Design and Development of Visualization System for Marine Early Warning Products based on GIS

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Abstract. General marine environmental early warning data have not formed a unified standard, due to the different angles and dimensions in expression of marine environment. General formats of these data are text type, binary type, and mixed type. These data types cannot be read and processed by the GIS platform, so it is necessary to normalize these data to standard format supported by GIS platform. This paper studied the visualization system for marine early warning products which based on MFC framework and Arc Engine development kit and used GDAL and NetCDF function libraries, solved the problem of heterogeneous data sources and realized data production, results presentations, automatic drawing, 3D profile analysis and other functions. It will provide convenience for the comprehensive operation of different types data and improve the visual expression effect for marine early warning products and marine management at the same time.

Introduction

General marine environmental early warning products include the wind field, three-dimensional thermohaline circulation, storm surge, salt water intrusion, sediment and other numerical early warning products. Due to the non-uniform of the product formats and the different calculation modes, the data analysis and process will encounter various difficulties. Both the establishment of unified operational framework and research of a variety of visualization methods are imperative.

Rufu Qin [1] proposed solution that building mixed GIS system for the multi-dimension marine geographic data. Xinfang Li [2] constructed the marine environment visual simulation system by using open source OpenSceneGraph and ArcGIS data process tools. Lingda Wu [4] researched parallel visualization of large scale 3D scalar field. Zhe Bi [5] developed a marine GIS system based on ArcObject, and described the use of AO Library. Jie Huang [6] described the method of spatio-temporal model and visualization for marine environment integrated data. Wenwen Jiang [7] described the method of data formats and data process for marine environment. Jun Gao [9] discussed the modeling of visualization for geospatial data and the role of GIS in the visualization. Chao Tu [10] researched 3D visualization for the ocean temperature field. In the above researches, there is no research on the normalization of the marine currents field data and then building the visualization system for marine early warning products based on GIS.

The paper studied the visualization system for marine early warning products. This study solved the problem of heterogeneous data sources. It will provide convenience for the comprehensive operation of different kinds of data and improve the visual expression effect of marine early warning data and marine management at the same time.

Analysis and process for marine early warning data

Marine environment is a complex giant system, which is multi-coupling, multi-factor, and time-varying. Description, expression and reproduction for the marine environment requires a variety of monitoring platforms and a variety of data acquisition and process which means to cooperate with each other. At present, the basic marine information provided by China includes the

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following types: hydrological data, marine biological data, meteorological data, marine stations data, marine chemical data, geophysical data, ARGO data, Modis and other satellites data. Marine environmental early warning data is particularly important in a great deal of marine data due to its dynamic and predictive characteristics.

General marine environmental early warning data include wind field, three-dimensional thermohaline circulation, storm surge, salt water intrusion and sediment data. These data have not formed a unified standard, due to its different angles and dimensions in expression of marine environment. General formats of these data are text type, binary type, and mixed type. These data types cannot be read and processed by the GIS platform, so it is necessary to normalize these data to standard format supported by GIS platform. This study selects the ESRI shapefile format as the standard format. The conversion of NetCDF storage format of three-dimensional thermohaline circulation vector data will be described to illustrate the process of data normalization.

Data format analysis of NetCDF

The full name of NetCDF is Network Common Data Form. NetCDF is a kind of self-explanatory, cross platform data storage and exchange format, which is suitable for scientific data sharing.

The data of three-dimensional thermohaline circulation is usually three dimensional data with early warning cycle for one day, which contains three kinds of factors: temperature, salinity and marine current. General data storage format of three-dimensional thermohaline circulation is NetCDF format, opening the NetCDF data through the MeteoInfo software to read the metadata information. The main metadata types include nele node number, node node number, data layers, dimension, time, data length, etc.

Process of normalizing data formats

It is difficult to use hierarchical color to render vector field directly. The wind field and the wave field are the general vector fields of marine, which are usually stored in NetCDF format that need to be processed and normalized. Data normalization process is as follows:

