semi-annually; once in the boreal spring following the completion of the Northern Hemisphere TC season and again in boreal autumn following the completion of the Southern Hemisphere TC season.

Accessibility – NOAA's NCDC will maintain the official archive of this product in one format, but will provide the data set in many formats to be more accessible to all users (e.g., ASCII tables, providing readers in various languages, etc).

The remainder of this article describes in more detail the process by which the data were collected and merged (section 2), as well as a discussion of the many types of issues encountered (section 3). To illustrate the capabilities of this new data set, a brief overview of varying tropical cyclone statistics is provided in section

* *Corresponding author address:* Michael C. Kruk, National Climatic Data Center, Asheville, NC 28801; email: michael.kruk@noaa.gov

4, and a discussion of the long-term goals and data uses are concluded in section 5.

2. METHODOLOGY

The creation of a global best track data set requires the input of data from all available known resources. The compilation process began by acquiring the available best track data from each of the six Regional Specialized Meteorological Center's (RSMC, Fig. 1). The RSMC's were created by the World Meteorological Organization (WMO), and each tropical cyclone basin is covered by at least one RSMC. Best track data was available on the Internet for the RSMC Miami (NHC; discussion available from Jarvinen et al. 1984; Neumann et al. 1987a), RSMC Tokyo and Australia Bureau of Meteorology (BoM). The remaining RSMC's, Nadi (Fiji), La Reunion, Wellington, Honolulu (Central Pacific Hurricane Center), and New Delhi were contacted for their data. Additional resources for available data were also sought, including warning centers such as the Hong Kong Observatory (HKO), the Chinese Meteorological Administration (CMA), Shanghai Typhoon Institute (STI), and the JTWC (Chu et al. 2002). Finally, to complement the Southern Hemisphere, the data from Neumann (1999) was also fully incorporated. The complete list of centers providing data is given in Table 1.

2.1 Identifying duplicate storms

Upon receipt of the electronic data, the first step was to convert the data into a common format. The data from the 12 centers arrived in numerous formats: NOAA data tape format (e.g., HURDAT), MS Excel tables, various ASCII formats, and even photocopied storm reports, which will be eventually be digitized. All storm data were converted to netCDF format.

An automated algorithm then identified storms tracked by multiple centers by sorting storms in time and space. Any observations at identical times and within 60 km (~0.5 deg latitude) were identified as identical storms. Also, four storm positions (equivalent to one day) were extrapolated beyond the end of the storm to find those dropped by one center and picked up by another. Any storms crossing a geographic basin were identified as a single storm regardless of the intermediate storm intensity. While this is at odds with the procedures of some centers (e.g., NHC), users can modify how storms are counted to account for our merge technique. In contrast, if these storms were left as separate tracks, then those interested in cross-basin storms would have to re-merge the data.

Based on data obtained through 2007, the result of the merger technique is that the collective 16,326 storms provided by the centers were identified as 8,020 individual TCs. Of these, 4,108 were only reported by one center and 3,912 storms were tracked by more than one center. Details for each center are provided in Table 1. Each storm position for the entire period of record is plotted in Fig. 2, color coded by the number of centers tracking the storm. Two basins are made up of single source data: the North Atlantic and the Northern Indian Ocean. Conversely, the storms in the Western Pacific were generally tracked by four centers (JTWC, Tokyo, CMA/STI and HKO). The Eastern Pacific and the Southern Hemisphere storms are less cohesive with any number of centers tracking each storm.

Once a TC was identified as unique, a storm serial number was created which distinctively numbers the storm. The storm's serial identification number contains detailed storm information specific to its genesis: calendar year, day of the year, hemisphere (N or S), and latitude and longitude.

2.2 Merging storm data

Once storms were successfully merged, the BT data need to be assembled. This procedure is summarized in Fig. 3. The processing steps include merging time coordinates, storm positions and storm intensities: maximum sustained wind (MSW) and minimum central pressure (MCP).

In merging the time coordinate, the longest possible storm track was pieced together by using the earliest observation to the last observation from any center. Future work will also normalize the time coordinate to 6-hr (because some records are provided daily or as 12-hr observations).

Merging the storm positions was accomplished via mathematical means. The variation of the positions is recorded in the final merge file as a measure of uncertainty of the position. Future work will include data quality control (QC) of the positions, in particular, to determine potential errors in storm positions (Fig. 4).

A significant difference among the data sets is the averaging period used in reporting the MSW. The WMO standard is the 10-min average. Variance from the WMO standard includes the 1-min average in use by the U.S. (JTWC, NHC and CPHC) and the 2-min average used by China (CMA/STI). Since a goal of the project is to produce a homogeneous best track, all winds were normalized to the 10-min average via:

$$V_{10} = V_1 * 0.88$$

The factor 0.88 (Sampson 1995) was chosen as it is the median of the values used by Neumann (0.87; 1993), La Reunion (0.88) and HKO (0.9). The conversion of all basin winds to a 10-min average allows for a reliable approach to tropical cyclone statistics and this procedure is consistent with Neumann (1993). In the NGTCS BT data, the reported wind is a 10-min sustained wind which is a mean of all available wind reports.

