Using Coastal Louisiana to Develop Hydrologic Web-based Learning Modules

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Abstract

The overall goal of the study is to utilize advances in research and technology to develop visual, case-based, data and simulation driven learning experiences. Three regional scale ecosystems provide the context for the learning modules, which are referred to collectively as "HydroViz" (www.hydroviz.org). This paper focuses on the development and implementation of web modules based on one of the three ecosystems, coastal Louisiana, which provides an abundance of concepts and scenarios appropriate for use in many water resource and hydrology curricula. Recent developments in hydrologic modeling, data and resources provide the core of the new learning modules. Developments also include an instructional interface and an instructor's guide to provide guidance and support to both learner and instructor. The new modules are designed be instructionally and technically adaptable and transferable to independent institutions.

Background

Traditionally, textbook-based hydrologic education uses idealized examples focused on specific hydrologic unit processes and/or engineering applications. However, hydrologists today deal with intricate problems rooted within natural ecosystems with a multitude of interrelated physical, chemical and biological processes across wide spectrum of temporal and spatial scales. Combined with research advances such as observational settings, instrumentation and modeling methods, and hydrologic theory and practices, similar improvements in undergraduate hydrology and water resource education are needed. The use of authentic and realistic situations to provide context promotes student motivation and engagement by creating subject relevance and helping to develop critical thinking skills necessary for professional life as scientists or engineers [1]. Integrating research into the classroom can be effectively accomplished by using the research in an inductive approach to teaching [2]. The creators of the HydroViz educational web modules have designed active learning modules based on real world research using technologies which will encourage engagement with the material and foster wide implementation, dissemination and adaptation.

Recent Developments in Research and Technology

Coastal Louisiana is a unique ecosystem, a multi-use transition from inland to coastal wetland which contains a multitude of economic as well as ecological assets. The crisis of landloss in

coastal Louisiana and the ensuing threat to economic, cultural and ecological assets has resulted in a coordinated effort by local, state and federal agencies to protect and restore the wetlands. Institutional, academic and engineering research has played a vital role in these efforts. This has given rise to a wealth of data and resources which can be used to teach a wide range of topics.

Louisiana's 2012 Coastal Master Plan is the groundbreaking plan built on a comprehensive analysis of the effects of over 100 projects, both proposed and currently implemented, aimed at protecting and restoring the coast. This analysis also considers the combined effects of climate changes and different degrees of sea level rise [3]. In the Master Plan analysis, several models were developed to evaluate project impacts on hydrology, vegetation, wetland and shoreline morphology, and water quality, among others. The eco-hydrology model developed for the Master Plan uses a differential equation solver designed to model and analyze dynamic systems called Berkeley Madonna. Using Madonna, the mass-balance compartment based eco-hydrology model calculates changes in water level, salinity, sediment, and water quality within estuaries [4]. The educational modules developed for the Coastal Louisiana HydroViz are based on the eco-hydrology model developed for the Chenier Plain region of the Louisiana coast, shown in Fig. 1, and the interconnections between water level and salinity. Another model developed for the Master Plan is the vegetation model (LaVegMod) which receives output from the eco-hydrology and other models and delivers information on plant growth conditions [5, 6]. Designed to predict the vegetation location and type, part of the vegetation model is used in the HydroViz modules to illustrate the effects of hydrology and salinity on plant growth.

