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Xin Zhang
Lei Wang
Xiaoyi Jiang
Changming Zhu *Editors*

Modeling with Digital Ocean and Digital Coast

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Charles W. Finkl
Department of Geosciences
Florida Atlantic University
Boca Raton, FL 33431, USA

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Changming Zhu
Editors

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Editors
Xin Zhang
State Key Laboratory of Remote Sensing Science
Institute of Remote Sensing and Digital Earth
Chinese Academy of Sciences
Beijing, China

Xiaoyi Jiang
National Marine Data and Information Service
State Oceanic Administration of China
Tianjin, China

Lei Wang
Institute of Remote Sensing and Digital Earth
Chinese Academy of Sciences
Beijing, China

Changming Zhu
Department of Geography and Environment
Jiangsu Normal University
Xuzhou, Jiangsu, China

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Preface

The Earth is the only known blue planet in the universe. Approximately 71 % of the Earth's surface is covered by oceans, which operate as an elementary component of the global life support system and act as a balance for the human resource treasury and environment. Coastal regions all over the world are densely populated. Oceans and coastal regions are changing at faster rates, over broader scales, than ever before and in fundamentally new ways. Digital analysis based on multisource data can greatly improve the knowledge about the oceans and coasts. The data are obtained by diverse observation systems such as satellites, airplanes, ships, high-frequency ground-wave radars, buoys (moored and drifting), and land-based stations. Though there are many global information systems, such as Google Ocean, which can provide information, such as videos of ocean life, and allow the public to watch unseen footage of historic ocean expeditions, more studies should be carried out to meet the requirements of scientific research and governmental applications, especially from the Digital Ocean and Digital Coast perspective.

Based on various types of data analysis of the ocean, including survey and evaluation data, historic data, basic geographic data, remote sensing data, socio-economic data, and model estimate data, the specific content of the Digital Ocean and Digital Coast system construction modeling theories and technologies is included in this book. The modeling theories and technologies in this book are described from data, computation, analysis, application, and decision-making perspectives.

As modeling with Digital Ocean and Digital Coast relates to a number of research areas on a technical level, such as remote sensing, geographical information systems (GIS), virtual reality, scientific data visualization, computer network, geodesy, and data warehouse, the study content of modeling with the Digital Ocean and Digital Coast is introduced in Chap. 1 by Xin Zhang, Lei Wang, Xiaoyi Jiang, and Changming Zhu. Then ocean big data characteristics, acquisition, integration, and web service technologies are introduced in Chaps. 2 and 3 by Xin Zhang. In Chaps. 4, 5 and 6, the coastal flood forecasting modeling and analysis, coastal flood frequency modeling, spatial decision-making, and analysis theories and technologies are introduced by Lei Wang and Xin Zhang. In Chap. 7, the ocean and coast disaster data modeling technologies are introduced by Xin Zhang. Chapter 8 by Changming Zhu and Xin Zhang investigates several new methods, including coastline automatic extraction, intertidal zone identification, coastal wetland classification, and coastal invasive plant detection using remote sensing. In the end, some applications and practical achievements of Digital Ocean and Digital Coast study in the China Offshore Digital Ocean Information Infrastructure Program are introduced by Xiaoyi Jiang.

In terms of modeling with Digital Ocean and Digital Coast, these preliminary results and applications push Digital Ocean a step forward from an unrealized concept to realistic systems. For more powerful Digital Ocean and Digital Coast studies and applications, more in-depth future research is needed.

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Chaoyang District, Beijing, China — Xin Zhang
Chaoyang District, Beijing, China — Lei Wang
Hedong District, Tianjin, China — Xiaoyi Jiang
Xuzhou, Jiangsu Province, China — Changming Zhu

Contents

Chapter 1
Introduction

Xin Zhang, Lei Wang, Xiaoyi Jiang, and Changming Zhu

Abstract The oceans are an important part of the earth that is a treasure house of resources and an important regulator of the global environment. There is a great part of the human being living in the coastal region all over the world. Oceans and coastal regions are changing at faster rates, over broader scales, than ever before and in fundamentally new ways. Digital analysis based on multisource data can greatly improve the cognition about the oceans and coasts, which are from diverse observing approaches such as satellites, airplane, ship, high frequency ground wave radar, buoys (moored and drifting) and land-based stations. This chapter briefly describes the concepts of the digital ocean and digital coast (DO&DC), discusses the modeling and visualization technologies for the realization of the DO&DC system, and notes the important roles of the DO&DC in digital earth development.

