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Dataset of Risk Assessment of Tropical Cyclone on the Western North Pacific Basin (1980–2022)

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Abstract: A tropical cyclone is a cyclonic vortex that originates on the surface of tropical or subtropical oceans. It can cause several natural disasters including intense winds, large waves, torrential rain, storm surges, and others, all of which can seriously harm human lives and productivity. China is one of the nations most severely affected by tropical cyclones, suffering enormous annual losses of human life and direct financial damage in the Western North Pacific basin. Hence, for the preservation of the marine biological environment and the growth of the marine economy, scientific evaluation of the risk level of tropical cyclone disasters is important. The China Meteorological Administration's "TC best-track datasets for the Western North Pacific basin" served as the foundation for this dataset. An analysis of the tropical cyclone track data obtained between 1980 and 2022 was conducted using the ArcGIS platform and Python application. First, the kernel density approach was used to examine the degree of impact of tropical cyclones in the Western North Pacific basin between 99°E–160°E and 2°N–52°N, classifying the danger of disaster. Second, the total number of tropical cyclones that occurred in China's land area from 1980 to 2022 was calculated. The findings indicate that: (1) The South China Sea and the Philippine Sea have the highest risk levels and are most severely impacted by tropical storms in the Western North Pacific basin. (2) The pattern of gradually decreasing tropical cyclone frequency from coastal to interior locations is evident in China's land area. Hainan province experienced the highest number of tropical cyclones, followed by Taiwan province and Leizhou Peninsula in Guangdong province. The dataset comprises the following components: (1) the risk level of tropical cyclone disasters in the Western North Pacific basin, (2) the cumulative number of tropical cyclones in the Chinese land area, and (3) tropical cyclone statistics for the Western North Pacific basin. The dataset was archived in .tif and .xls formats, consisting of three data files with a data size of 1.15 MB (compressed into one file, 224 KB).

Keywords: tropical cyclone; risk assessment of tropical cyclone; risk level of tropical cyclone; kernel density estimation; cumulative number of tropical cyclone

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[2] Tong, J. Y., Wu, Q. T., Qian, Q. L. Dataset of risk assessment of tropical cyclone on the Northwest Pacific (1980–2022) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2024.. https://doi.org/10.3974/geodb.2024.01.04.V1. https://cstr.escience.org.cn/CSTR:20146.11.2024.01.04.V1.

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1 Introduction

The National Comprehensive Disaster Prevention and Reduction Plan was established as part of 14th Five-Year Plan of China[1]. Natural disasters are common in China and follow the trends of multiple disaster agglomerations and disaster chains[2]. In the face of complex and changeable natural disasters, it is vital to strengthen research, monitoring, and early warning systems of natural disasters. Tropical cyclones generated in the Western North Pacific basin are one of the main natural disasters affecting China. Their secondary effects, such as rainstorms and strong winds, often lead to major losses in social production. Therefore, scientific assessment of the risk level of tropical cyclones is of great practical significance and can serve as a guide for the comprehensive prevention and management of tropical cyclones by land and sea. Additionally, it can enhance China's strategy to mitigate disasters, provide relief, and encourage superior development of the marine economy.

Currently, risk assessment of tropical cyclone disasters in China mainly focuses on loss assessment, risk zoning, and transmission models[3]. The three primary categories of assessment methods are those that rely on physical simulation[4] and those that rely on the entire index systems[5, 6], as well as mathematical model-based techniques for risk assessments[7, 8]. Among these methods, risk assessments based on physical simulations are usually applicable to smaller-scale analyses because of their high requirements for simulation environments and experimental equipment. Comprehensive indicators are based on the regional disaster system theory, selecting variables of disaster factors, pregnant disaster environments, and disaster carriers, and assigning corresponding weights for comprehensive risk assessments. However, the evaluation of this approach is highly dependent on the rationality of the index system. Moreover, significant disparities exist in the analysis findings under different index systems, leading to doubts regarding the scientific nature of the assessment. With the continuous development of digital technologies, many scholars have begun to assess the risk of tropical cyclone disasters by combining mathematical modeling and machine learning. This method offers the advantage of overcoming the limitations of physical simulations and the subjectivity of index selection by processing and analyzing vast amounts of data comprehensively. Compared to other methods, analysis methods based on mathematical models are more suitable for large-scale tropical cyclone disaster risk assessments. Therefore, this dataset uses the "TC best-track datasets of the Western North Pacific basin" provided by the China Meteorological Administration and employs the big data analysis method to conduct a spatial risk assessment of tropical cyclone disasters.