Further analysis is required to ascertain whether this approach is appropriate for global wind applications, as it is still unclear which global wind-pressure relationship to best apply in order to obtain the truest estimate of the missing variable. It is widely recognized that each basin may have its own wind-pressure relationship (e.g., Kraft 1961; Harper 2002; Harper et al. 2006; Knaff and Zehr 2007); though a singular global conversion value remains inconclusive.

The minimum central pressure (MCP) is then a mean of all reported central pressures available for each observation time. Future work will make use of wind-pressure relationships to determine a central pressure for each observation based on MSW when MCP is not reported. This will help to make the MCP and MSW values inter-consistent.

The synoptic characteristic of the storm (i.e., tropical, extra-tropical and sub-tropical) is very important to note since most centers track circulations prior to naming them as well as track storms long after transitioning to extra-tropical cyclones. When the synoptic characteristic (i.e., nature) of the storm is reported by at least one center, then the storms nature is recorded in the NGTCS BT data.

Lastly, the storm location is classified by basin and sub-basin to aid in the generation of basin-wide statistics. Altogether, six different basins were defined as follows: North Atlantic (97W to 20W, 5N to 55N), Eastern North Pacific (90W to 180W, 5N to 55N), Western North Pacific (180E to 100E, 5N to 55N), North Indian Ocean (40E to 100E, 5N to 25N), Southern Indian Ocean (15E to 105E, 5S to 55S), and South Pacific Ocean (105E to 160E, 5S to 55S). In addition, each storm was assigned a "season", representative of its location and in accordance with WMO standards, such that storms in the Northern Hemisphere follow the calendar year, and storms in the Southern Hemisphere follow a 6-month offset year, from July to June (for more discussion of Southern Hemisphere offsets, see Lander and Guard 1998).

A summary of variables provided in the NGTCS BT data is provided in Table 2. This list will likely grow as the data are quality-controlled and other processing is completed. As described above, the data will be fully documented as to how any data were changed and the steps used in developing the final NGTCS BT product.

3. DATA ISSUES

During the merging process, it became clear that in several instances, more than one RSMC had best track data for the same storm (i.e., multiple tracks), despite each storm's unique storm identification number. This raised a number of "red flags" and prompted a manual assessment of a sampling of these multiple track storms to identify key issues. A number of concerns were identified (Table 3) and others likely exist. Some of the more noteworthy examples include diverging tracks (Fig. 5), different cyclogenesis and cyclolysis dates (some RSMC's consistently follow a storm later in its life), different wind speeds and units, and cross-basin storms (e.g., an Atlantic storm surviving its way into the Eastern North Pacific or a Western North Pacific storm trekking into the Northern Indian Ocean, etc.). For each of these issues, a systematic, objective means of quality controlling the data is required.

Although required, quality control efforts on the merged best track data have not yet been fully explored, as it is not well understood which method(s) may be appropriate for addressing each of the identified issues. However, since the merging system is designed to account for these issues and tracks them in the metadata, quality control efforts could be initiated based on these data. Nevertheless, despite the number and types of issues encountered, the important point is the data set is comprehensive and accurate to the point where it should be suitable for research applications.

4. GLOBAL TROPICAL CYCLONE STATISTICS

The availability of a global best track data set that consists of data from each of the RSMC's as well as other international warning centers, and individual researchers provides for an opportunity to compute comparative tropical cyclone statistics to verify that all the named storms have been captured and to demonstrate the differences that arise between this data set and others. While six major basins are provided in the data, the uniqueness of the storm serial identification number advocates that any individual or research group can compute regionally-specific statistics based on their own basin-boundary definitions.

For example, we configured six basins to match those defined by Webster et al. (2005, Table 1) and computed tropical cyclone storm counts for category 4 and 5 storms for two consecutive 15-year periods (1975-1989 and 1990-2004). Due to the uniqueness of the scale used by Webster et al. (2005) to classify category 4 and 5 storms (a category 4 storm began at 56 ms^{-1} instead of 59 ms^{-1}, and a category five storm at 67 ms^{-1} instead of 70 ms^{-1}), we computed these period counts using their scale and the results are shown in Table 4.