Keywords Digital ocean • Digital coast • Digital earth • Modeling

X. Zhang (✉)
State Key Laboratory of Remote Sensing Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100101, China
e-mail: zhangxin@radi.ac.cn

L. Wang
Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100101, China

Hainan Province Key Laboratory of Earth Observation, Sanya Institute of Remote Sensing, Sanya 572029, Hainan Province, China
e-mail: wanglei98@radi.ac.cn

X. Jiang
National Marine Data and Information Service, State Oceanic Administration of China, Tianjin 300171, China
e-mail: andyjiangxy@126.com

C. Zhu
Department of Geography and Environment, Jiangsu Normal University, Xuzhou 221116, Jiangsu, China
e-mail: ablezhu@163.com

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1.1 Digital Earth

Advances in the past few years have demonstrated that many aspects of the Digital Earth (DE) that Al Gore envisioned in 1992 and later described in his 1998 speech are now technically feasible (Goodchild 2008). Chen and Genderen (2008) state that DE is an integrated approach to build the next level of scientific infrastructure to support global change research. They present a number of examples, including cover forest and grassland fires, desertification and sandstorms, deforestation, forest carbon sequestration, wetlands conservation, the observation of migratory birds for the spread of avian influenza (bird flu), the Tibet Plateau uplift, the rise of sea levels, and underground coal fires. In terms of DE's potential fields of applications, Guo et al. (2009, 2010) studied the DE prototype system DEPS/CAS and, through this research, defined DE systems as either scientific systems (such as the World Wind of the USA, the DE Prototype system/Chinese Academy of Sciences (DEPS/CAS) of China, the Blue Link and the Glass Earth of Australia, and the Earth Simulator (ES) of Japan, among others) or commercial systems (such as Skyline and Google Earth) and proposed that DE is a comprehensive platform for the integration of future information resources. Wright et al. (2010) presented a methodology for visualizing reconstructed plumes using virtual globes, such as that of Google Earth, which allows the animation of the evolution of a gas plume to be easily displayed and shared on a common platform. Yasuko et al. (2010) developed a visualization system (KML generators) for multidisciplinary geoscience data that visualizes seismic tomographic models, geochemical datasets of rocks, and geomagnetic field models by exploiting Google Earth technologies. Chen et al. (2009) put forward a solution to render the vertical profiles of atmospheric data from the A-Train satellite formation in Google Earth, using data from the NASA Cloud satellite as a proof-of-concept. However, these authors have not yet solved the problems facing the exploration and visualization of three-dimensional ocean data on visual globes.

DE is a powerful digital information world that can be accessed of space-time data of the earth in a virtual form (Vahidnia and Alesheikh 2013). With the development of technology, science has entered into an era of big data in which early research on the earth does not meet development of the earth's needs (Chaowei Yanga et al. 2013; Guo 2013). In the digital information era, huge volumes of geo-referenced data can be transformed into useful information that can be analyzed, visualized and shared and is of great interest to scientists (Manfred Ehlers and Peter Woodgate 2014). Guo (2013, 2014) noted that the use of DE technology can address real world human challenges (e.g., climate change, natural disasters, and urban expansion, and in the cloud computing platform), support dust storm forecasting, soil erosion monitoring, and forest disaster prevention (Peng Yue and HongxiuZhou 2013; Ick-Hoi Kim and Ming-Hsiang Tsou 2013). Lars Bernard and Stephan Mäs (2014) noted that scientific GDI (geodata infrastructures) could become one of the core components in the future DE. Yingjie Hu and Zhenhua (2015) proposed making 3D models, virtual earth map layers, remote sensing images, digital elevation models (DEMs), and other data formats to build the DE system in a unified virtual environment.

DE is becoming a global challenge and a widespread leading field in science and technology. It is a comprehensive embodiment of a country's science and technology, economic strength, and national security safeguarding ability is and also one of the important signs of a country's comprehensive national strength. DE has a very vigorous life-force and is a global strategic goal of science and technology development. DE is a comprehensive platform and integration of future information resources. In many ways, DE, as a collection of technologies, has integrated the huge and valuable body of geo-data resources. It will prove to be an important area of research in the coming years (de By and Yola Georgiadou 2014; Yingjie Hu and Zhenhua 2015), but we are also facing a series of challenges such as big data storage, communication and processing (Guo 2014, 2015; Chris Pettit and Arzu Coltekin 2015).

