Measuring and Mapping the Topography of the Florida Everglades for Ecosystem Restoration

Figure 1. A helicopter view of a part of the Florida Everglades looking south towards Florida Bay.

One of the major issues facing ecosystem restoration and management of the Greater Everglades is the availability and distribution of clean, fresh water. The South Florida ecosystem encompasses an area of approximately 28,000 square kilometers and supports a human population that exceeds 5 million and is continuing to grow. The natural systems of the Kissimmee-Okeechobee-Everglades watershed compete for water resources primarily with the region's human population and urbanization, and with the agricultural and tourism industries. Surface water flow modeling and ecological modeling studies are important means of providing scientific information needed for ecosystem restoration planning and modeling. Hydrologic and ecological models provide much-needed predictive capabilities for evaluating management options for parks, refuges, and land acquisition and for understanding the impacts of land management practices in surrounding areas. These models require various input data, including elevation data that very accurately define the topography of the Florida Everglades.

Surface water levels and sheet flow in the Everglades (Figure 1) are very sensitive to any differences in topography because of the region's expansive and extremely flat terrain. Hydrologic models require very accurate elevation data to simulate and predict water flow direction, depth, velocity, and hydroperiod. Water resources, ecosystem restoration, and other land management decisions will rely in part on the results of these models, so it is imperative to use the best elevation data available to achieve meaningful simulation results. Elevation data points are being collected every 400 meters in a grid pattern to meet the requirements of various hydrologic models. The vertical accuracy specification for these elevation data is ±15 centimeters (6 inches) as referenced to the North American Vertical Datum of 1988 (NAVD88).

Because traditional methods for collecting elevation data for the Everglades are impractical or too costly, the U.S. Geological Survey (USGS) conducted a feasibility study to determine if state-of-the-art techniques using the Global Positioning System (GPS) could meet the strict vertical accuracy specifications of the elevation data. The feasibility study successfully demonstrated that differential GPS techniques, using airboats to navigate transects (Figure 2), could meet the vertical accuracy requirement. Also, the land surface being surveyed in the Everglades is typically under water and obscured by vegetation. This precludes the use of other

Figure 2. Airboat configured for collecting GPS data launching for a surveying session.

methods for collecting very accurate elevation data, such as photogrammetry, Light Detection And Ranging (LiDAR), Interferometric Synthetic Aperture Radar (IFSAR), or other alternative remote sensing technologies. Therefore, topographic surveys over such a large area of the Everglades with such a stringent accuracy specification can only be accomplished efficiently by using GPS technology. This is especially the case in a harsh and inaccessible wilderness environment with unique landscape characteristics.

Because the Everglades is so expansive and remote and includes environmentally sensitive areas, impenetrable vegetation, or other areas unapproachable by airboat, access to many places is possible only by helicopter. To solve this accessibility problem, the USGS developed a helicopter-based instrument, known as the Airborne Height Finder (AHF) (Figures 3 and 4), which is able to measure the terrain surface elevation in a noninvasive, nondestructive manner. Using an airborne GPS platform and a high-tech version of the surveyor's plumb bob, the AHF system distinguishes itself from remote sensing technologies in its ability to physically penetrate vegetation and murky water, providing reliable measurement of the underlying topographic surface.

Accuracy tests have shown that the AHF system can consistently measure elevation points at the subdecimeter level. An accuracy test of the AHF was conducted in May 2000 when 17 National Geodetic

Figure 4. The Airborne Height Finder is operated using the USGS-developed electronic controller and interface.

Survey (NGS) first-order benchmarks (Figure 5) were measured at two different helicopter hover heights. The average difference between the AHF measured elevations and the NGS published data sheet values was 3.3 cm. The largest difference was 8.6 cm, and the smallest difference was 0.2 cm. The root mean square error was 4.1 cm. These accuracy test results provide confidence that the elevation dataset being produced meets the ±15 cm vertical accuracy specification.