According to Webster et al. (2005), there has been an increase in the number of hurricanes in categories 4 and 5 between these two periods for each of the major basins. While this appears to be the case for most of the basins, the results presented in Table 4 suggest that a slight decrease has occurred in the western North Pacific basin for category 4 and 5 storms. The decline can likely be attributed to the use of the NGTCS BT data, which in its creation averages all available wind observations thereby potentially lowering the maximum sustained wind for a given storm that might have otherwise been counted as a category 4 or 5. It is important to note that the JTWC does tend to bias high on their wind measurements (e.g., Wu et al. 2006; Hui et al. 2007) and some re-analysis or adjustment to their BT data is needed (e.g., Hoarau et al. 2006; Lander et al. 2006). Hence, the use of a mathematical average to assimilate winds in the NGTCS BT data should smooth out this bias and may prove to be a more accurate representation of the tropical cyclone winds in that basin.

At the same time, other basins show larger numbers of category 4 and 5 storms because the NGTCS BT data is inclusive of all available resources, thus the potential exists for the addition of new storms not previously captured by other centers. The differences in the North Atlantic basin appear to be linked to the counting of storms in the western Gulf of Mexico (generally west of 90W); an area that has been curiously disregarded in others' research efforts. The reproduction of Webster et al. (2005, Table 1) is not meant to refute their results, but rather demonstrates that tropical cyclone statistics can vary significantly depending on which BT data sets are used.

Another common tropical cyclone statistic is the Accumulated Cyclone Energy (ACE) index (Bell et al. 2000; Bell and Chelliah 2006), which is proportional to the accumulated kinetic energy generated by tropical storm and hurricane strength cyclones. Klotzbach (2006) computes the ACE index for two ten-year periods (1986-1995, 1996-2005) again for the six major basins. To assess what impact the NGTCS BT data set had on the ACE index, we replicated Table 1 from Klotzbach (2006), and the results are shown in Table 5a (1986-1995) and Table 5b (1996-2005). Upon examination of these results, it is interesting to note that for both periods, the ACE values in the North Atlantic basin are essentially identical. This is because only one center reports BT data for this basin. However, for those basins where several centers report intensity for the same storm, such as the Northwest Pacific and the South Pacific, the ACE values presented here are significantly lower and higher, respectively, indicating that there may be a substantial difference in the best track data acquired. Nevertheless, we find that Klotzbach (2006) results often fell within the range of the ACE maximum and minimum (computed from the highest and lowest maximum sustained winds as reported by the various centers for the same storm). The uncertainty resulting from the calculation of the ACE index values is on the order of about 20% for all basins, demonstrating that extreme caution must be used when computing the ACE solely from one reporting center (when data from more than one center is available).

Finally, to verify that the new global best track data set contains all potential named tropical cyclones (i.e., those storms with winds greater than or equal to 34 kts) tropical cyclone counts were totaled using the NGTCS BT data against the more widely used combination of data from the RSMC-Miami (NHC/HURDAT) and the JTWC. This comparison is shown in Table 6. The same two 15-year periods that were used in Webster et al. (2005) are repeated here for consistency. As expected, the counts are nearly identical for the North Atlantic and Northern Indian Ocean, as only one center was available for each basin[1]. However, for the western North Pacific basin, the new data set contained 39 additional named storms in the early part of the record (1975-1989), and another 15 named storms in the 1990-2005 period as compared with the JTWC. In addition, nearly 30 named storms were captured, in both periods, in the NGTCS BT data for the Southwestern Pacific basin that would have presumably been lost for those exclusively using the JTWC best track data. The supplementary storms likely stemmed from the addition of data from Neumann (1999), as well as the RSMC's of La Reunion, Wellington, and Nadi. A substantial increase also holds for the Southern Indian Ocean basin where an additional 43 named storms were captured in the first 15-year period, and 34 additional storms were identified in the second 15-year period. Such differences in these global counts strongly suggest and support the need for a new standardized global best track data set.

[1] However, when New Delhi data is digitized, the North Atlantic will be the only basin covered by just one center.

5. DISCUSSION

One of the fundamental benefits to this newly developed data set is that it will be freely and publically available through NOAA's NCDC. Moreover, semiannual updates and further quality control of the data are planned. In addition, all methodologies, metadata, and resources for attaining the data will also be made available and distributed as part of the best track data set. With seemingly many research groups and individuals using "in-house" best track data, which are often kept undisclosed from the greater tropical storms community, NOAA's NCDC is able to offer a robust tropical cyclone best track data set while accommodating continuous user feedback to improve the data. It is hoped that the data will be released with the ability for users to utilize a web form, perhaps similar to NCDC's Datzilla[2], where data quality issues or problems can be submitted for review. Once complete, all records of these requests and any subsequent changes to the data will be archived and added to the metadata.