1.2 Digital Ocean

The Earth is the only known blue planet in the universe. Approximately 71 % of the earth's surface is covered by ocean, which operates as an elementary component of the global life support system and acts as a balance for the human resource treasury and environment. Oceans and, indeed, the entire planet, are changing at faster rates, over broader scales, than ever before and in fundamentally new ways. In a very short period of time, the bounty of oceans has been depleted, and the ocean ecosystems have become seriously disrupted (Wright et al. 2007). The bounty and circulation of the oceans makes the study of the problems of rising sea levels, warming seawater, increasing storm intensities and other issues important from a global perspective. Since 2005, the Global Earth Observation System of Systems (GEOSS) has been implemented to achieve comprehensive, coordinated and sustained observations of the Earth to increase our understanding of the Earth's processes and to enhance the prediction of the behavior of the Earth system (GEO 2005). As the oceanographic component of GEOSS, one objective of the Global Ocean Observing System (GOOS) is to foster the development of data management systems that allow users to exploit multiple data sets from many different sources through "one-stop shopping" (Thomas 2003). The purpose of the Integrated Ocean Observing System (IOOS) is to make a more effective use of existing resources, new knowledge and advances in technology to provide the data and information required for global or regional scientific studies (Ocean.US 2002). As the National Science Foundation's contribution to the U.S. IOOS, the Ocean Observatories Initiative (OOI) will construct a networked infrastructure of science-driven sensor systems to measure the physical, chemical, geological and biological variables of the ocean and seafloor. Greater knowledge of these variables is vital for the improved detection and forecasting of environmental changes and their effects on biodiversity, coastal ecosystems and climate (COL 2009). In the future, ocean information will become an increasingly valuable commodity worldwide because of the role of maritime commerce and new ocean-related investments, vulnerability to ocean-related natural disasters, the need to provide security for coastal populations, and the challenges of providing food and water to more people (Interagency Ocean Observation Committee 2013).

The term of DO emerged after the DE program was proposed by Al Gore (1998). The DO is the embodiment and re-innovation of "DE" theory and technology for the oceans of the world (Hou 1999). Patrikalakis et al. (2000) studied a knowledge network of distributed heterogeneous data and software resources for multidisciplinary ocean research that brought together advanced modeling, observation tools and field estimation methods. However, these authors did not discuss the integration of the technologies based on the global visualization of the Earth. Su et al. (2006a, b, c) studied the technologies of ocean GIS and proposed the benchmarks and the key technologies of a China DO Prototype System. As a public application platform, Google Ocean (www.googleearth.com) can provide much educational information, such as videos of ocean life, and allow the public to watch unseen footage of historic ocean expeditions, but the site has many shortcomings for scientific research and governmental applications. There have been many visualization systems for regional ocean data developed using OpenSceneGraph, including the Regional Ocean Modeling System (ROMS) (Shen et al. 2007), but there are many other technologies that can be researched from the DO perspective.

Based on various types of data about the ocean, including survey and evaluation data, historic data, basic geographic data, remote sensing data and business data, the specific content of the DO includes the researching and developing the DO sphere system for social and business management services based on the earth sphere model to achieve the interactive 3D visualization, reproduction and prediction of various ocean subsystems (such as the seabed, water, and sea surface) and phenomena. The DO system can be divided into two versions, "management" and "public service", based on the analysis of the demand characteristics and application modes of different user groups.

The DO system can complete the integration of small-scale geographic data and thematic data of the ocean based on the earth sphere model. It can also realize the dynamic update of the ocean monitoring and forecasting information. The DO system can be used to achieve a variety of expressions of regional data and query and retrieval of ocean information and data. It can also display and distribute business information generated in the process of ocean management.

The DO public service system is designed to satisfy public information inquiries and share science knowledge and information products on Internet. They depend on the data integration of large-scale ocean basic geographic data, thematic data and real-time updated observing and forecasting information. The DO public service system applications span a variety of aspects, including sea and island management, ocean environmental protection, disaster prevention and mitigation, economy planning, law enforcement monitoring, rights and interests maintenance, science and technology management, and fisheries.