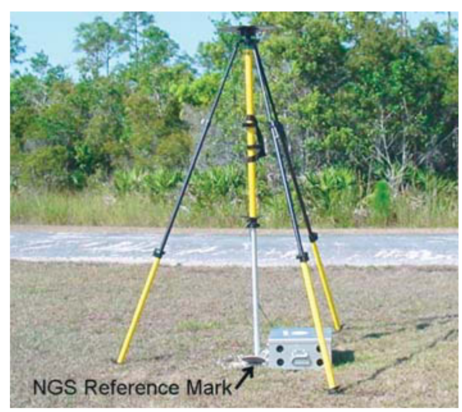

Figure 5. A typical GPS reference station set-up used during Airborne Height Finder operations. All GPS data are collected within 15 kilometers of the reference station to ensure data accuracy and quality.

Elevation data collected with the AHF have been applied in the USGS-

Figure 3. Operation of the Airborne Height Finder is demonstrated. The plumb bob is deployed from the helicopter to the surface being measured.

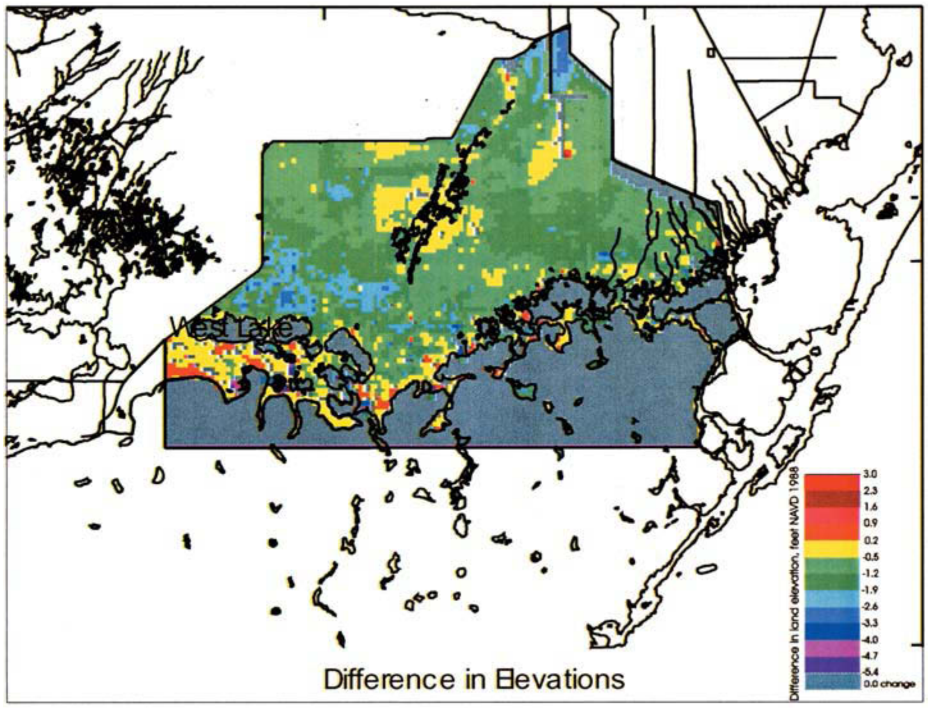

Figure 6. Elevation differences shown in increments of 0.7 feet for the Southern Inland and Coastal System hydrodynamic model domain.

developed Southern Inland and Coastal System (SICS) numerical simulation model, which requires very accurate data for its hydrodynamic surface-water computations. The SICS model was originally constructed with topographic estimates based on pre-existing contour maps. Although these contour maps meet national map accuracy standards, the derived elevation data are not adequate for hydrologic modeling purposes for the Florida Everglades. However, the distribution of surface-water flows simulated by the SICS model was greatly improved when the AHF elevation data replaced the previously estimated topography in the model. The differences between the two topographic surfaces are shown in figure 6.

Negative values in Figure 6 indicate where the AHF elevations are lower than the previously estimated topography. Flow and inundation estimates north of the West Lake area (southwest part of the SICS model domain) are most significantly affected by this elevation difference.

