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Sheet Flow in Vegetated Wetlands of the Everglades

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Project Objectives

This project is focused on quantifying the extremely slow flows in Shark River Slough and investigating internal and external forces that affect sheet flow behavior. Insight into the nature of sheet flow behavior in the wetlands, coupled with identification of the factors that influence the flow regime, is essential to the development and evaluation of models being used to assess and compare restoration scenarios for the greater Everglades ecosystem.

Monitoring Program

Flow velocities, water and air temperatures, and conductivities were variously recorded at eight stations in differing vegetative communities in Shark River Slough. At four sites, flow velocities were measured hourly or bi-hourly at a fixed point in the water column using acoustic Doppler velocity (ADV) meters (fig. 1 A). At two sites, flow velocities were measured bi-hourly throughout the upper water column in 1.6-cm increments using up-looking acoustic Doppler profiling (ADP) meters (fig. 1 B). At all eight sites, water and air temperatures were monitored at 5- or 30-minute intervals in 5- or 10-cm increments above the plant litter layer (fig. 1 C). Conductivities and water temperatures were measured bi-hourly near the top of the litter layer (fig. 1 D) at all four ADV sites. During intermittent visits to all sites vertical velocity profiles were collected at 3-cm depth intervals throughout the water column. The types of measurements and associated equipment at the sites are identified in Table 1.

Table 1. Types of measurements and associated equipment.

Continuous
Flow-velocity point measurements
- Sontek Accoustic Doppler Velocity (ADV) meter
Flow-velocity profiles
- Sontek Accoustic Doppler Profiling (ADP) meter
Water and air temperature profiles
- YSI thermistors
Conductance and temperature point measurements
- Seabird MicroCAT meter
Discrete
Flow-velocity profile point measurements
- Sontek Accoustic Doppler Velocity (ADVField) meter

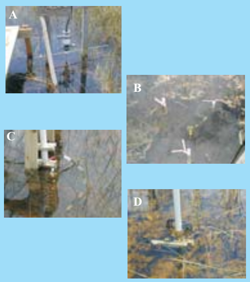


Figure 1. Photographs of field equipment.

Site and Data Descriptions

Of the eight continuous monitoring stations, one was established in 1999 (SH1), two in 2000 (GS-33 and GS-203), four in 2001 (X1, GS-202, SQBN and SQUB), and one in 2002 (GS-36). A brief description of the local vegetation and a list of parameters collected at each site are given in Table 2.

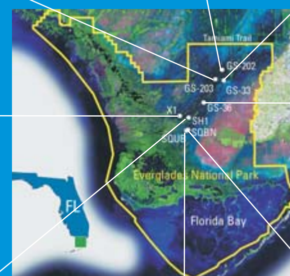
Table 2. Monitoring site descriptions.

Site Name	Parameters Measured	Co-located stations	Vegetation Description
GS-33	v,t,c,p	NPS P33/ET P33	Spike rush w/ heavy periphyton
GS-203	v,t,c,w	NPS NP203	Medium dense sawgrass on the edge of a dense sawgrass stand
GS-202	t	NPS NP202	Dense cattail
GS-36	v,t,c,w	NPS P36	Sparse spike rush
SH1	v,t,c	USGS/BRD SH1	Dense sawgrass stand
SQBN	v,t,c,s,w	SQUB	Sparse sawgrass, burned by June 2001 fire
SQUB	v,t,c,s	SQBN	Dense sawgrass, not burned by fire
X1	v,t,c,m		Medium dense rush

Parameter Key	
v - flow velocity (point)	m - meteorological data
t - water and air temperature	p - flow velocity (profile)
c - specific conductance	w - wind speed and direction

Study Area

Shark River Slough is the dominant path of shallow surface water (sheet) flow through Everglades National Park. It conveys freshwater inflows released from hydraulic control structures and discharged through culverts along Tamiami Trail to the coastal mangrove ecotone bordering the southwest Gulf coast. The low-gradient (10^{-6}) wetlands of Shark River Slough are a mixture of tree islands, sawgrass marshes, and wet prairies as is evident in the photographs below where flow velocities are being measured in this project.



ADV Data Processing

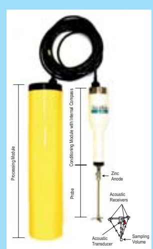


Figure 2. Sontek ADVField system.

Flow velocities were measured using Sontek ADVField units (fig. 2) employing a 3D acoustic probe consisting of three receivers and a transmitter. The 10 MHz ADV meter sampling at a 10 Hz frequency records 600 3D velocity components and statistical correlations every one-minute burst interval.