1.3 Digital Coast

The coastal zone is a special area that is under the effect and interaction of land and sea. Under the background of the global sea level rising, the coastal disasters seriously threaten the survival and living environment of the coastal zone living things. The dynamic monitoring of the coastal zone has gradually become a hot research topic in related research fields.

The coastal zone has abundant energy resources such as tidal energy, wave energy, and wind energy et al. It also has many biological resources such as reeds, seaweed, ocean microorganisms, mangroves and fish and many natural resources such as groundwater, seawater, minerals, beaches, and shoreline et al. However, the coastal zone can be subject to many natural disasters such as storm surge, typhoons and slow-onset disasters including coastal erosion, sea water intrusion, land subsidence, sea surface elevation, and estuary and harbor sediment deposition. It is difficult to use traditional methods to monitor the environment, especially large-scale coastal monitoring because of the characteristics of uncertainty in the surrounding coastal environment. With the development of remote sensing technology, more and more fields have been introduced. Remote sensing technology is large-range, short period and multi time phase, making coastal zone dynamic monitored in convenient and quick style.

Digital coast is an extension and application of the DE theory and technologies in the coastal zone, and it is a product of information technology development and application.

Under a broadband, high-speed computer information network environment as an information infrastructure, Digital Coast system takes a mass storage and distributed computing system to manage and process the ocean data.

As for the theory study, Digital Coast should study the method of water quality monitoring and analysis technologies systematically. It should research the change and development trends of coral reefs, mangroves and coastline, as well as the ocean oil spill pollution monitoring.

Digital Coast system can realize 3D visual expression and localization of high-precision satellite images, vectors data and terrain data of the offshore area and islands. It can take advantage of the ocean scene simulation function to show the real-world islands by integrating ocean water, ocean scene, coastal landscape, seabed topography and so on.

From the query and display of ocean usage information about the current situation, historical situation, statistics, and functional region division information in the different theme modules, we can achieve the functions of query, retrieval, location and statistical analysis of all types of information.

Based on the survey data from the islands and coastal zones in the ocean island theme, we can fulfill a variety of island information queries (such as location, area, length of coastline, and population), as well as the visualization of island images and terrain. Aimed at the ocean rights and interests, we can demonstrate the political, economic and military interests of a country and its neighboring countries from the aspects of the political situation, economic situation, military situation. We can also browse and view the interests of the island terrain, high-precision images, profile information, multimedia information and its relevant attribute information. For the polar ocean theme, we can achieve the display, query and 3D landscape simulation of the polar expeditions. The previous tracking information, thematic polar information, and research stations visualization can also be viewed.

1.4 Modeling with DO&DC

Modeling with DO&DC is the important content to build a digital information system. The process of using a model to describe the causal and interrelation is called modeling. The means and methods to achieve this process are varied, as there are different ways of describing the relationship.

Modeling with DO&DC mainly focuses on system applications and data modeling. The main contents of the modeling include determining the data and related processes, defining the data structure, numerical simulation and forecasting modeling, data organization and storage modeling, system application modeling, and so on.

Modeling with DO&DC relate to a number of related research areas on the technical level, such as remote sensing, GIS, virtual reality, scientific data visualization, computer network, geodesy, and data warehouse.

Modeling with the DO&DC includes:

1. DO&DC is a new concept and application model from the application level of the earth sphere model. It requires DO&DC transition from theory to practice and a break from concept to engineering application entity;
2. From the perspective of data integration in the global sphere, DO&DC cover the major data types in the ocean areas, such as ocean survey data, model forecast data, pattern prediction data, space remote sensing data, aerial remote sensing data, basic geographic data, business approval data, and statistical data;
3. In the space region, DO&DC covers oceans, the polar regions, key ocean areas, the islands and coastal zones, and the vertical dimension of the space related to the expression of the main elements (seabed, water, sea surface, and sea islands);
4. In the application services, DO&DC covers the major areas, including ocean comprehensive management and macro decision-making, the ocean economy, ocean disaster prevention and mitigation, ocean fisheries, ocean dynamic environment, and ocean homeland security and maintenance;
5. Aimed at the two demand groups of ocean thematic business and information services groups from the perspective of application service groups, it needs to put forward unique system programs of research and development, which have a strong relevance and practicality;

6. The system development should be based on the requirements of business applications. It has realized the development of various elements' multi-dimensional expression to study the visual expression of different types of ocean and ocean phenomena;
7. Research on the true 3D Earth sphere model space parameters integrated the feature in electronic chat and its construction technology;
8. Research on ocean real-time monitoring data management is based on the earth sphere model and application integration technology to achieve a unified space-time management and application integration of multi-source monitoring data;
9. Study of the data model of the process of the typical EI Nino phenomenon and the sea level rise based on the earth sphere model;
10. Research data loading and sphere integration techniques based on the cloud service architecture under a distributed network environment;
11. Research on the integration, process analysis, feature mining, and application service technology of large ocean space-time data.