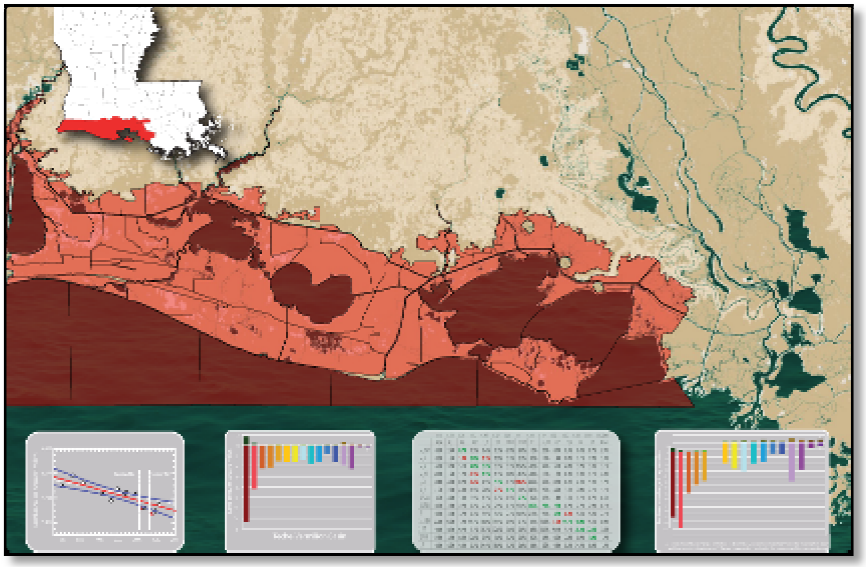

Figure 1: Coastal Louisiana HydroViz model domain

A major project undertaken to assist in coastal protection and restoration efforts is the Coastwide Reference Monitoring System (CRMS). CRMS is a network of hundreds of monitoring stations which gather hourly data on water level and salinity as well as annual assessments of vegetation, soil accretion and marsh surface elevation. This network is designed to allow restoration and protection projects to be monitored for effectiveness. The CRMS website user-friendly interface (Fig. 2) provides easy viewing and access to information, products and data collected through

CRMS stations [7]. In the educational modules, this data is used to provide field data to compare with model calculations.

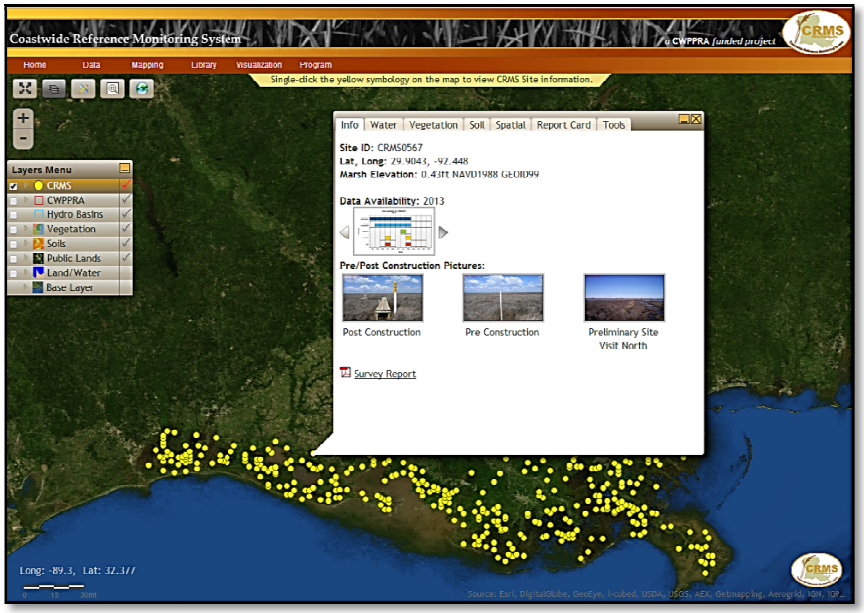

Figure 2: CRMS website user interface

Software and technologic developments are the backbone of HydroViz. Open source, free web-based technologies are used to facilitate integration into courses and modification by others in the form of additional modules, functionalities or applications. Google Earth/Maps are used extensively throughout HydroViz. Hydrologic geospatial data is rendered on the 3D/2D model of the earth as layers in the form of KML files or location markers. Educational content and geospatial data are stored on the HydroViz server and is presented to students through a web browser using JavaScript along with several free API's which format and deliver the materials. The user interface for the Coastal Louisiana HydroViz, shown in Fig. 3, is designed to provide reliable support to students and ensure consistent performance of students regardless of class or school.

