Measuring Flow Velocity in the Everglades "River of Grass"

Monitoring Program

Flow velocities, water and air temperatures, and conductivities were measured at eight stations in differing vegetative communities. 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 water column in 1.6-cm increments using up-looking acoustic Doppler profiling (ADP) meters (fig. 1 B). At all 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 litter layer (fig. 1 D) at all ADV sites.

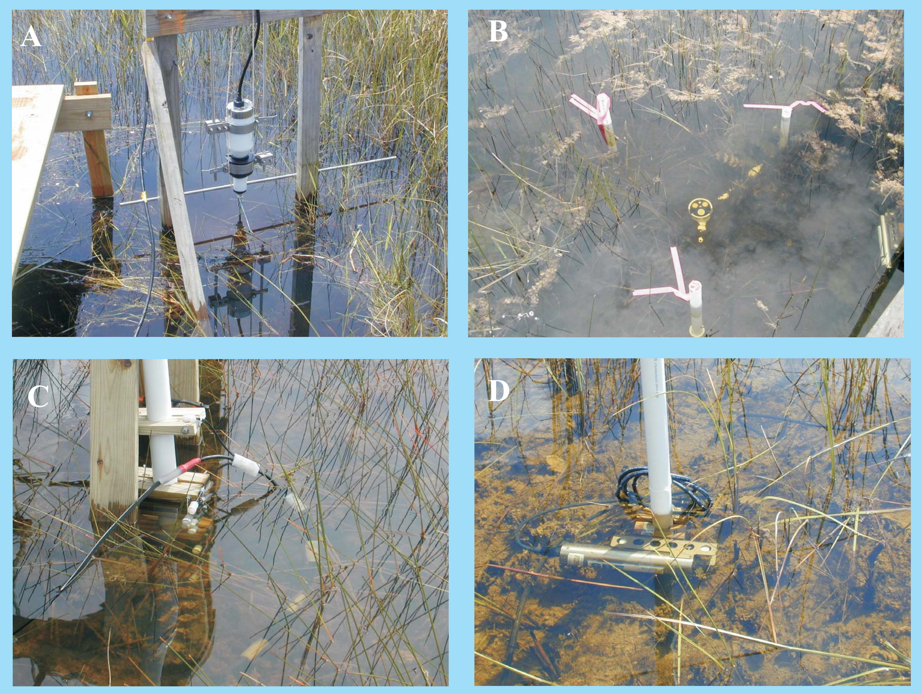


Figure 1. Photographs of field equipment.

Site and Data Descriptions

A brief description of the local vegetation and a list of parameters collected at each site are given in Table 1. Photographs in Figure 2 show the composition of vegetation at the four ADV monitoring sites.

Table 1. Monitoring site descriptions.

Site Name	Parameters Measured	Vegetation Description
GS - 33	v,t,c,p	Spike rush
GS - 203	v,t,c,w	Medium dense sawgrass
GS - 202	t	Dense cattail
GS - 36	v,t,c,w	Sparse spike rush
SH1	v,t,c	Dense sawgrass
SQBN	v,t,c,s,w	Sparse burned sawgrass
SQUB	v,t,c,s,w	Dense sawgrass
X1	v,t,c,m	Medium dense rush