5.1 Future work

Much remains to be done in preparing the NCDC Global Tropical Cyclone Stewardship (NGTCS) Best Track data. Future changes in the processing are summarized in Fig. 3 and Table 3. These planned changes to the processing are by no means comprehensive. In fact, they represent a simple "straw-man" for the community to analyze and change. In keeping with the driving principles of "Open" and "Ongoing," the future direction of such changes will largely be dependent on the opinions and experience of experts in the field of tropical meteorology.

Acknowledgements

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- RSMC Nadi, Fiji and Alipate Waqaicelua for providing BT data from the South Pacific Ocean.
- RSMC La Reunion and Philippe Caroff for providing BT data from the Southern Indian Ocean.
- TCWC Wellington and Peter Kreft for making BT data available for the Southern Pacific Ocean.
- RSMC Honolulu (CPHC) and James Weyman for providing BT data for the Central Pacific Ocean.
- Australian BoM and Blair Trewin for providing a preliminary version of a revised Australian BoM Best Track.
- Charlie Neumann for providing BT data for the Southern Hemisphere.

[2] http://datzilla.srcc.lsu.edu/datzilla/

- RSMC New Delhi, B. K. Bandyopadhya and Charan Singh for working to provide BT data for the Northern Indian Ocean.
- Tom Ross and NOAA Climate Database Modernization Program for keying the New Delhi data.
- Hong Kong Observatory and W. H. Lui for providing BT data for the Western North Pacific.
- NHC, JTWC, JMA and CMA for making their data publicly available via the internet.

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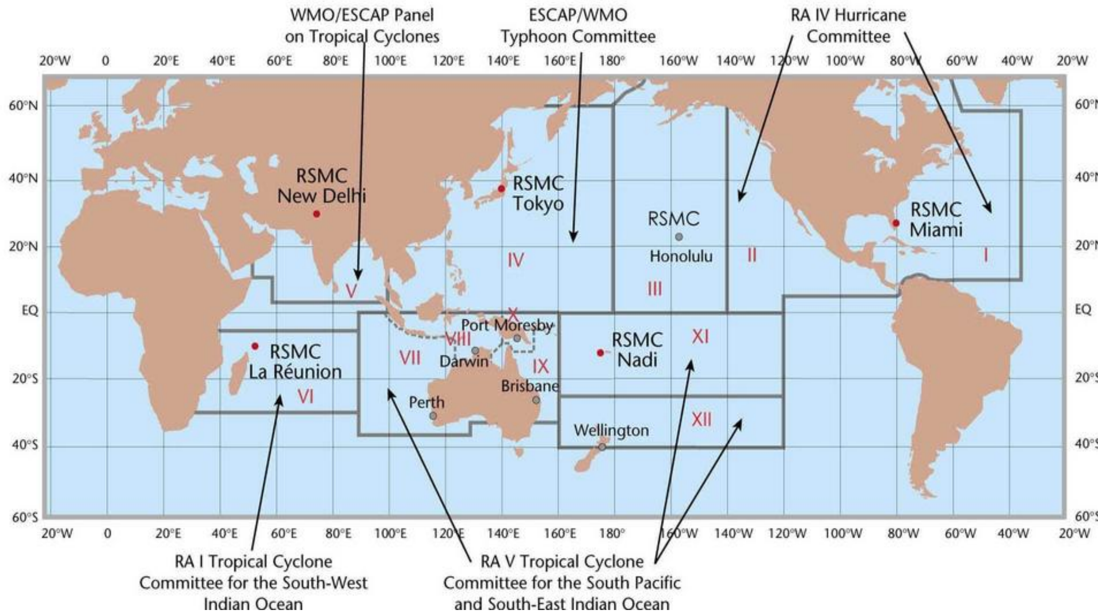

Figure 1 – The location of the Regional Specialized Meteorological Centers and their coverage areas (World Meteorological Organization).