1.5 Virtual Visualization Application in DO&DC

Virtual visualization is the interactive processing theory, algorithm and technology research branch of visualization technology, which is based on computer image processing and graphics technology converting the scientific computing data, engineering calculation data and measurement data into graphics or images drawn on the screen. Using virtual visualization technology, we can transform the spatial data into a graphic image, to help people to address and identify its characteristics and rules and to understand the nature of laws. The virtual visualization can be applied in many areas of ocean research.

1.5.1 Research of Global Climate Change

The visual simulation of ocean circulation phenomena is crucial for the analysis and prediction of global climate change and the effect on the oceans. The oceans regulate the climate of the earth's land and the height of the oceans, the air dry or wet effect, and control of the wind speed and direction. Thus, the modeling and visualization of ocean temperature changes can help scientists understand the impact of climate change and predict future impacts on human activities. The research results of the modeling, simulation and visualization of the spatial analysis of global warming, El Niño, sea level change, carbon cycle, ocean circulation variability and other global climate changes in the research field could provide support services for international negotiations on climate change.

1.5.2 Management of Fisheries and Ocean Biology

The DO is capable of showing the ocean nature to reveal the living environment and ocean organism behavior. It can also be used to study the ocean habitats and explore the ocean resources.

1.5.3 Ocean Emergency Decision-Making

Under the information of wind field, flow field and the temperature field emergency incident background information, real-time monitoring information, all kinds of statistical information (surrounding economic losses, casualties and ecology destruction), we can build all types of ocean emergency (oil spill, hazardous chemicals leakage, leakage of nuclear, maritime) contingency plans and impact assessment models to realize the dynamic visualization expression to evaluate the emergency influence and assess the thematic information products made from the impact of unexpected events. By assessing the impact of emergency situation, it is possible to make an assessment of thematic information products.

1.5.4 Ocean Scientific Research Field

Using DO&DC data resources and computing resources integrated ocean numerical model, GIS spatial analysis model, ocean phenomena visualization model and other ocean research and development model to provide a virtual platform for scientific research users to load and test the mechanism of the ocean phenomenon, simulation and comprehensive analysis of scientific research results.

1.6 Conclusions

DE could provide support to social and economic development. On the one hand, it can support the overall sustainable development of a country, and on the other hand, it is closely linked to the integration of research on global change, resources, and environment as well as on global economic unifying processes.

DO&DC construction is a long-term engineering with strategic and prospective, and the modeling theories and technologies research is the core of the whole engineering. In future work, we should actively carry out strategic planning on DO development and establish the management and service system of ocean and coast information resources, as well as build up the information exchange and share channels.

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Chapter 2
Ocean Big Data Acquiring and Integration Technologies

Xin Zhang, Lei Wang, Xiaoyi Jiang, and Changming Zhu

Abstract Digital Earth is an integrated approach building scientific infrastructure. The ocean data is a typical big data, which can be seen from the data volume, velocity, variety, and value perspectives. The Digital Earth systems provide a three-dimensional visualization and integration platform for ocean big data, which include ocean management data, in situ observation data, remote sensing observation data and model output data. Based on the analysis on the characteristic of ocean big data, this chapter studies the ocean big data acquire and integration technology that is based on the Digital Earth system. Firstly, the construction of the Digital Earth based three-dimensional ocean big data integration environment is discussed. Then, the ocean management data integration technology is presented which is realized by general database access, web service and ActiveX control. Third, the in situ data stored in database tables as records integration is realized with a three-dimensional model of the corresponding observation apparatus display in the Digital Earth system using a same ID code. In the next two parts, the remote

X. Zhang (✉)
State Key Laboratory of Remote Sensing Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100101, China
e-mail: zhangxin@radi.ac.cn

L. Wang
Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100101, China

Hainan Province Key Laboratory of Earth Observation, Sanya Institute of Remote Sensing, Sanya 572029, Hainan Province, China
e-mail: wanglei98@radi.ac.cn

X. Jiang
National Marine Data and Information Service, State Oceanic Administration of China, Tianjin 300171, China
e-mail: andyjiangxy@126.com

C. Zhu
Department of Geography and Environment, Jiangsu Normal University, Xuzhou 221116, Jiangsu, China
e-mail: ablezhu@163.com

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sensing data and the model output data integration technologies are discussed in detail. The application in the Digital Ocean Prototype System of China shows that the method can effectively improve the efficiency and visualization effect of the data.