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

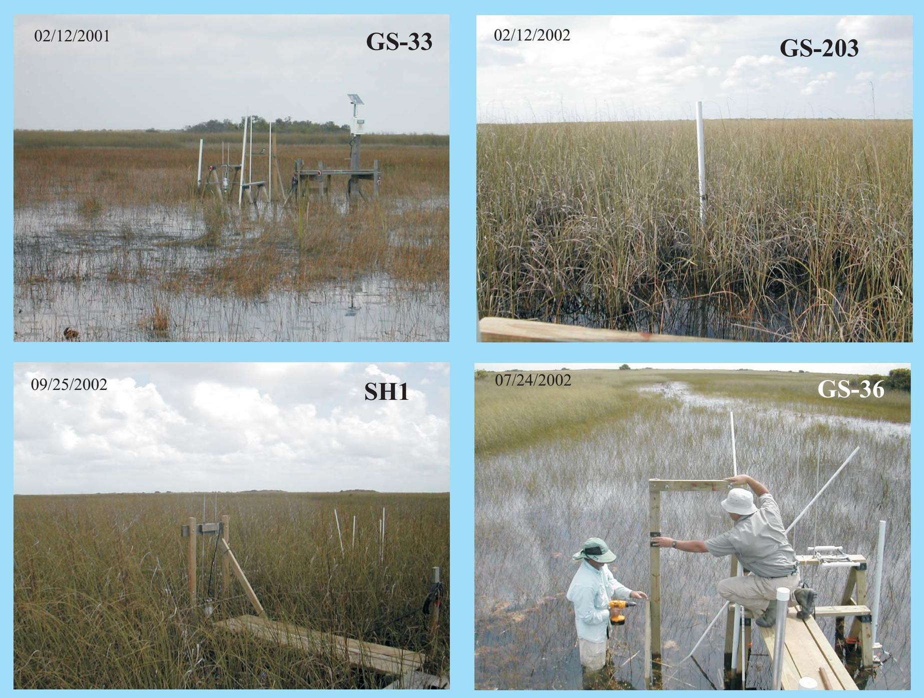


Figure 2. Photographs of ADV monitoring sites.

ADV Data Processing

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 post processing, any sample with a horizontal velocity component having a correlation less than 70% is filtered from the burst. Any burst having less than 200 resultant samples is eliminated from the data set. Unfiltered and filtered East/West velocity components, measured at SH1 in August and September 2000, are shown in Figure 3. All three filtered and edited 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).

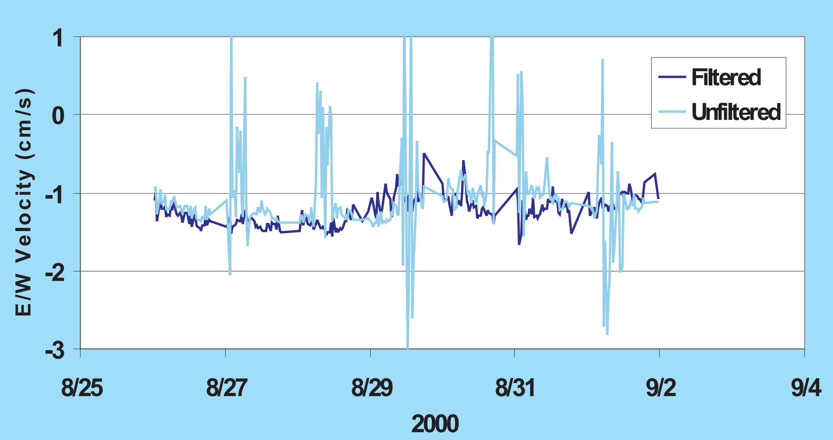


Figure 3. SH1 filtered and unfiltered East/West velocity components.