2 Metadata of the Dataset

The dataset of risk assessment of tropical cyclone on the Northwest Pacific (1980–2022)[9] is summarized in Table 1.

3 Methods

3.1 Data Sources

The tropical cyclone data was obtained from the "TC best-track datasets for the Western North Pacific basin"[10–12], provided by the China Meteorological Administration (CMA), This dataset records the optimal tropical cyclone path information generated in the Western North Pacific basin since 1949. Its attributes include the occurrence date

Table 1 Metadata summary of the Dataset of risk assessment of tropical cyclone on the Western North Pacific (1980–2022)

Items	Description
Dataset full name	Dataset of risk assessment of tropical cyclone on the Western North Pacific basin (1980–2022)
Dataset short name	RiskTropCycloneNWPacific
Authors	Tong, J. Y., Guangzhou Institute of Geography, Guangdong Academy of Sciences / School of Geographic Sciences and Remote Sensing, Guangzhou University, junyuetong10@163.com Wu, Q. T., Guangzhou Institute of Geography, Guangdong Academy of Sciences, wuqitao@gdas.ac.cn Qian, Q. L., School of Geographic Sciences and Remote Sensing, Guangzhou University, Qianlynn@21c n.com
Geographic area	99°E–160°E, 2°N–52°N and China land area
Year	1980–2022
Temporal resolution	Year
Spatial resolution	20 km
Data format	.tif, .xls
Data size	1.15 MB (224 KB after compression)
Dataset files	The dataset consists of two raster data and one table data. It contains “the risk level of tropical cyclone disasters in the Western North Pacific basin”, “the cumulative number of tropical cyclones in China land area” and “the tropical cyclone statistics for the Western North Pacific” calculated using the TC best-track datasets for the Western North Pacific basin from 1980–2022
Foundations	National Natural Science Foundation of China (42071165)
Data computing environment	Python, ArcGIS, Microsoft Excel 2019
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the ‘ten per cent principal’ should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[14]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

(year/month/day/hour (UTC)), intensity category, longitude, latitude, central minimum pressure (hPa), 2 minutes average maximum wind speed (MSW, m/s), and 2 minutes average wind speed (m/s)[13], This dataset is made available for download in a text-file format. The intensity category in the TC best-track datasets for the western North Pacific basin is divided according to the national standard “Grade of Tropical Cyclones (GB/T 19201—2006)”[15], which is based on the average wind speed within 2 minutes: 0-weaker than the tropical depression or class of unknown, 1-tropical depression (TD, 10.8–17.1 m/s), 2-tropical storm (TS, 17.2–24.4 m/s), 3-Severe tropical storm (STS, 24.5–32.6 m/s), 4-Typhoon (TY, 32.7–41.4 m/s), 5-strong typhoon (STY, 41.5–50.9 m/s), 6-super typhoon (Super TY, 51.0 m/s) and 9-denaturation in 8 classes. The spatial visualization of the TC best-track datasets for the Western North Pacific basin is shown in Figure 1.