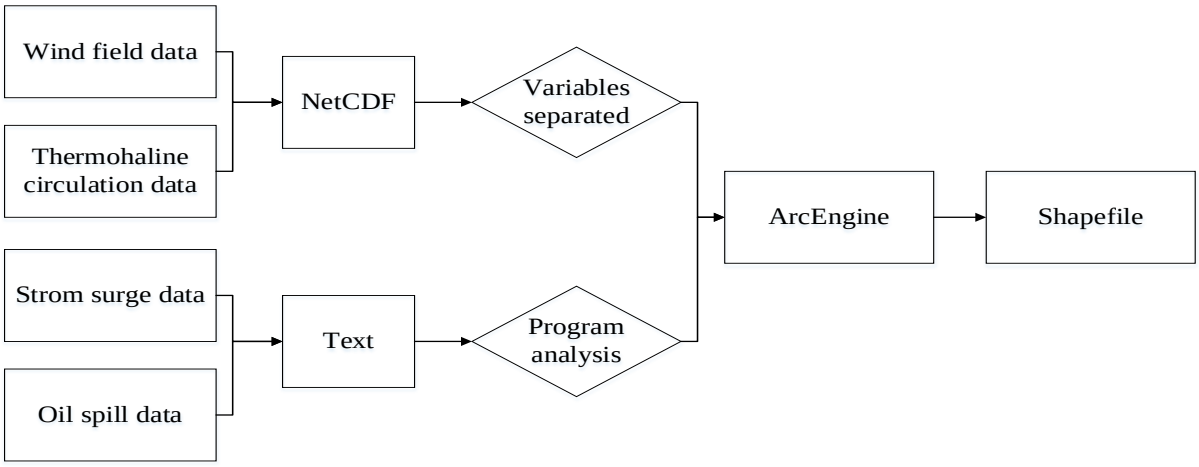

Fig.1. Data normalization flowchart

The three-dimensional thermohaline circulation data contains many parameters, but not all the variables are useful for visualization, so that the first step is to select the useful variables. NetCDF or GDAL/OGR parsing library can be used for data parsing, we use the NetCDF official parsing library for the data parsing. Then turn it into shapefile, a standard format of GIS, by using the ArcEngine interface of secondary development. We should pay attention to the consistency of the spatial reference in the process of data normalization.

The NC files require three variables in the process of reading. ID is the unique identifier for the read variables. Status indicates whether the operation is successful. And the other is the variable to be read. We can easily access to all variables according to the method described above.

The design and development of visualization system for marine early warning products

The visualization system for marine early warning products is a comprehensive system which integrated a number of technologies, such as GIS technology, computer technology, database technology and the marine environmental early warning technology.

The architecture of visualization system for marine early warning products

The architecture meets the user's business needs. The users are usually divided into two categories. One is the business staffs, who are usually responsible for the maintenance and update of system database, and the production and distribution of the early warning maps and background controls. The other is the public, which require the visualization system to have a good results browsing ability. The logical structure of the system is shown in figure 2.

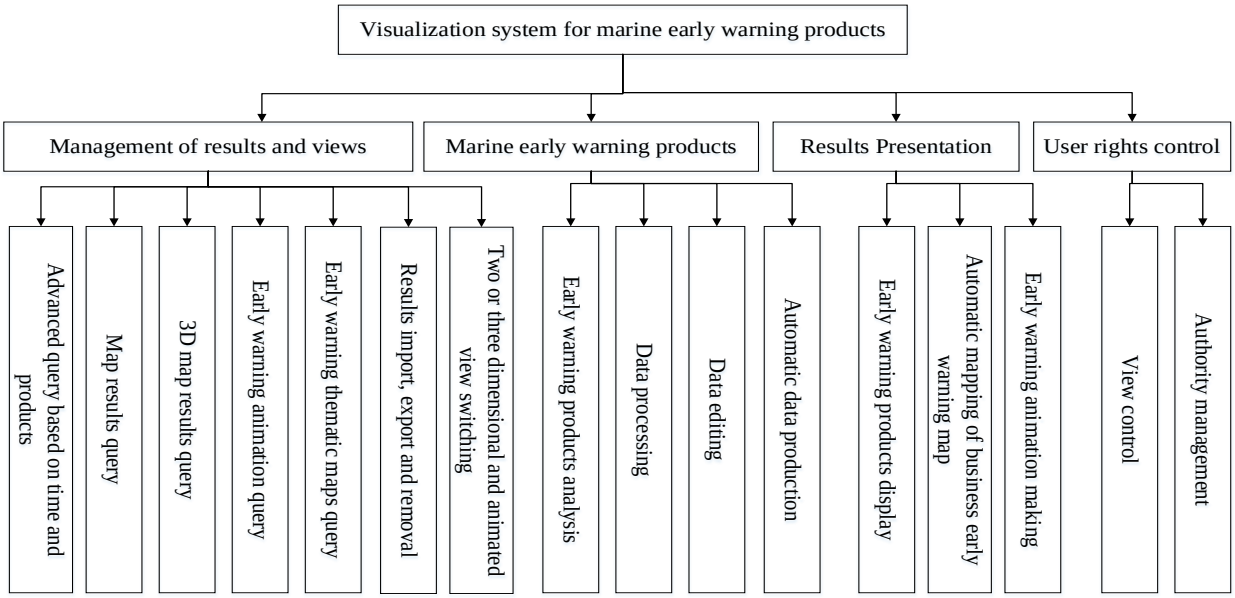

Fig.2. The logical structure of the system

As a modular system, the integrated visualization system for marine early warning products based on GIS provides a good environment for the reuse of modules and secondary development with the favorable flexibility. Users can expand a variety of new functions according to personal needs.