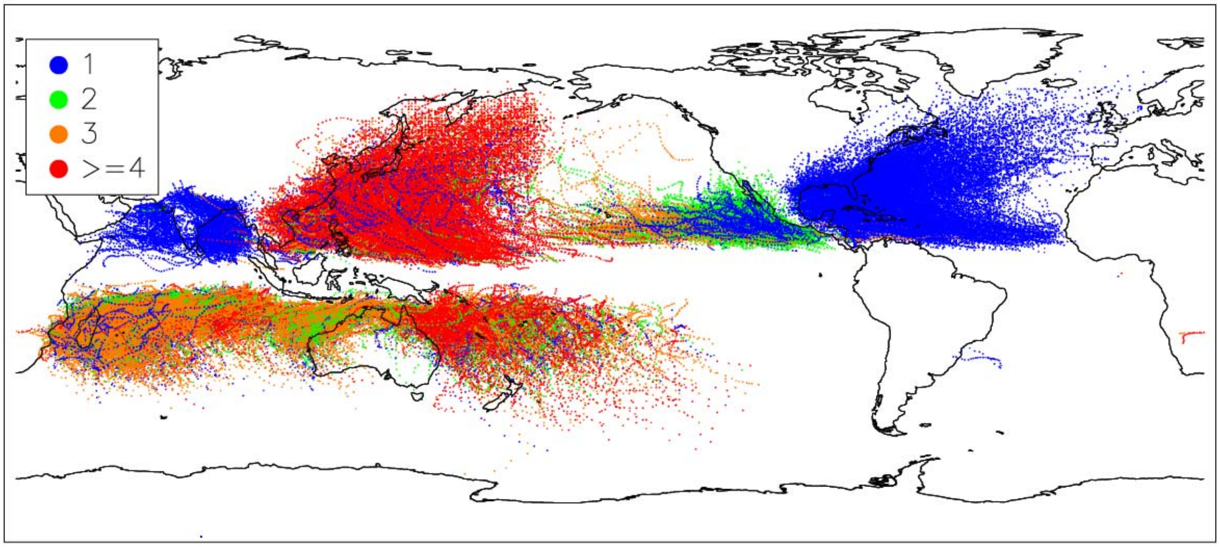

Figure 2 – Storm positions from the 8020 unique storms color coded by the number of centers providing BT data for the storm.

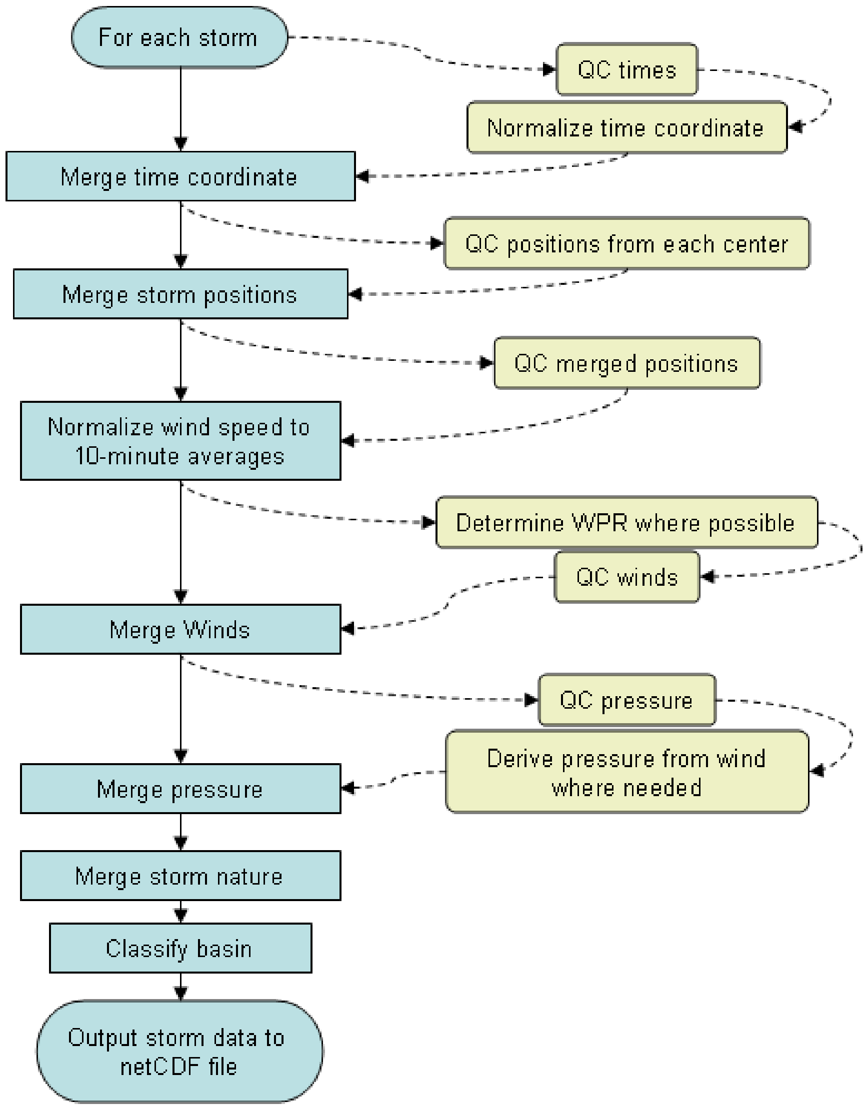

Figure 3 - Flowchart showing the current structure of the NGTCS best track production (blue) and the planned improvements (yellow).