To date, tens of thousands of elevation data points covering significant parts of the Florida

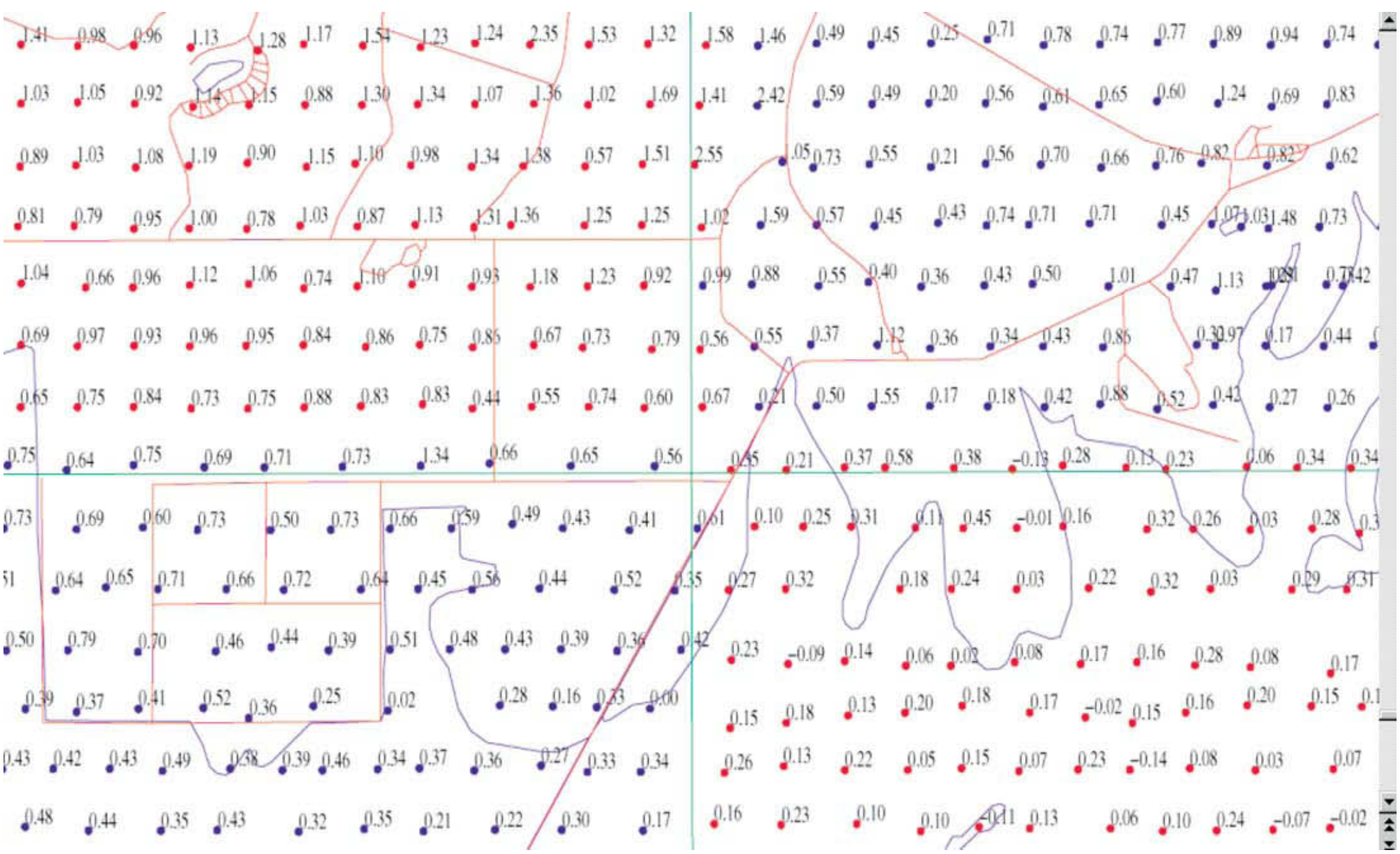

Figure 7. A sample plot of the point elevation data overlaid on a USGS digital line graph.