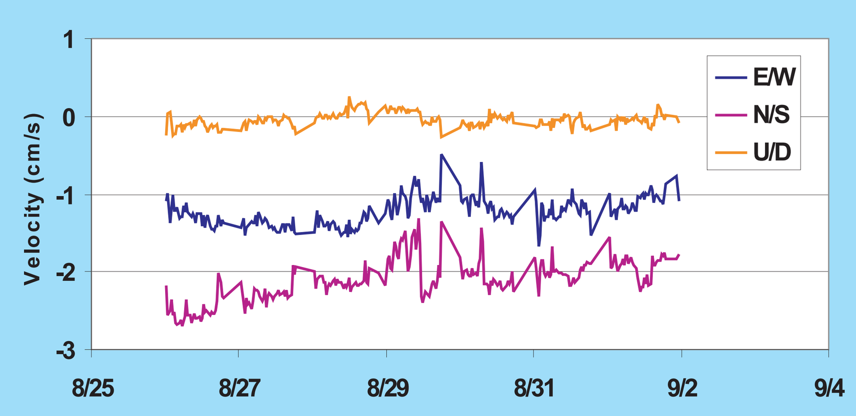
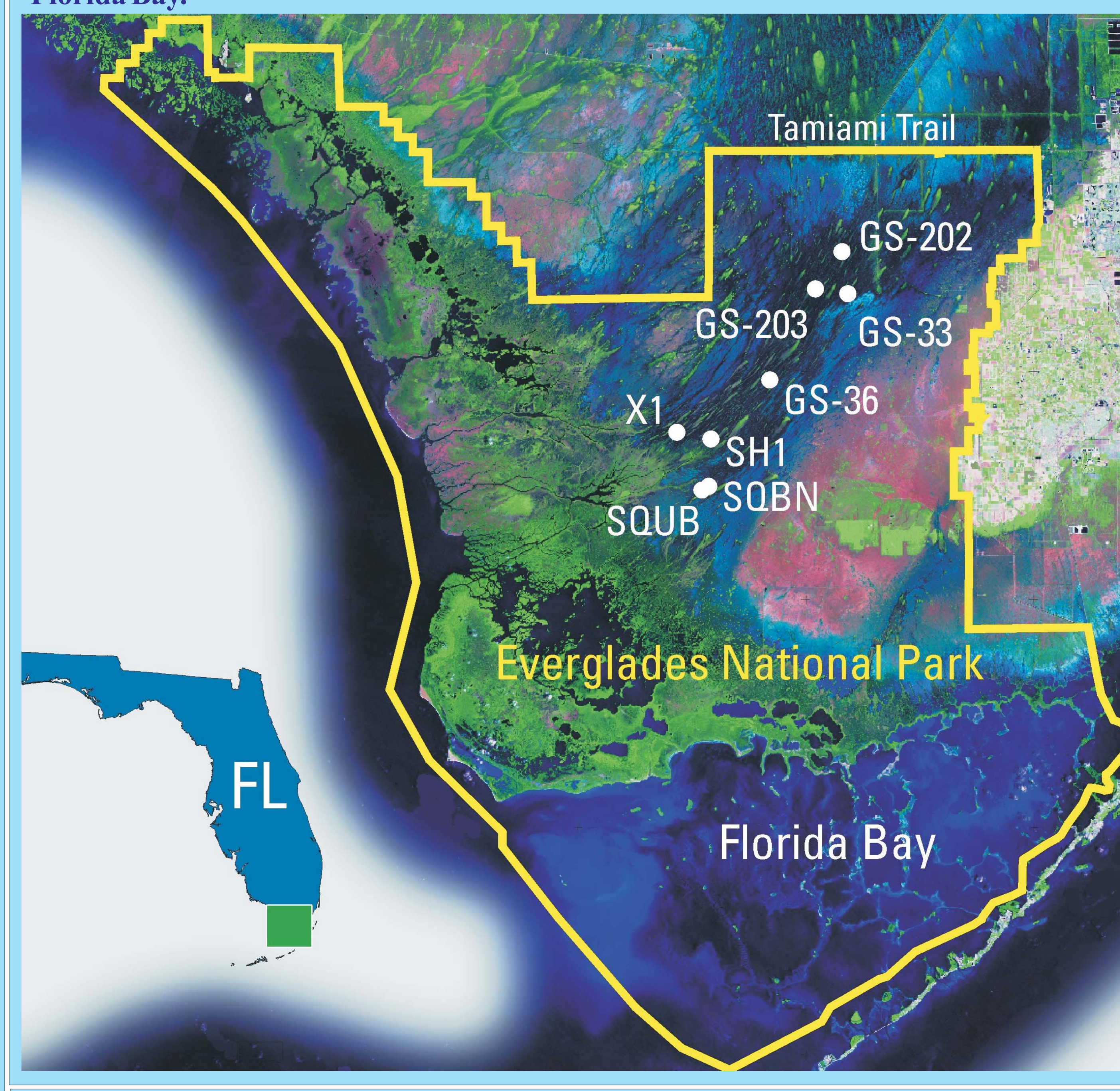


Figure 4. SH1 filtered and edited 3D velocity components.

Study Area

The low-gradient wetlands in Everglades National Park are a mixture of tree islands, sawgrass marshes, and wet prairies. Freshwater inflows released from hydraulic control structures and discharged through culverts along Tamiami Trail are conveyed through the wetlands to the coastal mangrove ecotone bordering the Gulf of Mexico and Florida Bay.



Project Objectives

This project is quantifying the extremely slow flows in the Everglades wetlands and investigating forces that affect its behavior. Insight into 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 Everglades restoration scenarios.

Summary and Conclusions

Acoustic Doppler velocity measurement techniques and processing methods have been developed to collect and evaluate the extremely low flow velocities in the Everglades wetlands. Sheet flow velocities have been found to range from 0 to 4 cm/s. The dynamics and the magnitude, direction, and nature of sheet flows are attributed in varying degrees to both local and regional factors. Local factors influencing the flow include the type, density, and physical attributes of vegetation, as well as the presence and composition of submersed aquatic plants and (or) periphyton. At shallow depths (<10 cm) microtopography plays a major role in local flow behavior. At deeper depths, landscape gradients, presence of tree islands, proximity of drainage controls, and vegetative heterogeneity dominate local factors and regionally affect sheet flow conditions. Thermally driven convective mixing occurs nightly in the water column except during the passage of major storm events.