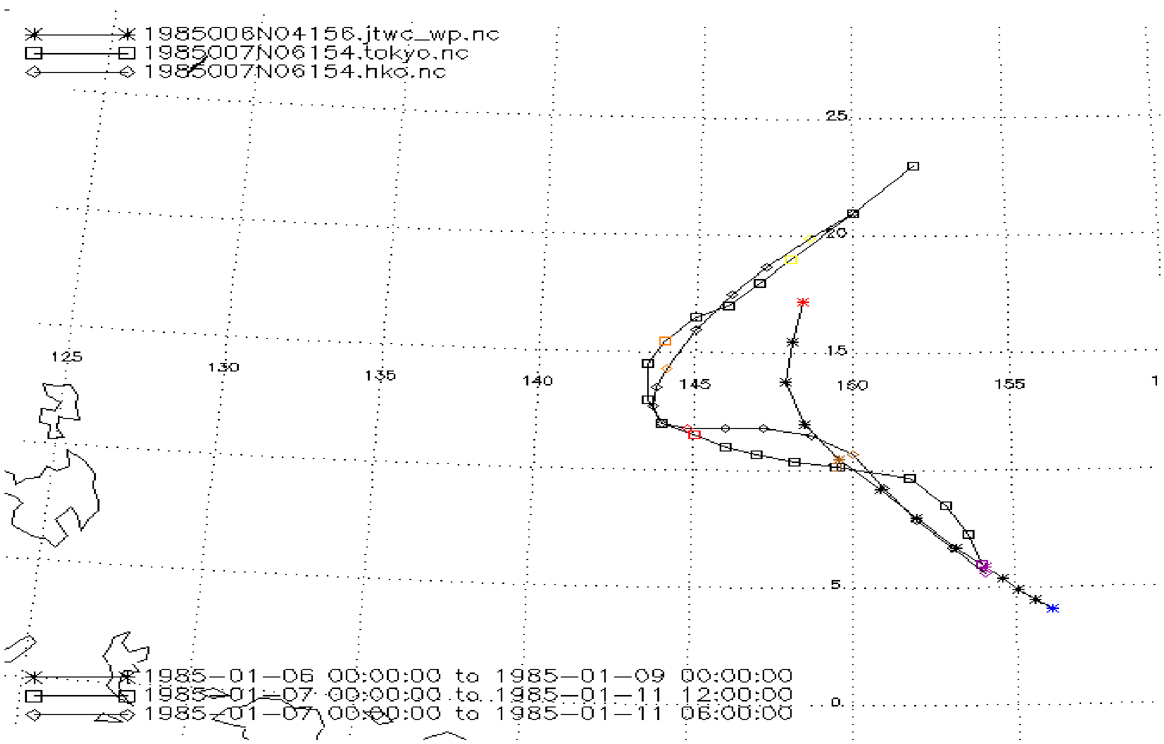

Figure 4 – Tracks for a tropical cyclone in the North Western Pacific Ocean in 1985 from JTWC (asterisks), RSMC Tokyo (squares) and HKO (diamonds). Observations are 6-hr with 0000 UTC observations color-coded.