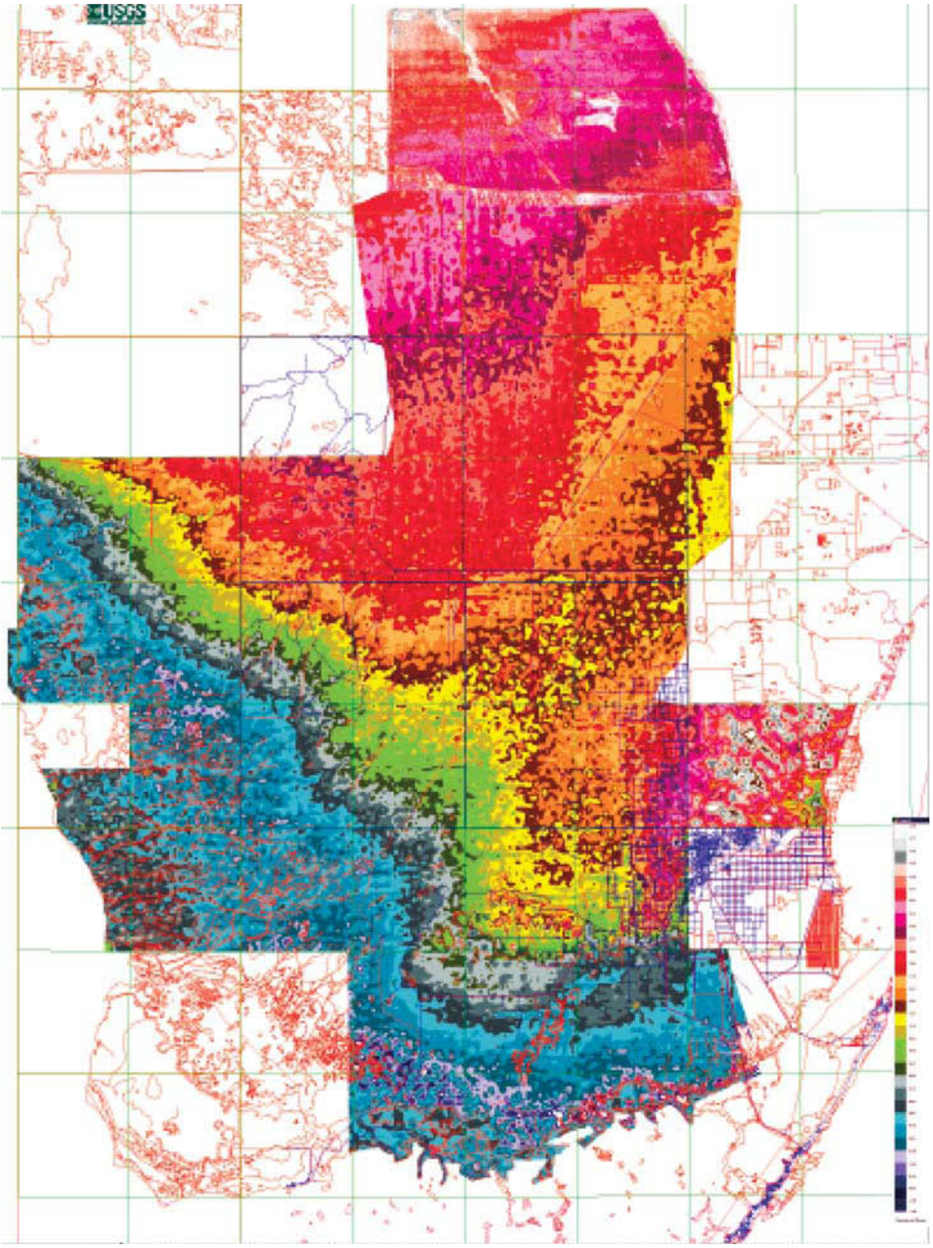

Figure 8. A hypsographic map generated from the GPS-derived elevation data points detailing the topography of the Florida Everglades.

Everglades (Figures 7 and 8) have been collected and processed using differential GPS methods with airboats and the helicopter-based AHF system. These data are organized by USGS 7.5-minute quadrangle maps and are available from the South Florida Information Access Web site at sofia.usgs.gov.

Information

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