3.2 Algorithms

This dataset considers the Western North Pacific basin within 99°E–160°E, 2°N–52°N as the study area. The TC best-track datasets for the Western North Pacific basin, recorded by the CMA from 1980 to 2022, were selected for disaster risk assessment in the Western North

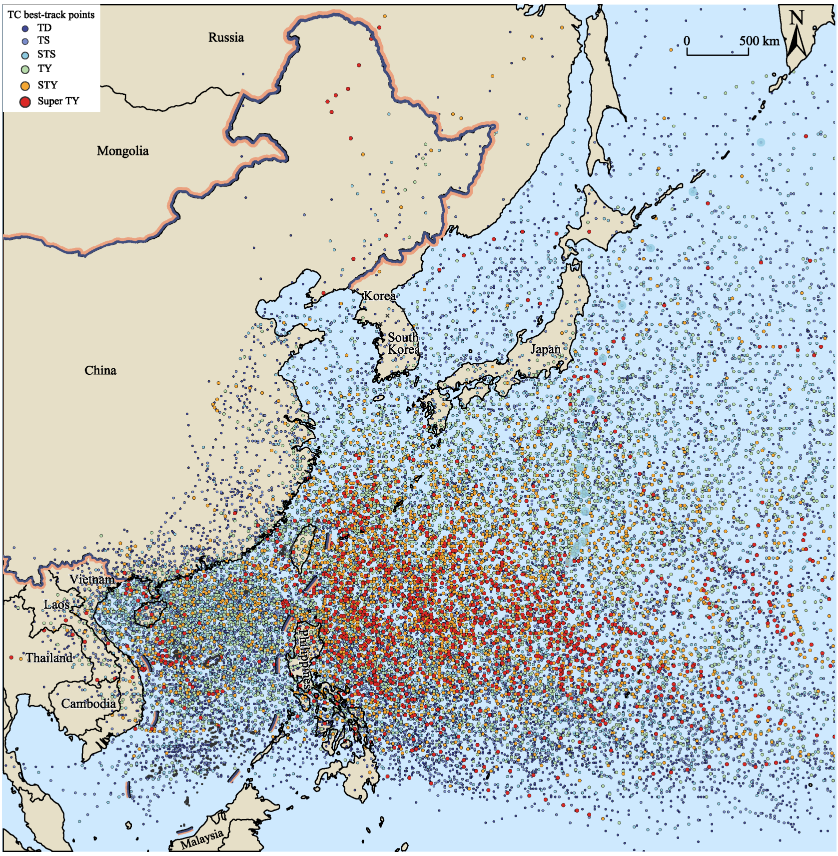

Figure 1 Spatial visualization of the TC best-track datasets for the Western North Pacific basin
(Notes: TD, tropical depression; TS, tropical storm; STS, strong tropical storm; TY, typhoon; STY, strong typhoon; Super TY, super typhoon)

Pacific basin and the land area of China. The results included the extent of tropical cyclone impact and the cumulative number of tropical cyclone intrusions in China's land area. Some missing records were removed during data processing and the impact range of the tropical cyclone recording points was estimated (using the Level 7 wind circle radius) from the IB-TrACS dataset published by the National Oceanic and Atmospheric Administration (NOAA). Geographic information technology and big data analysis tools, such as Python were predominantly used in the data analysis process.

The study area was divided into 20 km by 20 km spatial units for spatial analysis. Second, the range of influence of the TC best-track points should be defined according to the intensity level of each best-track point. This would enable the characterization of their life cycle into the stages of generation, development, maturity, and extinction. The generation of new best-track points indicates attenuation or extinction of the previous best-track point. Additionally, the radius of the strong wind designates the direct weather range of the tropical cyclone, which can be divided into radii of 12, 10, and 7 wind circles; the latter is believed to be the most common, causing strong winds and waves. For a certain spatial unit, it can be assumed that the early stage of tropical cyclone development is within the Level 7 wind circle and is impacted by tropical cyclones. However, with the continuous movement of the tropical cyclone, when the spatial unit is outside the wind circle of the above-track point, it can be considered almost unaffected by the tropical cyclone disaster. Figure 2 shows the trajectory data of tropical cyclone "QingSong" (Sonamu) in 2000. Initially, the range of influence of each tropical cyclone trajectory point was set according to the radius of the level 7 wind circle. In the early stages of development, tropical cyclones belong to the tropical depression (TD), and with an increase in time and movement of the trajectory, they continuously evolve into tropical storms (TS), strong tropical storms (STS), typhoons (TY), and other stages. For space unit A, the influence of the tropical cyclone "QingSong" is the sum of points 1 and 2 only when the tropical cyclone trajectory moves to these points and A falls into the wind field range of the cyclone. However, when the trajectory moves to point 3, the influence range does not cover unit A. Therefore, iterating through each TC best-track point is necessary to calculate the impact and effects of disasters within its influence range. If an iterative algorithm is not used for the calculation, the core density surface construction and intrusion times are calculated simultaneously, potentially expanding the scope of the disaster.

