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Eco-Hydrology Modeling in Coastal Louisiana to Assess Project Effects on the Landscape

ECO-HYDROLOGY MODELING IN COASTAL LOUISIANA TO ASSESS PROJECT EFFECTS ON THE LANDSCAPE

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The future of the Louisiana Coast is uncertain due to the combination of natural and engineered alterations that have occurred over time. As such, it was imperative to develop tools to better understand how these changes affect the coastal system. These tools were used to assess proposed measures to mitigate or eliminate adverse changes in an attempt to restore and protect the coast. A computationally efficient numerical tool was developed to accomplish this goal. This numerical tool is a mass-balance compartment model that was used to perform long-term eco-hydrology analyses of the Louisiana Coast. The model consists of three sub-basin modules: Lake Pontchartrain/Barataria Basin (PB), Atchafalaya Basin (AA), and Chenier Plain (CP). The PB model was previously developed in FORTRAN and was used as the basis for developing the AA and CP models in the Berkeley Madonna modeling environment. The models were designed to calculate hydrodynamic and water quality processes over a 25-year period. They take into account water and constituents entering and exiting the domain, as well as the exchange between the compartments and the atmosphere. In addition to the hydrodynamics (stage, flow rate, and velocities), the following water quality constituents were included in the model: total suspended solids, salinity, total Kjeldahl nitrogen, water temperature, nitrate + nitrite nitrogen, ammonium nitrogen, dissolved organic nitrogen, total phosphorus, soluble phosphorus, phytoplankton as chlorophyll-a, detritus, water age, nitrogen removed, and accretion. These parameters were computed using a hybrid upwinding and central difference numerical integration scheme in the PB model and using the UPWIND scheme in the AA and CP models.

The dynamics of the PB and the AA and CP model are displayed in Fig. 1. The PB model separated the areas inside each compartment into upland, marsh, and open water sub-compartments with links providing the exchanges between the open water sub-compartments. These open water sub-compartments consisted of the bays, lakes, and any other water bodies located within the PB domain, and the links consisted of the channels, passes, and waterways that connect the larger water bodies. Local tributaries, including the Mississippi River, supplied fresh water to the open water sub-compartments. Upland sub-compartments exchanged with the marsh sub-compartments via runoff. AA and CP compartments were explicitly separated into three types: channel, open water, and marsh, where either compartment type could exchange with the other two types via links.

Channel compartments encompassed a certain length of an existing channel or river while open water compartment encompassed an entire bay or lake. Marsh compartments could contain patches of open water depending on the productivity of the marsh. To account for the water inside a

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marsh compartment, a percentage of land was applied to each compartment, where 100% corresponded to all land/marsh, and 0% corresponded to all water. Local tributaries provided fresh water to any of the compartment types. The size of the compartments across the three regions was on the order of one to several square kilometers.

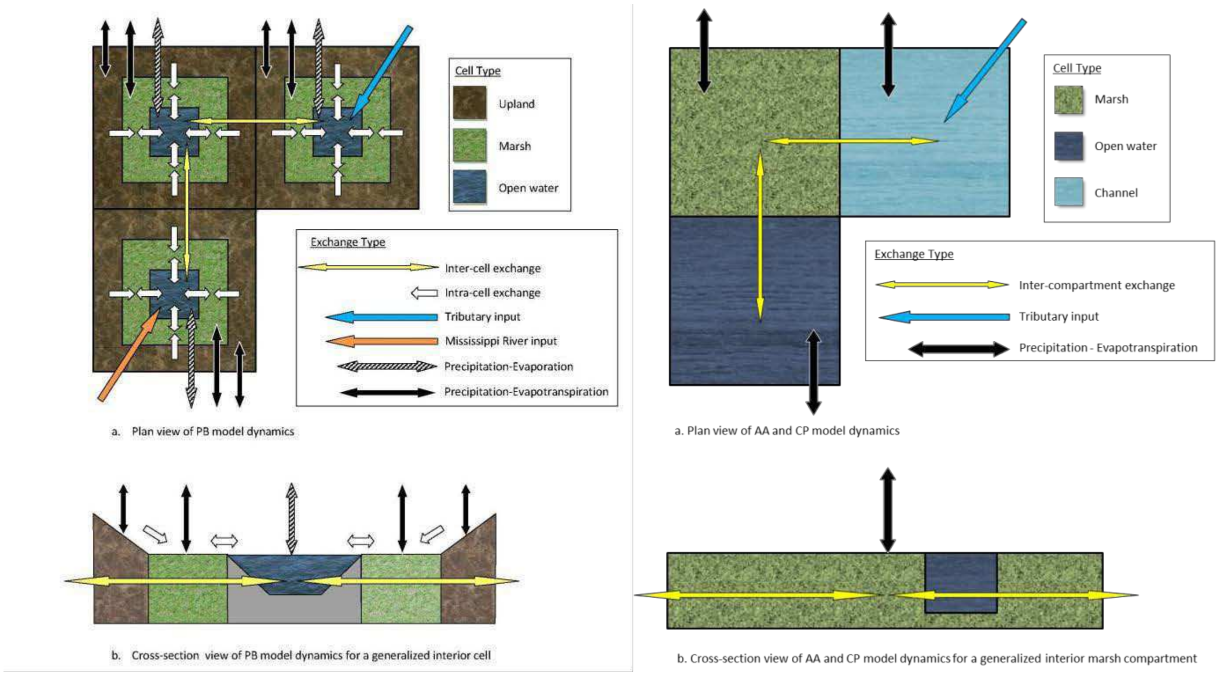

Figure 1 Model Dynamics for the PB and AA and CP models

All regions were calibrated and validated to observed data. Proposed restoration and protection projects included in the models were marsh creation, hydrologic restoration, shoreline protection, ridge restoration, diversions, channel re-alignments, oyster reef developments, and hurricane protection projects. Simulations of these projects were performed to provide input values for other expert eco-system process models with a final goal of producing a comprehensive 50-year output that was used to assess the effects of each proposed project as compared to a 50-year output where no projects were introduced. The Eco-Hydrology models provided essential information on the hydrodynamics and quality of water in the coastal regions of Louisiana. The Fortran and Madonna models were capable of simulating long periods of time (25 years maximum for this modeling effort), which created a “foresight” of the future effects on the system. When both year-sets were completed, this 50-year “foresight” allowed for adequate planning-level screening of proposed projects, which can assist decision-makers in their chore of selecting the most efficient methods to achieve their near and long-term goals of protection and restoration.