In processing, any sample with a horizontal velocity component having a correlation less than 70% is filtered from the burst and any burst having less than 200 (out of 600) resultant samples is eliminated from the data set.

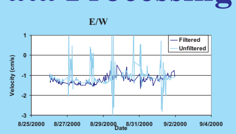


Figure 3. SH1 filtered and unfiltered East/West velocity components.

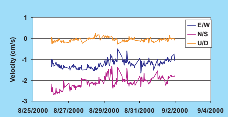


Figure 4. SH1 filtered and edited 3D velocity components.

Unfiltered and filtered East/West velocity components, measured at SH1 in August and September 2000, are shown in Figure 3. All three completely filtered and edited directional velocity components are shown in Figure 4. Data filtering and editing methods are documented in Riscassi and Schaffranek (2002), available for downloading from the TIME website (http://time.er.usgs.gov).

Edited data are available for downloading from SOFIA (http://sofia.usgs.gov).

Velocity and Temperature Data

Data collected to date in Shark River Slough illustrate typical flow conditions found in varied vegetative communities and reveal periods during which dynamic factors influence the flow behavior. Examples of the varied types of data collected to quantify sheet flow behavior are illustrated below.

Velocity - continuous point

Flow speeds and directions at SH1, shown as vectors in the horizontal plane relative to magnetic north, are illustrated in Figure 5. Velocities generally ranged from 1.5 to 2.5 cm/s and flow directions averaged approximately 210 degrees. The response of the flow to Hurricane Irene is evident by the higher velocity (4.5 cm/s) and directional change on October 15, 1999.

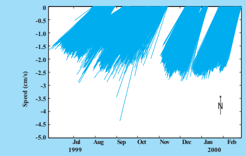


Figure 5. Flow velocities, shown as vectors, measured at SH1 during the 1999-2000 wet season.

Velocity - continuous profile

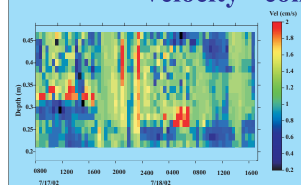


Figure 6. Profile of flow velocities in the horizontal plane measured at GS-33 on July 17-18, 2002.

The ADP unit deployed at site GS-33 yields flow velocities at 1.6-cm intervals every 30 minutes from about 15 cm above the litter layer to the water surface. The ADP data are being quality checked and analyzed to gain insight into the vertical flow structure. Preliminary horizontal velocities measured at GS-33 and shown in Figure 6 illustrate the daily range and variability of flow velocities throughout the upper water column.

Velocity - discrete profile

Flow velocities were measured at 3-cm depth increments in two-minute bursts with portable ADVField meters from the litter layer to the water surface during intermittent site visits. A profile collected at SQBN and shown in Figure 7 clearly illustrates the vertical velocity gradient and relatively stable uni-direction flow throughout the water column. Profiles taken throughout the re-growth of vegetation at this fire site have provided insight into the effects of vegetation on flow behavior and structure.

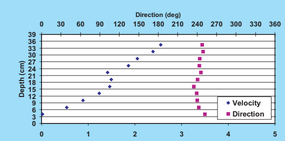


Figure 7. Point velocity profile collected at SQBN on November 8, 2001.

Temperature - continuous profile

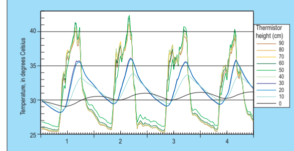


Figure 8. Water, air, and plant-litter temperatures recorded at SH1 during September 1-4, 2000.

Water and air temperatures have been monitored at 5-cm or 10-cm increments above the plant litter layer at all ADV sites. Temperature data measured every 30 minutes at SH1 and shown in Figure 8 illustrate a typical water column thermal pattern. Submerged thermistors (10, 20 and 30 cm above the litter) show the development of vertical stratification during the day and subsequent de-stratification of the water column during the night. The effects of daily water temperature changes on flow-velocity structure are currently under investigation.

Summary and Conclusions

Data collected at a variety of sites in Shark River Slough since 1999 are yielding insight into the typical range of flow velocities found in various vegetative communities and the dynamic factors that affect flow velocities and sheet flow conditions at and between sites. Measurement techniques and processing methods have been developed to evaluate the extremely low flows which have been found to range from 0 to 4 cm/s. Findings from all data collected and analyzed to date indicate that the dynamics and the magnitude, direction and nature of sheet flow conditions are attributed in varying degrees to both internal and external effects, both locally and regionally driven.