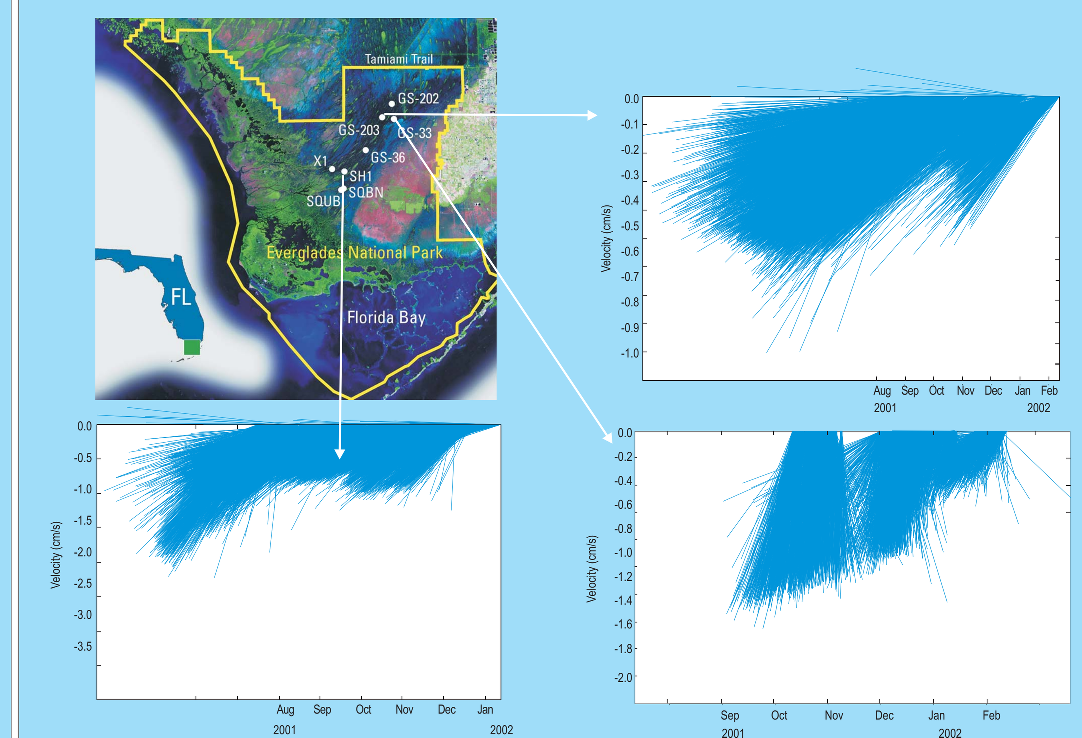
Acknowledgements and Contacts

Edward Simonds, USGS Orlando, provided technical and operational support throughout the duration of this project. Additional information about the project can be obtained from Raymond W. Schaffranek (rws@usgs.gov) and Ami L. Riscassi (ariscass@usg.gov), USGS, National Center, Mail Stop 430, Reston, VA 20192.

Velocity Data

Continuous velocity data collected in the wetlands of Everglades National Park illustrate flow conditions found in varied vegetative communities. The long-term flow-velocity data define the range of velocities, flow direction, and dynamic factors that influence flow conditions in the differing plant communities.

Continuous Point Velocity



Flow speeds and directions shown as vectors in the horizontal plane are illustrated in Figure 5. During the 2001 - 2002 wet season, velocities generally ranged from 0.4 to 2.5 cm/s at SH1, 0.4 to 1.8 cm/s at GS-203, and from 0.02 to 1.5 cm/s at GS-33. Directions averaged approximately 235 degrees at SH1, 251 degrees at GS-203 and 194 degrees at GS-33. The relatively slower flow at GS-33 appears to be related to the abundance of submerged aquatic vegetation and periphyton. Faster flows at SH1 are mainly due to its closer proximity to the centerline of the Slough as compared to GS-203.

Figure 5 . Flow velocities, shown as vectors, measured at SH1, GS-203, and GS-33 during the 2001 - 2002 wet season.

Continuous Velocity Profiles

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. Horizontal velocities and associated statistical correlations recorded at GS-33 and shown in Figure 6 illustrate the daily range and variability of flow velocities throughout the upper water column. The nighttime periods of low correlation data indicate turbulent mixing correlated to convective cooling as demonstrated by the temperature profile data plotted in Figure 7.

