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Lake Modeling System: An Integrated System for Lake 3D Hydrodynamics and Water Quality Modeling

Mutao Huang

Huazhong University of Science and Technology, School of Hydropower Engineering & Information Engineering, China (huangmutao@hust.edu.cn)

Simulation of hydrodynamics and ecological processes in lakes are of importance for sustainable lake water resources management. Recently, three-dimensional (3D) hydrodynamics and water quality lake models have been used to study a variety of lake water resources issues. However, these models are very difficult to use due to their complexity and high data requirements, which seriously hinders their applications in scientific research and management practice.

This study designed and developed an integrated system, Lake Modeling System (LMS), for Lake 3D hydrodynamics and water quality modeling. LMS streamlines the entire integrated modeling procedure, from data preparation at the very beginning to visualization and analysis of modeling results, in a uniform environment. LMS allows users to take advantage of all types of GIS data available for hydrodynamics modeling. It provides a GIS-based data processing framework to establish model and provides capabilities to display and modify model features and associated parameters (e.g., model grids, boundary conditions, etc.). It enables to visualize and analyze various model inputs and outputs dynamically in both space and time at cell and entire lake scale. LMS also provides complete access to the relational database, as well as mapping, and 3D visualization tools to support the model development process. All of this in a GIS-based data processing framework will make the task of hydrodynamics modeling easier.

We provide several strategies in the design of LMS for providing users with all necessary functionalities streamlined for integrated modeling. First, The FeatureSet, which is a general abstract object in most of GIS libraries, is used as a shared data model and provides shared geospatial data access between hydrodynamics model and GIS. Second, We use a multivariate-space-time data cube model that enables to represent both static and time-variant data sets in the hydrodynamics model. The data model provides a standard but also flexible mechanism to store and manipulate all kinds of data types involved in the hydrodynamics model, based on which we can develop a variety of tools to perform spatial-temporal analysis on the data. Furthermore, we designed a set of standard interfaces to capture common attributes and attributes and behaviors of models, packages, parameters and other necessary objects associated in the hydrodynamics model. The DotSpatial library was employed to provide complete geo-processing functionalities, and has an active developer community to provide state-of-the-art software developments. The Managed Extensibility Framework (MEF) embedded in .NET provides a mechanism through which developers are able to easily develop lightweight, extensible applications.

The applicability and effectiveness of LMS were demonstrated by a case study in the Lake Donghu, the second largest urban lake in China. The case study also showed that the visualization and spatial-temporal analysis in LMS can greatly facilitate process understanding and support management decision-making.