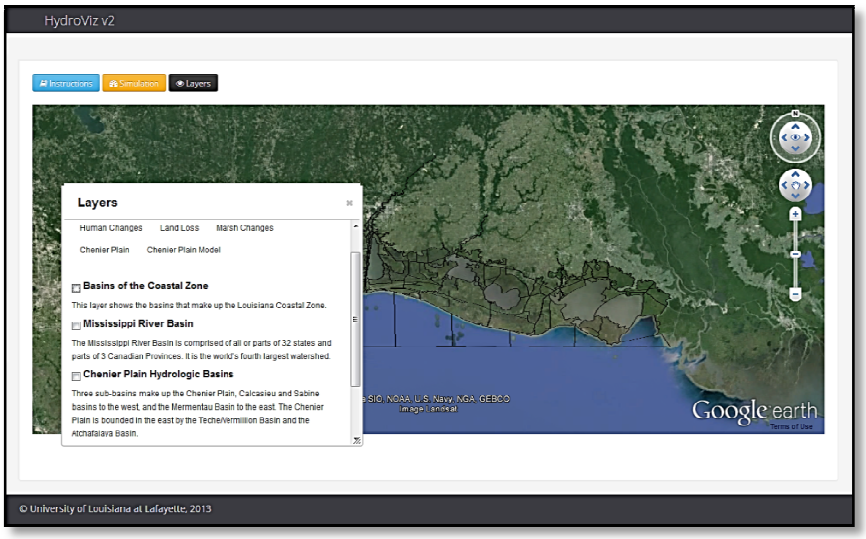

Figure 3: Coastal Louisiana HydroViz user interface

Educational Web Modules

The educational modules developed for Coastal Louisiana HydroViz are based on modeling and data resources recently developed. The inquiry based student activities are interactive and cover a range of hydrologic concepts. It is a goal of the HydroViz team to create modules which can be used in a broad range of courses and curricula, as well as in a range of levels within the same program. While some topics and tasks are more suitable for a freshman level course, such as an introduction to civil engineering course, many topics are appropriate for junior/senior level courses. In addition to analyses of the water budget and its individual components, the effects of water level and salinity on the occurrence of wetland vegetation and the impact of sea level rise and salt water intrusion are investigated. Qualitative and quantitative analyses are conducted on both large and small spatial scales as well as on long and short temporal scales.

The objective of the modules is to promote students' understanding of eco-hydrology and the connection of hydrology to the endurance, resiliency, diversity and productivity of a complex ecosystem. The main topic of the web modules is the water budget. Initially, the students are led through exercises in data gathering and identifying the main features of the Chenier Plain and the corresponding features of the model used in the simulation exercises. Once familiarity with the model domain is established, the students learn how to customize the simulation, run the model and retrieve data. The data is then used in a series of analyses, beginning with a basin wide scale seasonal analysis of the inflows and outflows of the entire domain, followed by an analysis of the water budget components and an annual analysis of the water budget components. A compartment scale analysis is conducted following the basin scale analysis. This analysis is similar to the basin scale analysis and investigates patterns and variations in the water budget components in single compartments. The patterns in the exchange flows in a water control structure contained in the model domain are also investigated as well as the exchange flows in a pass to the Gulf of Mexico. A tidal analysis of a low lying marshy island is then conducted, followed by a salt budget analysis of selected compartments. These tasks demonstrate the

connections between water level and salinity in the Chenier Plain. A key component of the web modules is the vegetation analysis based on CRMS data and the partial vegetation model. As students become familiar with the CRMS web interface, they acquire field data and use it to recreate the same quantitative measurements of qualitative conditions used to evaluate the health and vitality of endangered wetlands. These indices consider the effects of both salinity and water level variation on vegetation productivity. Comparisons between the CRMS data derived results and the same calculations conducted using the Madonna model data are also made. The last task is the use of the vegetation model to calculate the occurrence of submerged aquatic vegetation based on data from the simulation model of the Chenier Plain.

Additional Materials

Additional web modules based on coastal Louisiana will also be developed. These modules will investigate the ways coastal marshes cope with changes in climate, evaluate the effectiveness of restoration efforts on ecosystem preservation, examine the impact of nutrient loading changes in the Mississippi River on the Gulf hypoxia and evaluate the effect of riverine sediment changes on delta subsidence rates. In addition to the educational modules themselves, supporting materials are also under development. These include an instructor's guide to assist instructors when integrating the web modules into courses and an array of helpful tutorials and a glossary to allow for a more consistent learning experience for the students as well.

Implementation and Evaluation

Institutionalization and dissemination plans include institutionalization at the developing institutions, and dissemination at collaborating institutions and through community web databases and the CUAHSI portals. Once the modules are complete and the web application fully functional, the modules will be used in courses at the developing universities. The modules are applicable in a variety of courses and programs as well as different levels within the same program. Topics covered range from freshman introduction to civil and environmental engineering and water resources engineering to coastal sciences and environmental data analysis. Further use at four collaborating universities, a college and a high school will provide additional feedback. Necessary revisions will be performed in an iterative process based on the feedback from the developing and collaborating institutions. The evaluation plan is improvement focused to ensure that issues are managed and resolved early. It is a main goal of the HydroViz team that independent institutions not only utilize the web modules created for HydroViz but also adapt the design and functionality and develop additional applications based on their own watersheds.

Summary

The development of case-based, visual, data and simulation driven learning experiences based on recent advances in research and technology is aimed at improving the traditionally textbook based hydrologic education. Advances in research and technology can be used to facilitate these improvements through the use of observational data and model simulations which more accurately reflect the complex problems with which today's hydrologists contend. Coastal Louisiana is a distinctive region with many cultural, economic and ecologic resources as well as

the wealth of research conducted in the area provide a rich source of learning opportunities. The web modules developed and to be developed cover a variety of topics appropriate for a range of educational levels as well as courses and curricula. In addition to the educational modules, instructional guidance materials are also under development. Through wide dissemination, it is hoped that further applications be developed based on the watersheds of adapting institutions.

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