The Evaluation System Design of GIS-Based Oil and Gas Resources Carbon Emission Database Management

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Abstract. Due to the importance of research on carbon budgets in natural processes, it is critical to be able to effectively manage and process all types of data in order to get measure carbon emissions. For this purpose, data produced in oil and gas exploration and natural processes are the focus of this research. Various tools are used including Oracle11g for data storage, Arc Engine combined with Microsoft Visual C# among others including C++ and the Database Storage Management Platform with GIS software functions. The IPCC algorithms are the most important reference, combine this with actual events, a new calculation model about oil and gas resources carbon emission was constructed. This model will analyze and predict the amount of carbon emissions in the oil and gas production in the future. Putting the new calculation model into the Database Storage Management Platform, an Intelligent Prediction Database Platform contained the new calculation model was established.

1. Introduction
Since the Industrial Revolution, due to the human activity, it has caused the increase of global greenhouse gas emission. During the process, carbon budget in the natural process has an important influence on atmospheric Carbon Balance. It became one of the reasons which caused the global climate change. United Nations Climate Change Conference held in Copenhagen, Denmark, in December 2009, China has promised to the world that the intensity of carbon emission per unit GDP based on 2005 would be decreased to 40% to 45% by 2020. The impact assessment of construction project’s carbon emission can provide a reasonable reference for carbon emission reduction during the project, and it will also contribute to the development of low carbon economy.

The research about the influence of carbon emission started abroad in the twentieth century after the first oil crisis. Ang\textsuperscript{1} has used Index Decomposition Analysis method to prove and analyze how industrial structures impact the energy consumption. Davis\textsuperscript{4} has analyzed the reason why the energy intensity and carbon emission intensity of the United States declined from 1996 to 2000. Guyana is one of the South Africa National which has used the enterprise-level geographic information system (GIS) technology of ESRI in the United States to draw up the first nation-level low-carbon development strategy (LCDS) in the world. The core technology for monitoring, reporting and verification (MRV) system is GIS. NASA\textsuperscript{2} has designed a satellite (Orbiting Carbon Observatory) which can trace out...
details of the atmosphere carbon emission and can also determine the specific location of carbon dioxide emission and absorption on the earth's surface.

Domestic carbon emission research began in 1990s. Many scholars has proved and analyzed their impact on carbon emission in macroscopic scale (country) and medium scale (provincial administrative region), from the point of view of the population, the level of economic development, energy intensity, energy consumption per unit of GDP, energy consumption structure, industrial structure and urbanization level\(^5\), foreign trade level and other factors. They have mainly analyzed the relationship between carbon emission and economic growth\(^5\), the relationship between energy use and carbon emission, the influence of the CO\(_2\) collected sequestration to carbon emission reduction, the economic impact of carbon emission and so on. They have used methods such as the time series analysis method\(^5\), the correlation analysis method, the decomposition analysis method, the model analysis method\(^6\), the grey correlation analysis method, causality analysis method, etc. These studies have effectively promoted the work of energy-saving and emission-reduction. Simultaneously they have played an important role in rich and innovative research methods.

The system from the perspective of GIS technology integration in the field of carbon emission to study one part of carbon budget’s problems in the natural process—carbon budget in Oil and Gas resources development process. Various types of data which was produced from the sample, the test, the simulation, the forecast, the assessment of the Oil and Gas resources carbon emission carbon has been stored and managed effectively. Then nationwide estimate about the Oil and Gas resources carbon emission has been carried out by spatial information technology. Lastly the system can generate the final analysis report.

2. The design and construction of Database Management Evaluation System

The study of GIS combined with professional models has become a hot spot in GIS applications. GIS combined with the professional models in carbon emission areas, which is based on Geodatabase, uses the geographical model analysis method and combines with the related knowledge in carbon emission field, has achieved the integration analysis of space attribute, display and output of carbon emission spatial data.

2.1. The architecture of the system

The Oil and Gas Resources Carbon Emission Database Management Evaluation System which had fully considered the flexibility of data, had tried to establish a reliable and open geographic information database. It had been not only provided a relationship between elements closed computer system. So it had used Access2007 as the front–end attribute data acquisition software. Access2007 as a Microsoft released relational database management system has powerful data import and export function. It can export to Word, Excel, PDF, XPS and other formats, so users can be use it repeatedly.

In the mean time, there are a large number of spatial data associated with the system and data related to the spatial position, such as vector diagram, remote sensing image data, statistical data, etc. in order to manage all kinds of data. So the system has chosen the ArcSDE and Oracle11g for terminal storage all the attribute data and spatial data to build a Database Storage Management Platform.