Keywords Digital earth • Digital ocean • Ocean big data integration

2.1 Introduction

Since the concept of Digital Earth was put forward by Al Gore in 1998 (2010), many studies have been carried out from the perspective of the Earth. In 2002, Skyline Inc. released the Skyline TerraSuite software. In 2004, NASA launched WorldWind version 1.1, marking the first Digital Earth platform software with a complete scientific research function, which provided scientists with a simulation and display platform for conducting Digital Earth research. In 2005, Google Inc. introduced Google Earth to the world, which raised the Digital Earth application to a new level. Google Earth supports the visualization of DEM data and realizes the virtual representation of the Earth. Similar software includes Leica Visual Explorer (LVE) form Leica Inc., the Visual Earth system from Microsoft Inc., ArcGlobe from ESRI Inc., the digital earth prototype system from the Chinese Academy of Sciences and so on (Guo Huadong 2009). In terms of Digital Earth's potential fields of application, Guo et al. (2009, 2010) studied the digital earth prototype system DEPS/CAS and, as a result of this research, defined digital earth systems as either scientific (such as those of World Wind of the USA, the Digital Earth Prototype system/Chinese Academy of Sciences (DEPS/CAS) of China, Blue Link and Glass Earth of Australia, and the Earth Simulator (ES) of Japan) or commercial (such as Skyline and Google Earth) and proposed that Digital Earth was a comprehensive platform for the integration of future information resources (Guo et al. 2009, 2010).

– With the development of ocean observation technologies, a substantial amount of oceanic data and model products are produced from the three-dimensional ocean observation system, which is composed of diverse monitoring sources such as satellite, airplane, ship, high frequency ground wave radar, buoys (moored and drifting) and land-based stations (Ocean 2010). How to efficiently and effectively integrate the data has become an urgent problem because these heterogeneous and widely distributed data and model products are usually collected in a project-based fashion. So far, the primary ocean observation data integration technologies are GIS (Geographic Information System) and web applications (Yingqi Tang and Wong 2006). In America, portals such as the Oregon coastal atlas, SCCOOS portal (Chongjie Zhang et al. 2007), provide clearinghouses for common decision-support tools, as well as data, maps and ancillary information. In Australia, there are several portals: the Oceans Portal proposed by the Australian National Oceans Office (NOO), Australian Ocean Boundaries Information Systems (AMBIS), and CSIRO's ocean data directory – Marlin (Strain et al. 2006). Global-level ocean portals are being developed as well, such as the Oceans Biogeographic Information System (OBIS) – a virtual repository of oceanographic and biogeographic information (Malone 2003). Since 2005, the Global Earth Observation System of Systems (GEOSS) has been implemented to achieve comprehensive, coordinated and sustained observations to improve the monitoring of the state of the Earth, to increase understanding of the Earth's processes and to enhance the ability to predict the behavior of the Earth ocean system (GEO 2005). As the oceanographic component of GEOSS, one objective of the Global Ocean Observing System (GOOS) is to foster the development of data management systems that allow users to exploit multiple data sets from many different sources through "one stop shopping" (Thomas 2003). The purpose of the Integrated Ocean Observing System (IOOS) is to make more effective use of existing resources, new knowledge and advances in technology to provide data and information for global and regional scientific study (Ocean.US 2002). The National Science Foundation's contribution to the U.S., IOOS, the Ocean Observatories Initiative (OOI), will construct a networked infrastructure of science-driven sensor systems to measure the physical, chemical, geological and biological variables of the ocean and seafloor. Greater knowledge of these variables is vital for the improved detection and forecasting of environmental changes and their effects on biodiversity, coastal ecosystems and climate (Consortium for Ocean Leadership (COL) 2009). These achievements have provided data and product resources as well as the communications environment for information sharing and scientific research.