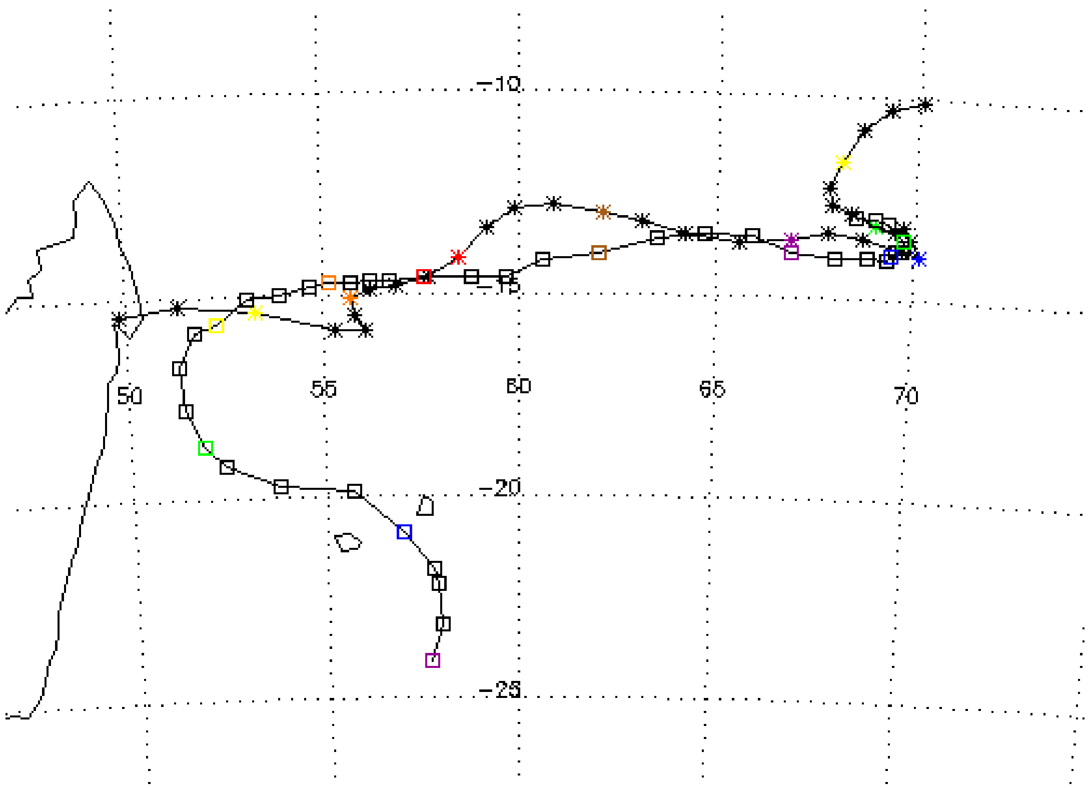

Figure 5 – A sample of a multiple track storm sampled by JTWC and La Reunion for a tropical cyclone beginning on December 24, 1987. The square markers represent the cyclones position according to La Reunion, and the star markers represent JTWC. Note that La Reunion ends the storm on January 4, 1988, whereas JTWC ends it on January 1, 1988.

Center	First Year[3]	# of Storms[4]	# of storms after 1970	Unique storms	% of storms with valid pressure	% of storms with valid wind
HURDAT_atl	1851	1364	410	1379	54	100
HURDAT_epa	1949	825	604	95	43	100
CPHC	1966	166	151	23	30	100
JTWC_ep	1949	756	550	70	0	100
JTWC_cp	1950	47	36	1	4	100
JTWC_wp	1945	1801	1115	215	10	96
Tokyo	1951	1515	1000	37	100	53
CMA	1949	2023	1223	338	100	100
JTWC_io	1945	629	267	622	5	27
JTWC_sh	1945	1751	1055	321	7	52
BoM	1907	847	451	209	96	23
Nadi	1992	91	91	6	96	86
La Reunion	1848	1238	397	712	24	24
Wellington	1968	350	349	22	100	100
Neumann	1960	1351	1097	33	34	100
Hong Kong	1961	1414	1093	25	100	100
New Delhi	1990	136	136	?	100	100
All sites	1848	16,304		8020		

Table 1 – A summary of the data acquired in the development of a global best track tropical cyclone dataset. Data from New Delhi remains in hardcopy paper format and full digitization is not yet complete.

[3] The first year a storm is observed regardless of the completeness of the archive that particular year

[4] Total number of storms provided in the best track files. This does not limit storm occurrence to some intensity threshold (e.g., hurricane strength).

Parameter	Unit	Description
Genesis basin		Basin in which the first observation is made
Number of basins		Number of basins where the storm went
Season		Season assigned to the storm (follows the year for the Northern Hemisphere and is the prior July through the current June for the Southern Hemisphere)
Center		Sources providing BT data for the storm.
Name		Name assigned to the storm by each center
Time		Time of the storm observation
Latitude	° N	Storm center latitude (mean value from all centers).
Longitude	° E	Storm center longitude (mean value from all centers).
MSW	knots	Maximum sustained wind over a 10-min period (mean value from all centers).
MCP	hPa	Minimum central pressure (mean value from all centers).
Basin		Basin of the storm for each position
Sub-basin		Sub-basin name of the storm for each position
Nature		Storm nature: ET (Extra-tropical), TS (Tropical), SS (Subtropical), MX (centers report a contradicting natures) or NR (not reported)
Position error	km	Variance in the position of the storm centers
Position condition		Condition flag describing how the data were merged
Position flag		Flag denoting which centers provided information for the merging of the position
MSW error	knots	Variance in the MSW reports
MSW condition		Condition flag describing how the data were merged
MSW flag		Flag denoting which centers provided information for the merging of the MSW
Maximum MSW	knots	Maximum MSW (10-min) reported by any of the centers
Minimum MSW	knots	Minimum MSW (10-min) reported by any of the centers
MCP error	hPa	Variance in the MCP reports
MCP condition		Condition flag describing how the data were merged
MCP flag		Flag denoting which centers provided information for the merging of the MCP
Maximum MCP	hPa	Maximum MCP reported
Minimum MCP	hPa	Minimum MCP reported