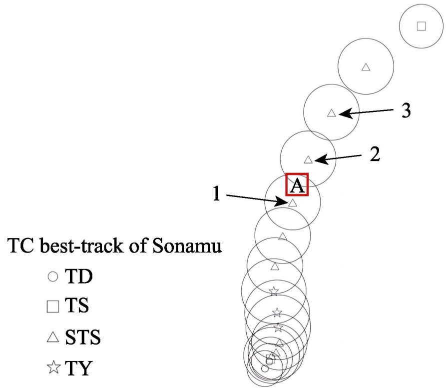

Figure 2 An example of TC best-track datasets (Notes: TD, tropical depression; TS, tropical storm; STS, strong tropical storm; TY, typhoon)

The impact rank of tropical cyclones in the sea area and the cumulative number of impacts in the land area were calculated separately to summarize the tropical cyclone disaster risk at each 20 km resolution space unit between 1980 and 2022. Due to the presence of varied landforms or living and production environments, the disaster risks of tropical cyclones need to be comprehensively analyzed in combination with natural landform attributes and disaster statistics. Therefore, this analysis focused on the number of intrusions in the land area.

(1) Using the nuclear density algorithm, the intensity level value was recorded as the assignment field and the radius of the seven wind circles was set as the search radius. The nuclear density analysis was performed by iterating each TC best-track point to calculate its influence. After the iterative calculation was completed, the density results of all waypoints were superimposed to obtain the impact results of tropical cyclone disasters based on intensity grade values. Finally, the disaster impact analysis results were divided into regions and the spatial distribution of tropical cyclone disaster impacts in the sea area was obtained.

(2) Using the iterative idea, the influence range of each TC best-track point was defined by the radius of the 7-level wind circle, the spatial unit within the range was considered to be disturbed once, the number of intrusions of each spatial unit within the land range was counted, and the cumulative number of intrusions of each spatial unit from 1980 to 2022 was obtained.

3.3 Technical Routes

The establishment process of this dataset is shown in Figure 3, which includes: (1) data pre-processing; (2) dataset operation (visualization of TC best-track points, tropical cyclone disaster risk level in the Western North Pacific basin, and cumulative number of tropical cyclone intrusions in China); and (3) data accuracy verification.

3.3.1 Data Pre-processing

First, Python was used to conduct data pre-processing, including invalid record elimination, data format correction, and attribute information classification. Second, the text format data was transformed into an SHP format for processing in ArcGIS according to latitude and longitude coordinates. Values were assigned according to the intensity category, and points weaker than TD or with an unknown grade were deleted. For best-track points in a denatured state, the corresponding intensity category value was assigned based on the central maximum wind speed. Finally, the TC best-track point assignment table was obtained, as shown in Table 2.

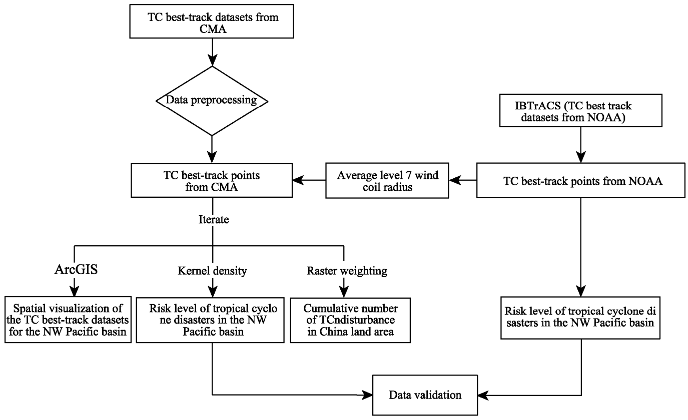

Figure 3 Technical flow chart of the spatial risk assessment dataset of tropical cyclone disasters in the Western North Pacific basin (Notes: TC, tropical cycle; CMA, China Meteorological Administration; NOAA, National Oceanic and Atmospheric Administration)