– The ocean management data, in situ observing data, remotely sensed data, and model output are produced in a distributed geographical environment. These data have significant scientific value for scientists and decision-makers in government. There are some studies on distributed geographic information processing that focus on geographic information processing from the Geographical Information System (GIS) view (Yang and Raskin 2009; Yue et al. 2009; Friis-Christensen et al. 2009; Zhang Tong and Tsou Ming-Hsiang 2009; Wang Shaowen and Liu Yan 2009). However, given the relatively high temporal frequency and the intrinsic spatial nature of the data, ocean data integration technology based on the Digital Earth system has not been widely implemented. This study is based on ongoing research in China that seeks to construct the China Digital Ocean Prototype System (CDOPS) as part of the China Digital Ocean Information Basic Framework. The experience with the development of the Digital Ocean prototype system in China is relatively rich and thus helpful for addressing this question.

2.2 Acquiring Ocean Big Data

There are many kinds of ocean data produced every day, which operates as an elementary component for the study and application on the oceans. In this chapter, the big data cognition for ocean is studied from four perspectives. Form the data volume perspective, the ocean data acquire and analysis can produce big volume data. Form the data velocity perspective, the ocean data is collected from the eyes in the sky and objects on-the- ground networks, together with demographic, geologic, and socio-economic data and model estimates. Form the data variety analysis perspective, the database stored data and the unstructured data and model estimates are included. Form the data value mining perspective, there are many kinds of knowledge can be mined. Among the ocean big data, the three-dimensional data play an important role.

The three-dimensional data includes Digital Elevation Model (DEM) data for the seafloor and coast, in situ observational data, remote sensing data and model output data.

The DEM data are acquired from single- or multi-beam ship-borne echo sounders, which are the traditional systems used to map the seafloor topography with high precision results; in addition, data are produced from airborne AIRSAR/POLSAR synthetic aperture data or other methods (Maged et al. 2009). The DEM data from below the sea surface are used to construct the three-dimensional seafloor model as well as the model of the sea surface. The DEM data from the coast are used in land surface three-dimensional modeling, remote sensing data with different spatial resolutions represent as the surface texture.

Station observation data better reflect the environmental condition of the waters within their zones, and the changes in data offer a certain representativeness. Station observation also offers the characteristics of continuity, accuracy, and timeliness and mainly reflects the two aspects of continuous time and continuous space; a reasonable measure of space is continuous in the horizontal direction of the site layout and the vertical direction of the air, surpolygon and subsurpolygon. With regard to ocean profile measurement; continuous time refers to the various processes that can be captured by long-term continuous observation data; its accuracy is derived from the use of the infinite sequence of sample recovery. We care about the continuous process of change. With regard to the station system, on the one hand, the field observation data are a fast, accurate and reliable means of communicating in real time with ocean forecast and other departments for the purpose of controlling the ocean environmental features and evolution process. On the other hand, the field data are a historical resource that can be stored permanently.

The continuous space means in the horizontal direction and vertical direction of the air, surface and subsurface, and ocean profile measurement. The continuous time refers to the various processes in long-term continuous observation.

A self-propelled type of ocean platform is mainly used for underwater, unmanned, wide range, extended underwater environmental monitoring, including the physical parameters, the ocean geology and geophysics, and the ocean chemistry and biology parameters as well as aspects of ocean engineering – all of which can be performed close to the observation area. Its features are the following: low cost; environmentally adaptable; able to surpass the artificial diving limit and enter the field observation area; small size; easy to use; easy to wash; operates according to the acoustic signal remote control or preset program control; built according to the requirements for related observation projects; independent power and relatively long underwater running time; noise is low; and can be hidden from observation.

The data buoy is anchored or floating on the ocean observation platform; plays an important role in the ocean observation system. Although remote sensing by air and satellite can be performed at great speed and over a wide area, only the surpolygon data are accessible; the unattended buoy submerged in an ocean environment works continuously for a long period of time in combination with other buoys for a comprehensive, profound, all-weather assessment of the ocean environment and the changes that it undergoes.

