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The Tides and Inflows in the Mangroves of the Everglades Project

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The coastal land-margin interface of the freshwater Everglades with Florida Bay and the Gulf of Mexico provides nesting habitat, and is a primary productivity area for the food web of numerous endangered species. Land-margin ecosystems, composed mainly of mangrove thickets, brackish marshes, tidal creeks, and coastal embayments, constitute roughly 40 percent of Everglades National Park (ENP). The need to preserve hydrological and ecological conditions that are consistent with habitat requirements in these sensitive ecosystems is particularly problematic for water management agencies implementing the Comprehensive Everglades Restoration Plan (CERP) due to the delicate balance that exists among freshwater inflows, tidal fluxes, meteorological forces, and salt concentrations.

A coupled hydrodynamic/transport surface-/ground-water model is under development in the Tides and Inflows in the Mangroves of the Everglades (TIME) project of the U.S. Geological Survey (USGS) South Florida Ecosystem Program. The TIME model is needed to provide insight into saltwater and freshwater mixing in the wetland/coastal transition zone of ENP that presently is not considered by existing management models of the south Florida ecosystem. Use of the TIME model will complement ongoing CERP efforts by addressing questions critical to preserving these land-margin ecosystems. How do the Everglades wetlands and coastal marine ecosystems respond concurrently to freshwater inflow regulation? What concurrent changes in wetland hydroperiods and coastal salinities are likely to occur in response to various restoration plans and management actions? What dynamic forcing factors, e.g., sea-level rise, meteorological effects, etc., could adversely affect regulatory plans? What factors affect salt concentrations in the coastal mixing zone and how do they interrelate? What effects will upland restoration and management actions have on endangered species in the land-margin ecosystems?

The TIME project (http://sofia.usgs.gov/projects/time/) is building on and using hydrologic process-study findings (Schaffranek, 1999) and results of modeling and monitoring efforts derived from the USGS Southern Inland and Coastal System (SICS) project (Schaffranek and others, 1999). The SICS project was conducted within the Taylor Slough and C-111 drainage basins of the southern Everglades interface with Florida Bay. Sensitivity testing with the precursor surface-water SICS model has demonstrated the importance of external forcing factors on land-margin ecosystems, including the dynamic effects of winds on flow patterns in the wetlands and discharges through tidal creeks dissecting the Buttonwood embankment along the Florida Bay boundary (Swain, 1999). For the TIME project, the same two-dimensional, vertically integrated, hydrodynamic Surface Water Integrated Flow and Transport (SWIFT2D) model (Leendertse, 1987) used in the SICS project is being explicitly coupled with the three-dimensional, variable-density ground-water flow model SEAWAT. SEAWAT is a coupled version of the Modular Ground-water Flow (MODFLOW) model (McDonald and Harbaugh, 1988) and the modular solute transport model MT3D (Zheng, 1990). The TIME model domain encompasses the entire saltwater-freshwater interface zone along the southwest Gulf coast and

Florida Bay boundaries of ENP. The model boundaries extend from Tamiami Trail south to Florida Bay and from L-31N, L-31W, and C-111 canals west to the Gulf coast and Everglades City. Additional flow-monitoring stations are being installed in ENP to provide boundary-value data as well as wider synoptic measurements of surface-water flows and ground-water levels for model calibration and verification. The coupled TIME model will be able to simulate flow exchanges and dissolved salt fluxes between the surface- and ground-water systems comprising the entire land-margin interface of the Everglades with Florida Bay and the Gulf of Mexico.

The TIME model-development effort involves collaborations among numerous projects within the USGS South Florida Ecosystem Program. Hydrological needs for critical estuarine species studies have been used to assign resolution scales and to develop information linkages between the TIME and Across Trophic Level System Simulation (ATLSS) (http://atlss.org/) models (Gross and DeAngelis, 1999). Initial progress has been made on a number of efforts within the TIME project including development of the model-coupling algorithm, computational surface-water and ground-water grids, vegetation classifications, hydrologic-process formulations, model data bases, and the field-monitoring network. A numerical algorithm, designed to synchronize SWIFT2D tidal-compatible time steps with SEAWAT stress periods, has been developed and is undergoing initial testing. A preliminary and partial land-surface elevation grid of 500-meter square cells covering the Dade County portion of the model domain has been generated from 400-meter-spaced helicopter Aerial Height Finder (AHF) survey data, collected by the USGS National Mapping Division. The model grid has been supplemented with land-surface elevations interpolated from the 2-mile square grid cells of the South Florida Water Management Model where AHF data are not yet available. A companion 500-meter-square aquifer grid for the SEAWAT ground-water model is under development. Ground-truthing of vegetation classifications determined from remote-sensing imagery has begun in support of hydrologic-process representations in the model. In preparation for design and setup of numerical simulations, a project Web site (http://time.er.usgs.gov) with a data-base repository for compilation of input data and sharing of model results has been developed and populated with data from more than 100 stations for 1995 to present. Flow data for approximately 70 culvert and structure openings along a 100-kilometer extent of Tamiami Trail have been compiled for water years 1987-99. The data have been entered into a spreadsheet for use in the TIME model and distribution to the south Florida scientific community via the South Florida Information Access (SOFIA) website (http://sofia.usgs.gov). An acoustic Doppler flow-monitoring station has been established in Shark River Slough to determine the feasibility of continuous in situ velocity measurements in the heavily vegetated marsh environment for use in model calibration and verification. Progress in development of the model and ancillary project findings routinely are posted on the TIME Web site.

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Question 1 – Physical Science