Table 2 The assigned tropical cycle best-track points

Tropical cyclone strength grade	2-min average wind speed (m/s)	assignment
Tropical depression (TD)	10.8–17.1	1
Tropical storm (TS)	17.2–24.4	2
Severe tropical storm (STS)	24.5–32.6	3
Typhoon (TY)	32.7–41.4	4
Strong typhoon (STY)	41.5–50.9	5
Super typhoon (Super TY)	≥51.0	6

In addition, the influence range of the cyclone point is necessary for algorithm processing. However, the tropical cyclone attribute information recorded by the CMA does not contain the wind coil radius; therefore, this study used the average wind coil radius from the International Best Track Archive for Climate Stewardship (IBTrACS) dataset, recorded by the National Marine Atmospheric Administration (NOAA), as the influence range of the best-track point. The statistical results are presented in Table 3.

Table 3 Average level 7 wind coil radius of tropical cyclones during different intensity levels

Tropical cyclone strength grade	2-min average wind speed (m/s)	Average level 7 wind coil radius (km)
Tropical depression (TD)	10.8–17.1	180
Tropical storm (TS)	17.2–24.4	220
Severe tropical storm (STS)	24.5–32.6	280
Typhoon (TY)	32.7–41.4	325
Strong typhoon (STY)	41.5–50.9	362
Super typhoon (Super TY)	≥51.0	376

Finally, the TC best-track datasets for the Western North Pacific basin were characterized in different colors according to different intensity levels to visualize the TC best-track datasets between 1980 and 2022.

3.3.2 Dataset Operation

Risk level of tropical cyclone disasters in the Western North Pacific basin: To create a continuous grid surface with a spatial resolution of 20 km, each best-track point was iterated and the kernel density within the radius of a class 7 wind circle was interpolated. The grid surfaces created above were superimposed individually to obtain the results of the tropical cyclone disaster risk assessment in the Northwest Pacific basin. The natural breakpoint method was used to classify the results. The higher the value, the more severely the region has been affected by tropical cyclones over the historical period.

Cumulative number of tropical cyclone disturbances in China's land area: First, the radius of seven wind circles was taken as the influence range of tropical cyclones, and the tropical cyclone best-track points were iterated successively to create the influence range buffer of each cyclone path point. A space unit in a buffer zone is considered to be affected by one tropical cyclone.

3.3.3 Data Accuracy Verification

The core value of this dataset was to effectively distinguish the different spatial risks of tropical cyclone disasters; therefore, the risk level of each spatial unit is the key to evaluating the accuracy and validity of this dataset. Hence, the TC best-track datasets for the western North Pacific basin from two different data sources, CMA and NOAA, were used to conduct a spatial risk assessment of tropical cyclone disasters and to compare the correlation of the two results and the distribution of high and low values. By calculating the Pearson correlation coefficient of the two results, we can judge the correlation between the two analysis results and further test the relative trend of the two results to determine whether there is a consistent distribution between them and then verify the accuracy of the spatial partition of the risk level.

4 Data Results and Validation

4.1 Data Composition

This dataset consisted of three data files, titled the "Tropical cyclone statistics for the Western North Pacific basin", the "Risk level of tropical cyclone disaster in the Western North Pacific basin", and the "Cumulative number of tropical cyclone infestations in China". The research scope of the data was 99°E–160°E, 2°N–52°N, within the Western North Pacific basin and China. The spatial coordinate system used was the WGS 1984 Mercator Projection. The dataset was archived in the .tif and .xls formats.