Table 2 - Summary of parameters available from the merged NGTCS BT data

Issue	Our Approach
Variation in mean wind speed period	Present: Normalize to 10-min using 0.88 *Planned: Normalize to 10-min using the same factor used by each agency (if one was used)*
Variation in the WPR	Present: Not applicable *Planned: Additional research to determine best global approach.*
Position errors	Present: Outliers are discarded *Planned: Perform temporal tests to determine outliers and discard when computing the mean position.*
Cross basin storms	Present: Count cross-basin storms as one storm, but flagged as an inter-basin storm *Planned: No change planned.*
Different begin and end times	Present: Use the longest lifetime of the storm possible (i.e., earliest positions from center tracking the storm first) *Planned: No change planned.*
Different storm natures	Present: When centers differ on the nature of the storm (e.g., tropical vs. extra-tropical), the storm is reported as mixed. *Planned: No change planned.*
Synthesizing wind and pressure observations	Present: Nothing. *Planned: Perform tests using Wind Pressure Relationships to synthesize data from centers when neither report the same intensity type (e.g., one center reports MSW and the other only reports MCP).*
Fujiwara	Present: This issue remains unaddressed. *Planned: To Be Determined.*
Data QC	Present: When possible, obvious data errors are corrected. *Planned: These corrections will be provided to the center having the error to fix their records.*
Varying time coordinates	Present: Nothing performed *Planned: Normalize time coordinates (and interpolate positions and intensities) to 6-hourly observations.*

Table 3 - Summary of issues in merging BT data from disparate sources, how we initially approached the issue and how it might be further corrected in the future.

Basin	Number of storms 1975-1989		Number of storms 1990-2004	
	Webster et al. (2005)	NCDC Global Best Track Data	Webster et al. (2005)	NCDC Global Best Track Data
East Pacific Ocean	36	41	49	50
West Pacific Ocean	85	82	116	77
North Atlantic	16	19	25	29
Southwestern Pacific	10	9	22	19
North Indian	1	5	7	9
South Indian	23	25	50	52

Table 4. A comparison chart of tropical cyclones that are either category 4 or 5 storms using the same modified Saffir-Simpson scale as suggested by Webster et al. (2005), where category 4 storms begin at 56 ms^{-1}, and category 5 storms begin at 67 ms^{-1}.

Basin	Accumulated Cyclone Energy (ACE, x10^4 kts^2) 1986-1995				
	Klotzbach (2006)	NCDC Global Best Track Data	ACE Minimum	ACE Maximum	Percent Uncertainty
North Atlantic	762	765	765	765	0
Northeast Pacific	1646	1669	1651	1692	1%
Northwest Pacific	3495	3457	2723	4253	22%
North Indian	**123**	186	183	191	2%
South Indian	1377	1460	1146	1811	23%
South Pacific	**757**	916	773	1123	19%
Northern Hemisphere	6026	6078	5323	6901	13%
Southern Hemisphere	2134	2377	1920	2934	21%
Global	8160	8455	7243	9835	15%

Table 5a. A comparison the Accumulated Cyclone Energy (ACE) index between Klotzbach (2006) and the new global tropical cyclone best track data set for the period 1986-1995. ACE is calculated only for those storms which were not rated as "extra tropical", and winds were at least 34 kts (17.5 ms^{-1}). Bold values fall outside the bounds of the computed ACE maximum or ACE minimum.

Basin	Accumulated Cyclone Energy (ACE x10^4 kts^2) 1996-2005				
	Klotzbach (2006)	NCDC Global Best Track Data	ACE Minimum	ACE Maximum	Percent Uncertainty
North Atlantic	1438	1437	1437	1437	0
Northeast Pacific	**1037**	983	973	995	1%
Northwest Pacific	3307	2929	2368	3662	22%
North Indian	**180**	188	187	190	1%
South Indian	1456	1590	1360	1877	16%
South Pacific	**755**	971	858	1125	14%
Northern Hemisphere	5962	5537	4966	6284	12%
Southern Hemisphere	2211	2561	2218	3002	15%
Global	8173	8098	7184	9286	13%

Table 5b. Same Table 5a only for the period 1996-2005. Bold values fall outside the bounds of the computed ACE maximum or ACE minimum.

Basin	Number of named storms 1975-1989		Number of named storms 1990-2004	
	NHC + JTWC	NCDC Global Best Track Data	NHC + JTWC	NCDC Global Best Track Data
East Pacific Ocean	264	264 (+ 0)	245	246 (+ 1)
West Pacific Ocean	388	437 (+49)	429	446 (+17)
North Atlantic	139	139 (+ 0)	184	184 (+ 0)
Southwestern Pacific	166	195 (+29)	151	180 (+29)
North Indian	67	68 (+ 1)	75	75 (+ 0)[5]
South Indian	241	284 (+43)	253	287 (+34)

Table 6 - A comparison of all tropical cyclones with intensity at or greater than tropical storm strength (34 kts, 17.5 ms^{-1}) between the combination of the data from RSMC-Miami (NHC/HURDAT), and JTWC versus the new NCDC Global Best Track data set using the same two 15-year periods as defined by Webster et al. (2005). Basins as defined in the text. Differences are noted parenthetically.

[5] This does not yet include BT data from New Delhi