The traditional single machine structure or the two layers C/S model can demote efficiency of the data process because of the large capacity and frequently update of the marine early warning data. The three layers C/S model solved this problem well, that means using the structure of Client--Application server-Database server, as shown in figure 3. The client includes UI and simple logic process functions. The server is divided into two parts: application server and database server. The application server implements the core functions, such as the network communication management, the data exchange scheduling, the model database management, and the template database management. The database server is responsible for the storage and management of basic data, and provides data layers support for the application server.

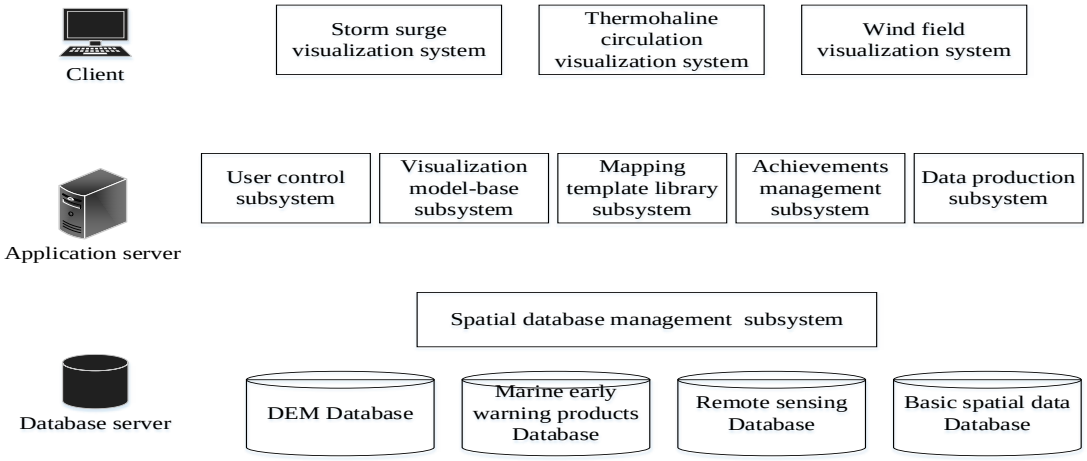

Fig.3. The overall frame of the system

The visualization system for marine early warning products can not realize the comprehensive operation for many kinds of data due to the diversity of data source and data formats. This system has completed the data normalization process by using NetCDF development library and GDAL open source engine for data interoperability. The normalized data types include remote sensing images data, text data, NetCDF data and other data types. On the basis, the data is stored in geodatabase for management together.

The achievement of visualization system for marine early warning products

The marine elements have 3D characteristics which is the concept of three-dimensional field. Two dimensional visualization has the characteristics of direct viewing, simple, easy to disseminate and publish. However, 2D visualization is a dimension reduction for three-dimensional space information. As a result there will be a loss of information. Three dimensional visualization is more consistent with human visual perception, the system has realized the 2D and 3D integrated display for different data, which meets the requirement for the cartographic representations and the visualization display for marine elements, and on the basis, GIS spatial analysis techniques, such as 3D profile analysis, have realized.

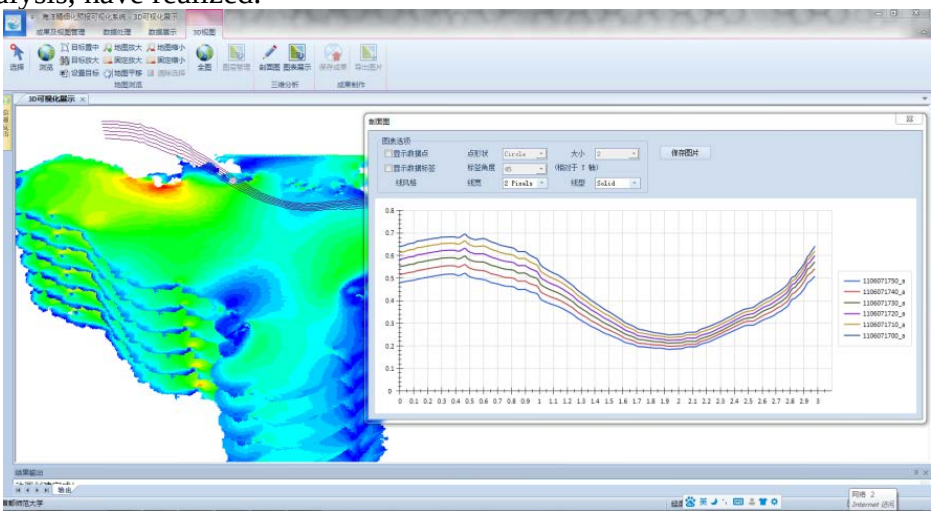

Fig.4. 3D profile analysis

The system has developed a thematic map template library in order to publish the thematic map for early warning products rapidly. The early warning product thematic maps which based on different requirements of time and elements will be rapidly completed through the dynamic scheduling of the template library. The paper made the early warning product templates for different elements by using ArcGIS and saved the configuration files as a map documents which