4.2 Data Products

4.2.1 The Tropical Cyclone Statistics for the Western North Pacific Basin

A total of 1,259 tropical cyclones were recorded in the Western North Pacific basin between 1980 and 2022. Statistical information for each year is shown in Figure 4, including the number of tropical cyclones occurring in that year and the maximum 2-minute average near-center wind speed (MSW, m/s) at the tropical cyclone point monitored in that year.

4.2.2 The Risk Level of Tropical Cyclone Disasters in the Western North Pacific Basin

According to the results of the nuclear density analysis, high levels of disaster are mainly located from the West Philippine Sea to the Sea basin, Maria Trench, and South China Sea, and there is a trend of decreasing influence from the Philippine Sea to the outer Pacific Ocean.

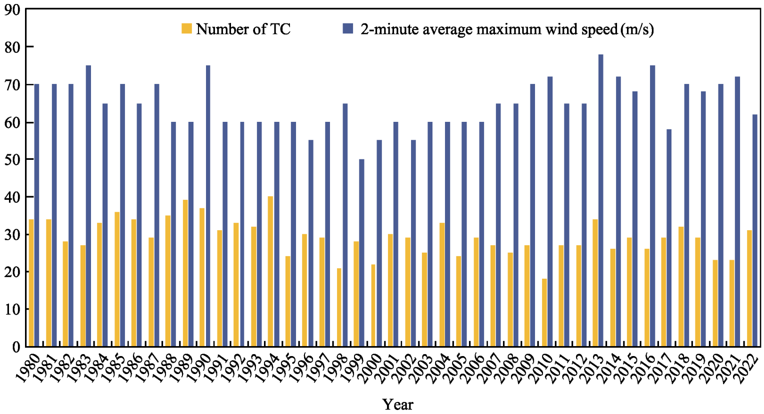

Figure 4 Statistics of the Western North Pacific tropical cyclone (TC) from 1980 to 2022
(According to the TC best-track datasets for the western North Pacific basin. Note: Individual missing records were not included in the statistics)

The kernel density analysis can specify the meaning of the values of the output grid divided into density (where the output value represents the density value per unit area of the space unit) and expected count (where the output value represents the density value of the space unit). In this dataset, the value of each grid pixel in the figure represents the fact that the density intensity of the 20 × 20 km space unit was affected by tropical cyclone disasters from 1980 to 2022, and the unit of analysis result was scored per square kilometer (a score of 1–6, according to the above assignment of the grid cell).

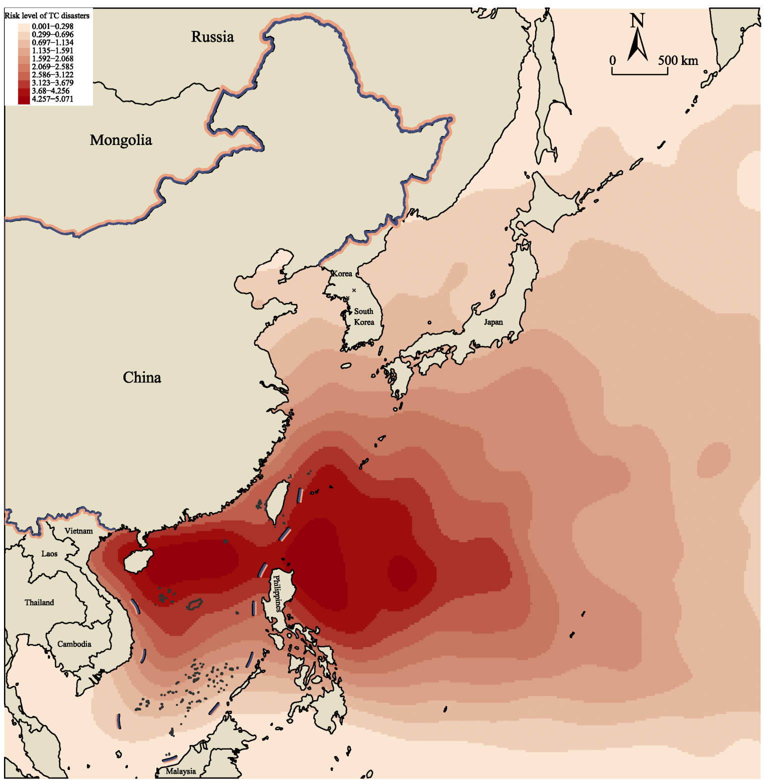

Figure 5 Risk level of tropical cyclone disasters in the Western North Pacific basin

