Golestan University

Geographical planning of space quarterly journal

Journal Homepage: www.gps.gu.ac.ir

Research Paper

Movement Pattern Recognition of Tropical Cyclone Using Spatial Data Mining

Safiyeh Firoozimehr [a*], Hossein Aghamohammadi [a], Majid Firoozimehr [b], Saeed Behzadi [c]

[a]. *Department of gis and Remote sensing, Faculty of Natural Resources and Environment, Science and Research Branch, Islamic Azad University, Tehran, Iran*

[b]. *Department of Physical Oceanography, Faculty of Marine science and Oceanography, University of Marine Science and Technology, Khorramshahr, Iran*

[c]. *Department of Surveying and Geomatics Engineering, School of Civil Engineering, Shahid Rajaee Teacher Training University, Tehran, Iran*

A R T I C L E I N F O

Keywords:
Tropical Cyclone,
Data Mining,
Clustering,
Moran Index.

Received:
06 April 2022
Received in revised form:
10 June 2022
Accepted:
08 August 2022
pp. 39-55

A B S T R A C T

The North Atlantic region is always exposed to severe storms, which are considered one of the most severe natural hazards in the climate field, and every year they cause serious damage to the economic infrastructure and human casualties in the areas affected by this event. These storms can help in the analysis and crisis management plans of this hazard and land preparation. The development of data collection and data mining technologies enables a more detailed study of this phenomenon. This issue requires the use of simple and efficient methods to investigate the behavior and extract the pattern from the database of this phenomenon. In this research, using spatial statistics methods, the trend of changes in the movement of tropical storms in the North Atlantic Ocean and the identification of their governing patterns in the period of 1995-2015 have been analyzed. The obtained results confirm the cluster pattern governing this phenomenon and that the occurrence of storms are not random events and follow spatial and temporal patterns in the studied area. The pattern of storms has a cluster pattern with the maximum value of the average value of the nearest neighborhood of 0.74 and the minimum value of 0.47. Also, the value of the general Moran index, the highest and the lowest correlation and clustering were calculated in 2006 with an index number of 0.66 and 2009 with an index number of 0.12 respectively, and a map of clusters and non-clusters and hot spots was prepared. With a better understanding of the patterns governing the movement of storms, it is possible to reduce possible damages caused by storms. Based on this, as a suggestion for future research, it is possible to include the effect of other parameters such as temperature, water salinity, and atmospheric general circulation systems, which play a significant role in the distribution of the distribution of the occurrence of storms, in the modeling and data mining of storms and get results closer to reality. Finally, as a useful research, the results of clusters and hot spots can be used in predicting the movement of storms in the future.

Citation: Firoozimehr, S., Aghamohammadi, H., Firoozimehr, M., & Behzadi, S. (2022). Movement Pattern Recognition of Tropical Cyclone Using Spatial Data Mining. *Geographical planning of space quarterly journal, 12* (3), 39-55.

http://doi.org/10.30488/GPS.2021.263881.3359

∗ . Corresponding author (Email: safiyeh.firoozi@gmail.com)

Extended Abstract

Introduction

Movement in natural phenomena produces a considerable amount of movement data. The development of data collection technologies and encountering a huge volume of Spatio-temporal data enables a more detailed study of natural phenomena and hazards, including hurricanes. This issue requires using simple and efficient methods to investigate the behavior and extract patterns from our database. Data mining can be used in such Spatio-temporal processes' databases to recognize better and understand the prevailing patterns. Investigating and preparing the trend of spatial and temporal changes governing these cyclones can help in the analysis and crisis management plans for this hazard and land preparation. Based on this, the main goals of this research are to use the efficient method of spatial statistics in order to explore the Spatio-temporal patterns of tropical cyclone in the North Atlantic Ocean from their database over 21-years and to prepare cluster maps and hot spots maps from their speed distribution. By reviewing previous research and summarizing those mentioned above, it can be concluded that although the existing methods can model and especially are clustering tornadoes and hurricanes, they have complex calculations in performance. Also, previous studies have not extracted the temporal-spatial patterns of the tropical cyclone and prepared illustrative maps. Therefore, while adopting an efficient and simple method for clustering and extracting a pattern from the cyclone dataset, it is necessary to prepare useful maps of this phenomenon over time.

Methodology

We performed this study based on descriptive-analytic and qualitative methods. The research sample includes 21 years of trajectories of North Atlantic hurricanes that occurred between 1995 and 2015. The raw dataset was obtained from NOAA with a sampling rate of 6 hours. Data analysis was performed in ArcGIS software. The first step includes data collection and necessary pre-processing to remove outliers from the study area. The second step is to check the geographic distribution of the data by calculating the mean center and the standard distance in order to summarize the information in the data distribution, which is the beginning of recognizing the possibility of a pattern or clustering in the data. Then, to investigate distribution patterns or concentration and the probability of random distribution of complications, Moran's index's average nearest neighbor and spatial autocorrelation were exerted. In the third step, two methods of cluster /outlier analysis and hot spot analysis based on spatial statistics were used to display the identified patterns. Furthermore, the IDW interpolation method has been used to prepare the final maps.

Results and discussion

The results of the average weight distribution of cyclones in the three time periods of 1995-2000, 2001-2008, and 2009-2015 show the trend of cyclones moving from the central Atlantic to the US coast and in the final period to the east of the ocean. Calculations of Standard Deviational Ellipse in all three periods show the maximum distribution in the east-west direction, which shows the spatial instability of the average centers in the east-west direction and the displacement of these centers in this direction. The global Moran index is close to one and the z-score and p-values obtained in all years studied indicate the spatial autocorrelation and the prevailing cluster pattern. Also, the average nearest neighbor's results confirmed the clustering of cyclones' spatial distribution. The pattern of cyclones has a cluster pattern with a high average value of the nearest neighborhood of 0.74 and a minimum value of 0.47. Also, the value of general Moran's index based on the characteristics of cyclones speed, the highest and lowest correlation and clustering were calculated in 2006 with an index number of 0.66 and the lowest in 2009 with an index number of 0.12 respectively in this research. After determining the type of patterns with the help of these two indices to investigate the changes in spatial autocorrelation of cyclones in this region, local Moran index

and hot spot analysis were used. The prevailing pattern in the output of this statistic is consistent with the pattern obtained from the distribution of mean centers. IDW interpolation method was used to better visualize the output of hot spots analysis on the map.

Conclusion

Preliminary results from measuring data distribution showed the probability of having a pattern and cluster in the data set. Supplementary analyses showed that cyclones are not random events but follow patterns. Another result of this research is that the results of cluster and outlier analyses and hot spots, considering the neighborhood, refer to Tabler's theory and the first law of geography, that "each phenomenon is related to another phenomenon and the phenomenon closer to ones are more similar to each other." The average nearest neighbor analysis results confirm the cluster pattern governing this phenomenon in the study region. Also, based on the cyclone's speed, the total Moran index calculates the highest and lowest levels of correlation and clustering for the years 2006 and 2009, respectively. The maps prepared for 1995 to 2015 show how the patterns governing the occurrence of cyclones move and change during these 21-year period.

Funding

There is no funding support.

Authors' Contribution

Authors contributed equally to the conceptualization and writing of the article. All of the authors approved thecontent of the manuscript and agreed on all aspects of the work declaration of competing interest none.

Conflict of Interest

Authors declared no conflict of interest.

Acknowledgments

We are grateful to all the scientific consultants of this paper.