Oracle11g had been used as a client/server database to centrally control and manage data. Meanwhile, it had completed processing the query on the server. And then it would send the results back to the work station. Due to the server software doesn’t display the data to the user by itself, Access2007 as the front-end of the client/server database can retrieve data from the database server and display as the statements, data sheets or diagrams. If the user has updated data in the form of Access2007, we would use the method of assessing to the client/server database Oracle11g to send the updated data back to the back-end database.
ArcSDE as the engine of ArcGIS space data is the path of storing and managing space database of many users in the relational database management system (RDBMS). Database is the back-end storage center of ArcSDE. Moreover, ArcSDE provides the fast spatial data access for the front-end GIS applications. Fast reading mass data and storing data safely and efficiently is the most important feature of ArcSDE. Combining with ArcGIS Engine, using Microsoft Visual C# as development environment, it has incorporated GIS function into the existing Database Storage Management Platform, has been created a custom application and finally has been formed a Database Spatial Analysis Platform.

There have been eight function modules in the Database Spatial Analysis Platform. They are the data management module, the data statistical analysis module, the spatial query module, the space simulation analysis module, the carbon data visualization module, the carbon emission mapping module, the carbon emission intelligent prediction module, the user management module.

The model algorithm tool that the system needs has been developed by Microsoft Visual C++ development environment. Based on this, we would call the data in the Database Storage Management Platform to construct an Intelligent Prediction Platform. The Intelligent Prediction Database Platform mainly provides the carbon emission simulation algorithm in Oil and Gas Resources and uses the feature algorithm model and analyzes a large number of historical data to predict the amount of carbon emission produced by Oil and Gas development process.

The Database Storage Management Platform, the Database Spatial Analysis Platform and the Intelligent Prediction Database Platform have worked together to construct the Database Management Evaluation System.

**Figure 1.** The main function modules of the Database Spatial Analysis Platform

**Figure 2.** The Master Flowchart of the Database Management Evaluation System
2.2. The collection and organization of carbon emission data

Systematic, rigorous and scientific classification and coding of carbon emission in the natural process is a prerequisite for systematic and scientific research. Considering the classification of coding methods in Geology, Soil Science and Oceanography, we have tried coding the data of the Oil and Gas resources carbon emission. According to the frame design of the Oil and Gas Resources Carbon Emission Database Management Evaluation System, basing on the understanding of the actual situation of the Oil and Gas resources carbon emission, consulting literature, investigating and studying the contents of the Oil and Gas resources carbon emission data, we have worked out a data dictionary which provides guidance for the operation of the related parameters for the Oil and Gas development field. The main content of the data dictionary has included the Fieldname, the data type, the data description, the determination of the key, the definition of the required field and the determination of relevant entity relationship.

The system input data has included various types of sample data and related test and analysis data which would be collected from the top-five typical Oil and Gas fields including the South China Sea and the Sichuan Basin, the Turpan-Hami basin, the Bohai Bay Basin and the Songliao Basin in 2010 to 2015. These data have been distinctly stored in six data sheet which are the air sample collection record sheet, the natural gas leakage on-site detection record sheet, the Oil and gas sample collection record sheet, the sample picture record sheet, the sample component measurement/simulation analysis record sheet, the sample carbon isotope test analysis record sheet.

2.3. The introduction of algorithm model

These data contain the various types of sample data collected from the top-five typical oil and gas field, the related test and analysis data, a huge number of production statistics data, the infrastructure data and the space image data of the formations or the basins where the top-five typical oil and gas field are located, so the data has been processed by a hierarchical calculation method.

First of all, the formation or the basin where the oil and gas field located have been classified and accounted for its area. Secondly, we have used the production statistics data to find out the type of equipment in different kinds of format or the basin, the number of wells and the annual output of oil, the length of the gas pipeline and the annual output of gas, the type and quantity of compressor and the number of well blowout, pipeline rupture and other accidents. Finally, all kinds of sample data collected in the field and related test and analysis data have been used to calculate the value of each production statistics data type corresponding emission factor in the various types of basin.

The value of specific carbon emission per year \[ E = \sum EF \cdot A \cdot B \cdot F \] (1)

Where:
- \( E \) = the value of carbon emission per year (Gg)
- \( EF \) = the production statistic data to find out the type of equipment in different types of formation or the basin
- \( A \) = the value of the production statistic
- \( B \) = the number of the same type basin
- \( F \) = the total area of the same type basin/the area of the tested basin
Figure 5. The attribute table

Figure 6. The data management interface

Figure 7. The user management interface

The standard Windows styles selected as the main interface of the Oil and Gas
Resources Carbon Emission Database Management Evaluation System.

A variety of function windows can be easily drawn out from the main interface. The following interface elements, provided by the main interface from top to bottom, are the main menu which is used to call up a variety of function windows, the toolbar which is used to fast tune out the common function window, the title bar and the status bar which are used to display the current state of the software.

3. Conclusion

Through the analysis of the system, we can make the following conclusions:
1) The establishment of the Oil and Gas Resources Carbon Emission Database Management Evaluation System is an important part of the study of carbon budget in the natural process and an exploratory attempt. The system will provide a good computer simulation support to the research of carbon budget in the natural process.
2) Scientific data structure and database management is the foundation and the key to set up a platform to display various achievements.
3) Setting the buffer and using several spatial interpolation methods, the carbon emission data on every observation point can lead to the nationwide results. It’s very scientific to compare the different data of carbon emission concluded by various methods.

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