4.2.3 The Cumulative Number of Tropical Cyclones over the China Land Area

From the perspective of number of disasters, the number of tropical cyclone disasters in the area around China shows a hierarchical structure that gradually decreases from southeast coastal areas to inland areas. First, the Hainan province and the Leizhou Peninsula area in Guangdong province were affected by more than 150 tropical cyclones between 1980 and 2022, significantly impacting production and life, particularly offshore aquaculture operations. Second, the Taiwan province and western Guangdong province were affected by more than 125 tropical cyclones, while the central and southern coastal areas of Guangdong province and southern Guangxi were affected by more than 100 tropical cyclones. Additionally, the coastal areas of Fujian province and southern Zhejiang region are also key areas affected by disasters, with tropical cyclones causing serious ecological damage and economic losses to fishery breeding and marine development.

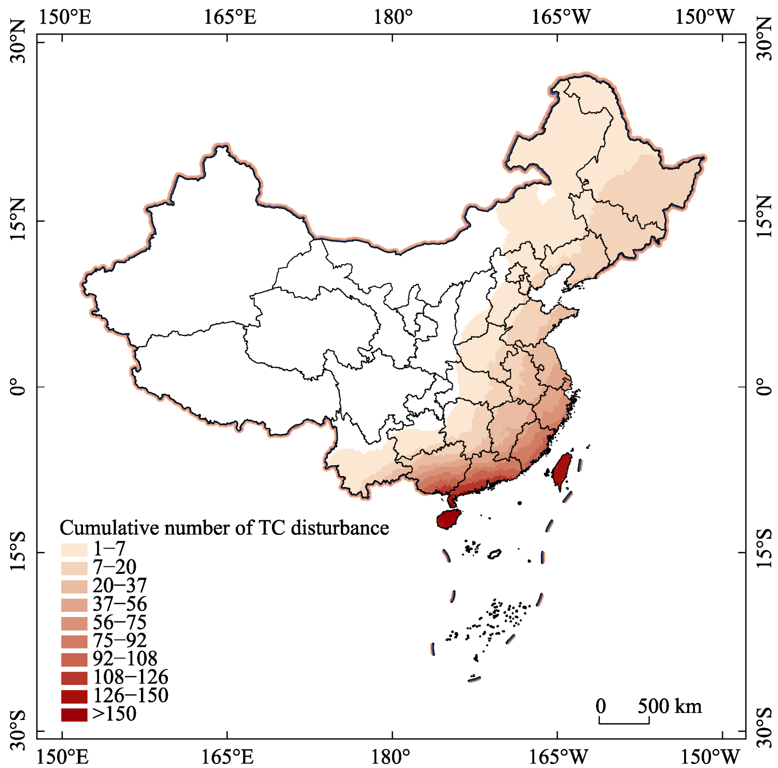

Figure 6 Cumulative number of tropical cyclone disturbance in China land area

4.3 Data Validation

The China Meteorological Administration is an authoritative weather forecasting agency. Each data source was carefully screened and compared to ensure accuracy. Simultaneously, the IBTrACS dataset provided by the National Oceanic and Atmospheric Administration (NOAA) was integrated the TC best-track datasets, which were published by several tropical cyclone monitoring agencies worldwide to help meteorologists understand the distribution, frequency, and intensity of tropical cyclones around the world. Therefore, by using the same nuclear density spatial analysis to deal with the tropical cyclone data of the two authoritative sources, we can measure the spatial distribution of the risk levels in the two analysis results, compare the differences between the two results from the data correlation and relative change trend, and evaluate the accuracy of the dataset in this study.