can be used again by replacing the regional data and dynamic scheduling of different factors. As a result, the thematic map for early warning products will be published rapidly.

Hierarchical rendering which based on the dimension attribute of the element directly affects the final results of visualization in the process of rendering for marine elements especially in the process of drawing. The dynamic hierarchical rendering technology was used in the system which based on statistical information. Gathering statistics of classified attributes for multiple time series elements, then the color rendering will be dynamically determined according to the maximum and the minimum value and the distribution of different attribute values in the total time series which avoiding the color to be too dark at certain moments in the process of rendering hierarchical for fixed ribbon. The final results for current field early warning maps in six consecutive time are as follows.

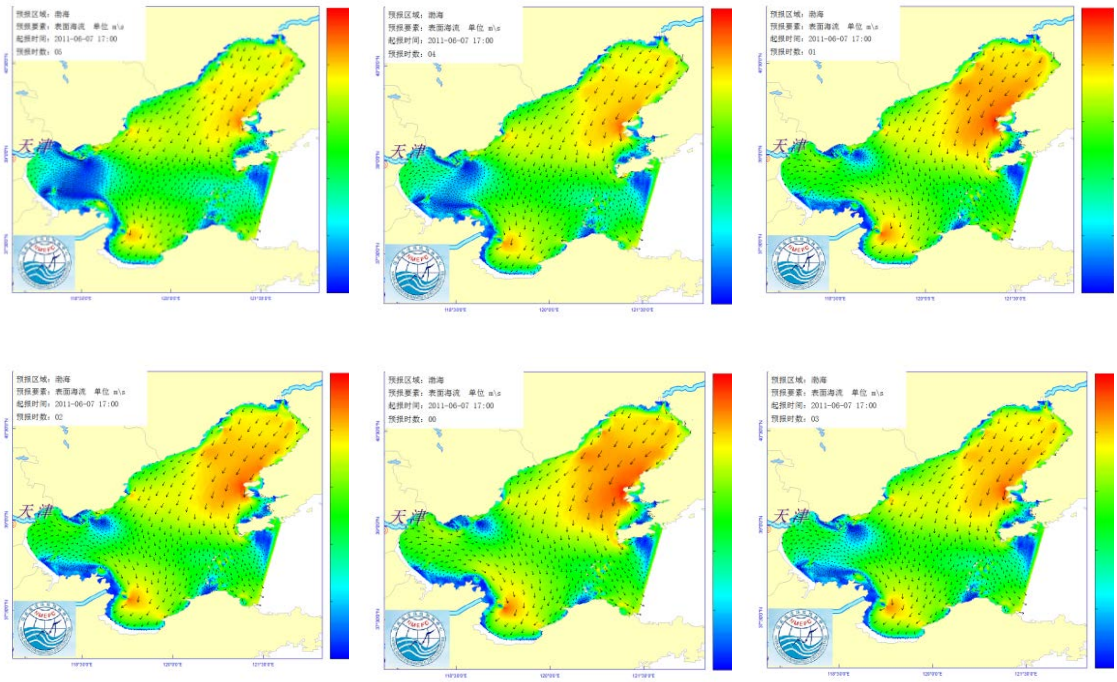

Fig.5. The maps for dynamic hierarchical rendering

Conclusion

The visualization system for marine early warning products which based on MFC framework and ArcEngine development kit and used C# development language, GDAL and NetCDF functions libraries, realized data production, results presentations, automatic drawing, 3D profile analysis and other functions. The development of the GIS based visualization system for marine early warning products can effectively improve the present situation for China's marine early warning products' publication which relying on matlab and other general softwares for simple geographic mapping. It is helpful to mining information for marine early warning data and improve the marine management abilities.

There are still some problems to be resolved due to the limited of personal ability.

a) The expression methods of vector field also include streamline traced method, texture and feature based method, besides the direct expression method. These methods need to be further studied.

b) 3D visualization abilities need to be strengthened, and methods of three-Dimensional roaming and information query need to be further studied.

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