The main technical instruments for field observation include the following: a specially designed oceanographic vessel and salinity (conductivity)–temperature depth gauge (CTD), acoustic Doppler velocity profiler (ADCP), profiler, side sonar, an underwater vehicle and underwater laboratory, underwater robots, and equipment for seabed deep drilling. Direct observation of the data and mathematical models used to provide reliable reference can also be verified by the results of the experiment and mathematical methods. In fact, the use of advanced research vessels, test equipment and technical facilities for direct observation have indeed promoted the development of ocean science; especially since the 1960s, almost all of the major progress in this field has been closely related to the use of these resources.

Direct observation data can either be used as reliable information for the experimental study and mathematical model or to verify the results of the experiment and mathematical methods. The basic features are direct observation data authenticity and discreteness. Direct observation data are the real basis for understanding complex ocean phenomenon and the calibration of the model test; in addition, the remote sensing data application plays an irreplaceable role. In other words, these are the most basic data, and they serve as a reference for other forms of data and theoretical results. The development of monitoring technology for the ocean environment improved monitoring, prediction and forecast ability and therefore promoted the development of the ocean and coastal economy.

The in situ observational data are being collected from different types of sensors on a range of time scales, such as the data produced by the Argo buoy. The data-obtaining devices include oceanic optical buoys, seafloor moored instrumentation (for dynamic factors), self-locating sub-water tide monitors, sea sound detection buoys, sub-water tide comprehensive admeasuring apparatuses, cruises and others. Real-time and delayed-mode monitoring data collected from the above equipment are transmitted to a local data center. The characteristics of the in situ observational data are that it is related to a fixed x, y, z location in space and has attributes that are attached or related to the location. Most of the data have the required temporal attributes.

– Satellite remote sensing covers most of the ocean environment parameters and information, including sea surpolygon temperatures, ocean currents, sea surpolygon wind fields, concentrations of chlorophyll, suspended mass concentrations, sea levels, gravity anomalies, ocean optical parameters, atmospheric aerosol ocean rainfall, direction of the wave spectrum, and sea pollution in the surpolygon. Satellite ocean remote sensing involves the electromagnetic wave scope of visible light, infrared waves and microwaves. Visible light remote sensing using the sun as a light source, thermal infrared remote sensing using the sea, and passive microwave remote sensing can be divided into the surpolygon of the microwave radiation source and spaceborne microwave remote sensing active source. Satellite remote sensing instruments presently use radar scatterometers, radar altimeters, synthetic aperture radars, microwave radiometers, visible light/infrared radiometer ocean color scanners, etc.

– The radar scatterometer is an active microwave device; strabismus observations can show the surpolygon wind speed, wind direction and wind stress and sea waves. Using the scattering of the wave field is a reliable basis for sea condition forecasting.
– Spaceborne radar altimeters are also a type of active microwave sensor; they can measure geoids, sea ice, tides, water depths, sea surpolygon wind intensity and effective wave heights, and El Nino phenomena.
– Synthetic Aperture Radar (SAR) is a high azimuth resolution type of coherent imaging radar; it uses phase and amplitude information and is a type of holographic system that can be divided into side, strabismus, Doppler sharpening and bunching of surveying and mapping as well as other applications. According to the difference in SAR image brightness, the sea ice ridge, thickness and distribution, water and ice boundary, tip height and other important information can be extracted. By using SAR images, not only large-area oil pollution can be found in a timely fashion, but sudden pollution incidents can also be detected.
– The microwave radiometer is a passive microwave sensor that conducts remote sensing by measuring the thermal radiation temperature from the sea surpolygon temperature. Sea surpolygon temperature tests one of the most basic parameters, water temperature, which is one of the main measures for determining water mass and is also used to analyze the ocean front and flow. NOAA – 10, one of the last three satellites in the United States, is an advanced, very high resolution radiometer (AVHRR); an image represented by the sensor can be accurately mapped to the surpolygon with a resolution of 1 KM, and 1 °C temperature accuracy is possible. Satellite remote sensing of the sea surpolygon temperature of the global ocean isotherm distribution reveals complex phenomena that conventional methods were unable to discover and has even corrected previous findings.

The visible/near infrared bands of the multispectral scanner and coastal zone color scanner act as passive sensors; these devices measure ocean color, suspended sediment, water quality, etc. Using multi-spectral information and reflectance, suspended load concentration and migration can be extracted. Satellite remote sensing images can display frontal systems, eddy currents, and bodies of water, e.g., mesoscale ocean phenomena, and, combined with other satellite data research, can reveal the phenomena of many dynamic ocean mechanisms and processes.