

Constructing a System for Water Quality Monitoring and Analysis in the Pearl River Delta Region

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This contribution was double-blind reviewed as extended abstract.

Abstract

Natural resources such as land, air, and water lay a critical foundation for the sustainable development of an urban community. The Pearl River Delta (PRD) is one of the most developed and rapidly developing regions in China, with abundant natural resources in water, intertidal zones, aquatic products, and a significant coastal estuary habitat. The PRD also covers two Special Administrative Regions (Hong Kong and Macao) and two Special Economic Zones (Shenzhen and Zhuhai), critically positioning it domestically and abroad. However, the increasing development of the economy has put pressure on the security of its water resources. These resources have sharply deteriorated in the PRD as the result of a mass and unordered overuse of water and soil resources and the lack of coordinated efforts among different functional departments. Various problems related to the water environment (such as flooding, rapid development of the deposition, water pollution, saltwater intrusion, and waterway atrophy) have directly threatened the social stability, sustainable development of the economy, and the supply of water in the region. To date, the population affected by a shortage of high-quality water has reached 16 million due to pollution of the water supply source in Guangdong province. At this time, the water pollution in the PRD has resulted in ever-increasing economic and environmental losses. Pollution coverage includes Hong Kong, Macao, and Guangdong and, because governmental functions and scientific technologies among these regions differ, there is little in the way of efficient, cooperative efforts to fully make use of their individual advantages to protect the water environment in the PRD. Moreover, the diversity and complexity of the problems even interfere with the abilities of functional departments within one region (e.g., flood prevention, pollution abatement, and channel maintenance) to make decisions and formulate protection policies using advanced spatial technologies such as remote sensing (RS) and geographic information systems (GIS). Consequently, the water environment in the PRD lacks unified and synergistic operations, and water resource protection is restricted to satisfying the demands of economic development and the requirements of sustainable development.

To date, it is clear that cooperation amongst Guangdong, Hong Kong, and Macao should be strengthened. More research is also essential, specifically regarding the reduction of gross pollution emissions by 8 to 10 percent. In addition, the water environmental protection of

the PRD has engaged with the Integrative Planning of the Environmental Protection in the PRD (2009-2020). This emphasizes strengthening the regional collaborative linkages, constructing an integrative platform of environmental monitoring, and realizing the shared and collaborative management of environmental information among different departments. With this in mind, the study on constructing a unified and synergistic system for water environment analysis in the PRD area are proposed as interdisciplinary and comprehensive research using multiple methods and fields. Based on the analysis of the fusion techniques of multisource, multi-date, and isomerous images, a database for integrating remote sensing monitoring data of water quality and quantity, actual measurement data, and relevant basic geographical data (watercourse data, section data, and a Digital Elevation Model) will be developed. Combining the research on general analytical methods and models, the capsulation mechanism of analytical methods and models will be designed. Lastly, using GIS integration techniques, an integrative monitoring demonstrative platform of water quality and quantity will be developed to assist collaborative research and decision making among the functional departments of the three regions. The goal is to promote the sustainable use of the water resources in the PRD, to achieve sustainable economic development and to increase the informatization of the PRD region. The construction of the system consists of four parts:

1 The Framework Design

The system is designed with three layers: the data layer, the function layer, and the user interface layer. The data layer responds to data organization and management. It contains a unified database for the storage of basic geographical data, remote sensing data, observed data, and simulated data, as well as data obtained from the Internet. The function layer is designed to offer various user functions wrapped as Internet services so that there is no need for a centralized server. In this way, researchers of the three cooperative areas can develop their individual functions and add them to the collaborative system. The user interface layer includes a desktop interface for data pre-processing, a website for information publishing, and a 3D visualization interface for water pollution simulation and prediction. Thus, the user interface provides an integrated workspace for researchers, the public, and decision makers. Internet-based conflict detection in related operations among different departments in Guangdong, Hong Kong, and Macao was considered to enhance cooperative work among different departments. Fig. 1 shows the framework of the system.

