Sheet Flow in the Ridge and Slough Landscape of Everglades Water Conservation Area 3A

Introduction

Sheet flow velocities were monitored continuously from August 2005 through March 2006 at a remnant ridge and slough site (3A-5) in central Everglades water conservation area 3A (WCA-3A) (fig. 1). The primary objective of the study was to quantify short term sheet flow behavior in order to evaluate the effect of particulate transport on the ridge and slough landscape.

Sheet Flow Behavior

Sheet flow velocities were measured continuously at a fixed depth in the water column using acoustic Doppler current profiler (ADCP) meters suspended vertically from rigid frames erected in the Proctor Pond slough at site 3A-5 (fig. 4A) and on the adjacent Cladium jamaicense ridge (fig. 4B). Whenever water levels were sufficiently high, flow velocities were sampled at a common depth below the water surface at both locations.

Point Flow Velocities

Ninety percent of flow velocities measured in the slough were between 0.11 and 0.56 cm/s with a mean of 0.31 cm/s and flow directions generally varied between south and southwest near the inlet (fig. 5A). On the ridge, ninety percent of flow velocities were between 0.06 and 0.54 cm/s with a mean of 0.28 cm/s and flow directions generally varied between south and southeast with a mean direction 153° east of due north (fig. 5B). The increase in flow velocity on October 24, 2005 was due to Hurricane Wilma. For periods of concurrent data, the mean flow velocity in the slough was 34% faster than on the ridge.

Daily Mean Flow Velocities

Vectors representing daily mean flow velocities at the slough (A) and ridge (B) locations are shown in figure 6. Flow directions were southerly at the onset of monitoring at both locations and generally varied between south and southeast during the hurricane season when water levels were high, mean flow velocities were similar at the ridge and slough. Unit-width discharges were computed for each velocity profile and for all continuous ADCP data recorded in the slough during the hurricane were invalid due to vegetation.

Vertical Velocity Profiles

Eight vertical velocity profiles were collected in the slough over a depth range of 48 cm (fig. 7A) and six were collected on the ridge over a depth range of 47 cm (fig. 7B). Mean flow velocities for the profile data ranged between 0.11 and 0.41 cm/s in the slough (table 1) and between 0.06 and 0.25 cm/s on the ridge (table 2). In the middle part of the wet season when water levels were high, mean flow velocities were similar at the ridge and slough and velocities were nearly uniform with depth. As water levels declined after Hurricane Wilma, mean flow velocities increased and velocities departed from uniform in the vertical at both locations. For all profiles, the maximum velocity on the ridge typically occurred about 10 cm above the surface of the floc layer whereas minimum velocities occurred within 10 cm of the floc surface in the slough. Velocities closer to the top of the floc layer were typically less than depth-averaged velocities. High flow velocities measured at both locations on December 9 when water levels were relatively low and falling are likely the result of rainfall that occurred during the 4 days prior to the profile.

Site Description

Ridges and sloughs have a predominant north-south alignment in central Everglades WCA-3A (fig. 1). The topography is representative of remnants of ridge and slough landscape. A 3D plot of topographic data derived from five transit surveys is shown in figure 2B. Transit data collected simultaneously over 10-20 m. At site 3A-5, the slough including the vegetative transition zone is about 80 m wide and 20 m in elevation in the slough to the eastern edge of a distance of about 10 m (fig. 2C).

Monitoring Program

In August 2005, two monitoring stations were established at site 3A-5, one on the edge of a ridge and the other 14 m to the west in the slough. Water level, water temperature, air temperature, and conductivity data were collected continuously at both locations. During site visits, vertical velocity profiles were measured at 1.5 or cm depth increments. Wind conditions also were measured. A summary of data presented in figure 3. Gaps in the grid indicate missing, erratic, or suspect data.

Extreme Flow Event

On October 24, 2005, Hurricane Wilma traversed the Everglades from southwest to northeast, about 30 km north of site 3A-5 (fig. 8). Mean wind speed, measured 3 m above the water surface on site, ranged from 2-4 m/s prior to arrival of the hurricane to a maximum of 14.2 m/s during the hurricane, briefly falling to zero as the eye passed (fig. 9). Wind directions shifted from north to east and east-southeast during the hurricane. Water levels quickly rose to a peak of more than 12 cm, gradually declining to about 3 cm higher than pre-hurricane levels (fig. 9). Maximum flow velocities, measured 30 cm above the floc layer on the ridge, were 3.05 cm/s at 79° west of due north during strongest northwest winds before the eye and 4.85 cm/s at 140° east after the eye during strongest east-southeast winds after the eye (fig. 9). Flow velocity data recorded in the slough during the hurricane were invalid due to vegetation contaminating the ADV probe.

Mass Transport

Mass transport, in terms of unit-width discharge, was computed from water levels derived from water-level data and mean flow velocities estimated from point-velocity data recorded continuously at the ridge and slough locations. Three methods were used to approximate the mean velocity. In the first method the mean velocity was assumed equal to the point velocity and in the other two methods the mean velocity was estimated from linear and quadratic relations derived from concurrent data from five velocity profiles. (see fig. 7) are shown in figure 10. Coefficients of determination for both relations at both locations ranged from 0.93 to 0.99.

Unit-width discharges were computed for each velocity profile and for all continuous ADV data recorded at the ridge and slough locations. Discharges computed from the continuous ADV data by the equal, linear, and quadratic methods were 111, 80, and 125 percent greater in the slough (fig. 11). Mass transport, in terms of unit-width discharge, was computed for water levels derived from water-level data and mean flow velocities estimated from point-velocity data recorded continuously at the ridge and slough locations. Three methods were used to approximate the mean velocity. In the first method the mean velocity was assumed equal to the point velocity and in the other two methods the mean velocity was estimated from linear and quadratic relations derived from concurrent data from five velocity profiles. (see fig. 7) are shown in figure 10. Coefficients of determination for both relations at both locations ranged from 0.93 to 0.99.

Summary and Conclusions

Sheet flow velocities were measured continuously at a fixed point in the water column and intermittently in vertical profiles at a remnant ridge and slough site in central WCA-3A from August 2005 through March 2006. The following findings were observed:

- Ninety percent of all velocities at the ridge and slough monitoring locations ranged between 0.08 and 0.55 cm/s. This is in deference to sheet flow velocities ranging between 0.46 and 2.29 cm/s ninety percent of the time during measurements made in ESR from July 1999 to July 2003.
- For periods of concurrent data, the mean flow velocity in the slough was 34% faster than on the ridge.
- The maximum velocity on the ridge typically occurred about 10 cm above the surface of the floc layer whereas minimum velocities occurred within 10 cm of the floc surface in the slough.
- Maximum flow velocities during Hurricane Wilma were an order of magnitude greater than pre-hurricane velocities and flows reversed direction briefly as the eye passed. After the hurricane, velocities quickly returned to typical sheet flow conditions.
- Mass transport in the slough was approximately twice that on the ridge.

Acknowledgments

The project was funded by the USGS Priority Ecosystems Science Initiative and funded by the USGS Priority Ecosystems Science Initiative. Contact Information

Raymond W. Schaffranek, U.S. Geological Survey, Reston, VA, USA

Jonathon W. Harvey, Gregory B. Noe, and Laurel G. Larsen, U.S. Geological Survey, Reston, VA, USA

Edward Simonds, John Shelton, and Jeffrey Woods, USGS, provided technical assistance.

References

A probability plot for each discharge for each period was created. The probability plot for each period was created. The probability plot for each period was created. The probability plot for each period was created. The probability plot for each period was created.