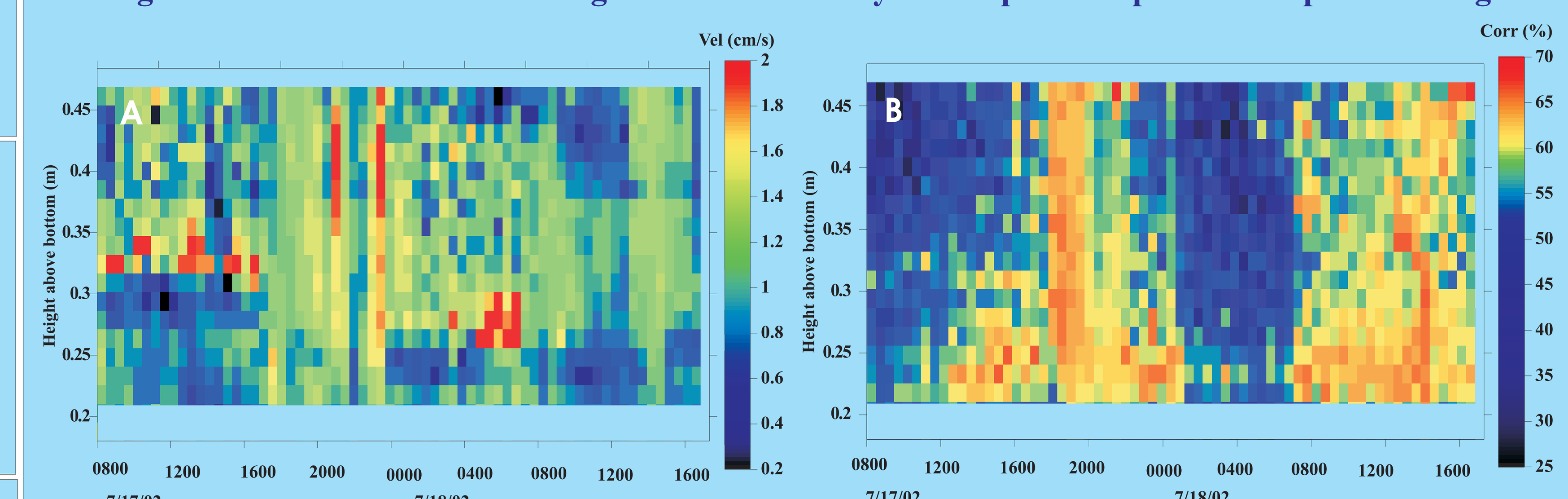


Figure 6. Profile of flow velocities (A) and associated statistical correlations (B) in the horizontal plane recorded at GS-33 on July 17-18, 2002.

Continuous Temperature Profiles

Temperature data measured every 30 minutes at GS-33 and shown in Figure 7 illustrate a typical water column thermal pattern. Submerged thermistors (0.00, 0.10, 0.20, 0.25, 0.30, 0.35, 0.40, and 0.45 m above the litter) show the development of vertical stratification during the day and subsequent de-stratification of the water column during the night. The thermal effects of the nighttime de-stratification of the water column on the flow-velocity structure are illustrated in the velocity data plotted in Figure 6.

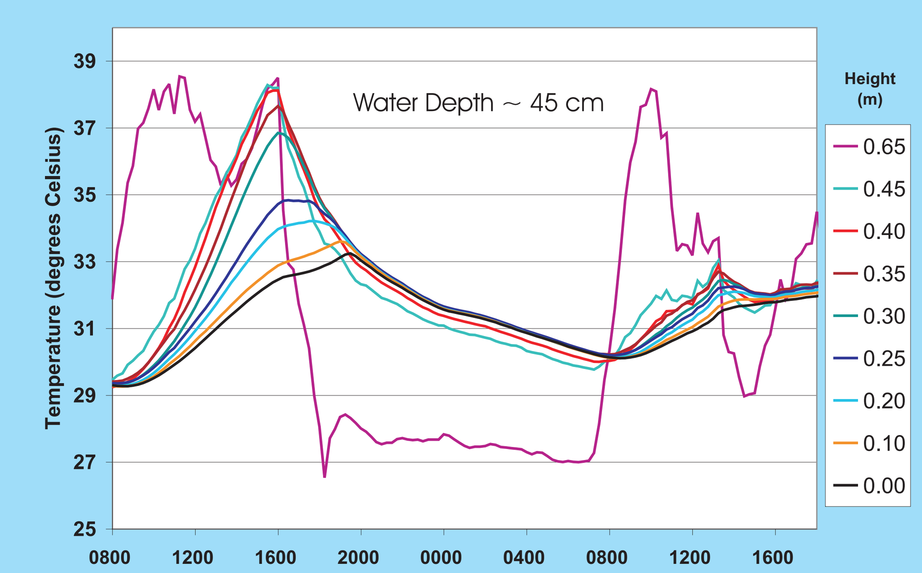


Figure 7. Water, air, and plant-litter temperatures recorded at GS-33 on July 17 - 18, 2002.