First, through data preprocessing, nuclear density analysis, and statistical analysis of the IBTrACS dataset, the spatial distribution of tropical cyclone disaster levels can be established. Second, by combining the above results with the risk level of spatial assessment results in the CMA dataset, the analysis results of the two were analyzed by grid values. By calculating the Pearson correlation coefficient, a high positive correlation of 0.995 was found between the two datasets. The positive correlation coefficient also indicated that the spatial change trend of the disaster level analyzed by the two data sources was consistent.

Table 4 Correlation analysis of tropical cyclone disaster levels based on China Meteorological Administration and NOAA

	China Meteorological Administration	The National Oceanic and Atmospheric Administration
China Meteorological Administration	1	0.995
The National Oceanic and Atmospheric Administration	0.995	1

5 Discussion and Conclusion

Based on the TC best-track datasets for the Western North Pacific basin set of the CMA and combined with the life cycle and movement trajectory, this dataset was analyzed using GIS, Python, and other big data methods to determine the impact of tropical cyclone disasters in the Western North Pacific basin and Chinese lands from 1980 to 2022. The results show that: (1) the Philippine Sea and South China Sea were most severely affected by tropical cyclone disasters and have the highest risk level; (2) the cumulative disturbance of tropical cyclone disasters in China showed a decreasing spatial distribution from the southeast coast to the Western North inland, and Hainan province, Leizhou Peninsula of Guangdong province, and Taiwan were most affected by tropical cyclone disasters from 1980 to 2022. In addition, this dataset used the IBTrACS dataset recorded by the National Oceanic and Atmospheric Administration as control data in conducting the spatial analysis of tropical cyclone disasters occurring in the same region during the same period. The Pearson correlation coefficient of the two results was 0.995, indicating the robustness of the results for this dataset.

Compared with the previous datasets for the analysis of tropical cyclone disasters, this dataset accounted for tropical cyclone samples on a longer time scale. It evaluated the spatial risk distribution of tropical cyclone disasters based on the intensity level and used an average of seven wind circle radii as the influence range. This approach can more accurately identify disaster risks in various regions, thereby helping to formulate relevant disaster prevention and mitigation measures. The application scenarios of this dataset mainly include: (1) # It can assess the disaster risk of far-reaching marine aquaculture and fishing: if applied to far-reaching marine aquaculture. By analyzing the historical disaster situation of the spatial unit to judge its potential disaster risk, delimiting the scope of breeding becomes relatively easy. Moreover, planning the breeding category and the production efficiency of far-reaching marine aquaculture will also be effectively improved by avoiding aquaculture activities in high-risk areas. If applied to the construction of modern marine pasture, by providing knowledge of historical disasters of the sea area and quantitative evaluation of the regional disaster level, it can provide a scientific reference basis for site selection of modern marine pasture, to achieve sustainable development. (2) The dataset can serve the route layout of offshore shipping, offshore wind power and offshore oil and gas site planning. For example, in the waterway route of ships, it can consider the disaster risk level of the sea area to reasonably avoid the high level areas with the impact of cyclone disaster. When selecting the site of the operation scope of offshore oil fields, the corresponding production mode should be formulated according to the disaster risk level and the possible disaster damage. This approach can reduce the losses to the production of oil and gas fields. (3) The dataset can be used to develop early warning of disaster risks and marine environment monitoring of marine emergency activities. It can also be used to provide scientific data support for the establishment of marine environment monitoring systems or early warning information platforms. It could help promote the protection of marine ecological environments and motivate the high-quality development of marine economies. (4) The dataset can serve in the development planning of coastal cities. Coastal cities can reasonably delimit spatial functional zoning and plan industrial layouts based on the number of tropical cyclone intrusions in regions within the cities.

Author Contributions

Tong, J. Y. collected and processed the data and wrote the paper. Wu, Q. T. designed the algorithms for the dataset and guided the writing of this paper. Qian, Q. L. provided ideas for the data verification.

Conflicts of Interest

The authors declare no conflicts of interest.

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