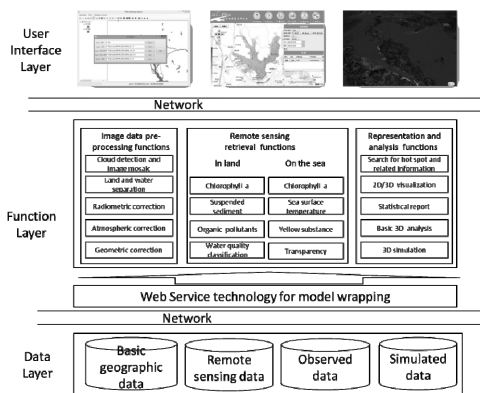


Fig. 1: The framework of water quality monitoring and analysis system in the PRD

2 Development of the Water Quality Database

The main source of data for this system is remote sensing data on land or on the sea, and basic geographical data in the PRD (including basic geographical data of the waters and the administrative divisions). At this point, we have collected three types of images: SPOT, TM, and HJ. Direct observations will be used to verify the inversion results and to provide information on the real water conditions in certain places. Figure 2 shows the detailed data tables for this system.

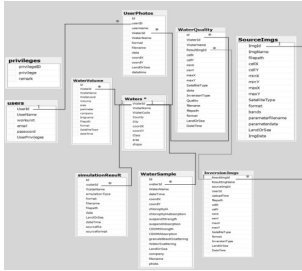


Fig. 2: Data tables for database development

3 Design and Development of the Model Base for the Applied Water Quality Analysis

Because this system is developed for collaborative applications among different departments in Guangdong, Hong Kong, and Macao, there is the challenge of finding and organizing the functional models that have developed independently in different areas with different systems. On the one hand, there are different types of models that fit different running platforms (e.g., Linux or Windows), and that may be programmed in different languages (e.g., ENVI IDL or PCI EASI). On the other hand, barriers to convergence may exist because some models are considered to be the core secrets of their departments. Under that condition, obtaining source codes of the models would prove to be difficult because the model owners prefer to provide the “final product” rather than the models themselves.

To deal with this problem, the models can be wrapped and published on the Internet. In this way, they can be remotely accessed regardless of the users’ physical locations. A management strategy will help users know how many models can be invoked and help them familiarize themselves with the models they are using. In this case, web service helps to wrap the remote models and design a description method for model reuse.

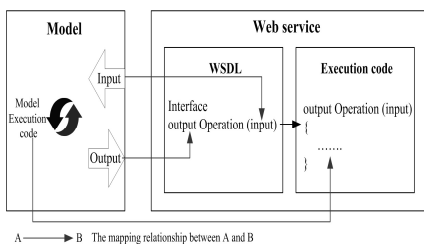


Fig. 3: Mapping a model to a Web service (Chen et al. 2014)

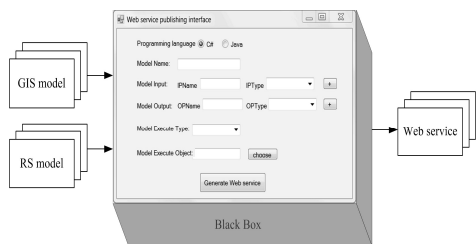


Fig. 4: The model description tool (Chen et al. 2014)

4 Interfaces for Multiple Users

To serve different users, the user interfaces are divided into three tools. The first tool is a desktop interface for data pre-processing. It is developed based on C# and DotSpatial (<http://dotspatial.codeplex.com/>). Figure 5 shows the usage of this tool. The second tool is a website for information publishing based on the ArcGIS API for Silverlight. Figure 6 shows the results of this web portal. Currently, virtual worlds have shown potential benefits to scientific research (e.g., Virtual Geographic Environments (VGEs), Lin et al. 2013a, 2013b). The third tool, a 3D visualization interface for water pollution simulation and prediction, will help researchers and decision makers because it can provide visual and understandable scenarios for dynamic analysis. Figure 7 shows the representation of this interface.

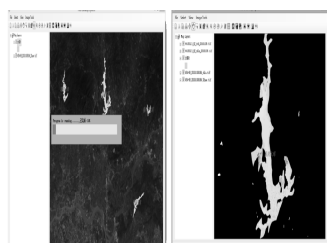


Fig. 5: Desktop interface

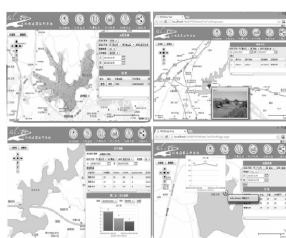


Fig. 6: Web interface

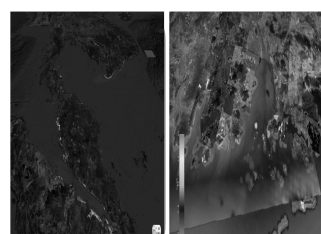


Fig. 7: 3D visualization interface

Acknowledgments

This work was supported by the National Key Technology R&D Program of China (grant nos. 2012BAH32B03) and the Hong Kong ITF Program (no. GHP/002/11GD).

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