Observations of Daily Temperature Patterns in the Southern Florida Everglades

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Abstract

Temperature is an important factor affecting key hydrological and ecological processes within the subtropical wetlands of the Florida Everglades. Comprehensive measurements are being made to quantify the temporal and spatial variability of the water-temperature regime. Data collected in 2000 at a location near the central flow pathway of the ecosystem showed both daily repetitive cycles and dynamic fluctuations in response to meteorological forces. Time-series data collected at spatial intervals throughout the water column, in the air, and in the underlying plant-litter layer revealed the dynamic nature of the temperature structure, e.g., uniformly well-mixed periods, stratified conditions, inversions, changing vertical gradients, and other characteristics important to understanding ecosystem processes.

Introduction

The heterogeneous wetlands of the southern Everglades are a vast mosaic of sloughs, wet prairies, sawgrass stands, tree islands, brackish marshes, and mangrove thickets. Drainage and human development during the last century alone have reduced the Everglades wetlands by half (Davis et al., 1994). The once pristine and free-flowing Everglades, dubbed "the River of Grass," is now a heavily managed ecosystem. Fortunately, major efforts are underway to restore the natural functioning of the ecosystem to stem the loss of wetlands. Water-management decision makers are relying heavily on scientists for insight into hydrological and ecological processes to guide the restoration efforts.

Most processes within aquatic systems are temperature controlled. Temperature routinely affects a variety of processes that function continuously within the Everglades, e.g., oxidation, organic decomposition, nutrient and contaminant cycling, evaporation, and plant transpiration. The shallow, slow-moving flow of the Everglades is susceptible to the dynamic effects of ambient and convective temperature fluctuations on a regular basis. The objectives of this ongoing investigation are to: 1) quantify the temperature regime, 2) describe the temporal and spatial behavior of the temperature structure, 3) identify meteorological effects on temperature dynamics, and 4) document the nature of temperature cycling within the variety of vegetative communities comprising the Everglades.

Data collected at a central location in Shark River Slough within the southern Everglades are presented in this paper. Two weeklong sets of data, collected at different times of the year, are shown to provide insight into the temperature regime. Several aspects of the nature of temperature fluctuations and properties of the temperature structure are identified that are important to understanding and evaluating ecosystem processes. The project, which began in December 1999, is currently being expanded to include monitoring at other locations to provide the data needed to compare and contrast the temperature regime in varied vegetative communities and to investigate the effects of anthropogenic influences, e.g., hydraulic control structures, roads, and canals, on temperature structure in adjacent wetlands.

Measurement Location, Instrumentation, and Deployment Technique

The temperature-monitoring station is in the southern part of Shark River Slough within Everglades National Park, which is bounded by Tamiami Trail to the north, Florida Bay to the south, and the Gulf of Mexico to the southwest. Temperature data were collected near a hydrologic monitoring station, referred to as SH1 that is in the freshwater wetlands approximately 2 km upstream of the headwaters of the tidal-affected Shark River. Shark River conveys freshwater wetland runoff about 30 km southwest to the Gulf coast. Temperatures were monitored at the edge of a stand of sawgrass in an area dominated by spikerush, both of which are vegetative communities common to the Everglades.

Temperatures were measured using thermistors manufactured by Yellow Springs Instruments, Incorporated[1] that have a rated precision of 0.01° C and stated accuracy of ± 0.1° C. To facilitate deployment, ten thermistors were spliced inline at a spacing of 10 cm and cabled together in a string. The thermistor string was secured to a section of PVC pipe and deployed vertically in the water column. The first (bottommost) thermistor was embedded 1-2 cm in the plant-litter layer and the others were suspended in the water column and air above it. The thermistor string was wired to a programmable data logger that sampled temperatures at a predefined internal frequency and recorded one-minute averages.

Discussion of Temperature Data

Two sets of temperature data measured and recorded every 30 minutes at SH1 during January 2-8 and October 1-7, 2000, are shown in figures 1a and 1b, respectively. The January set of data, shown in figure 1a, corresponds to the middle of the typical November-to-April dry season for the subtropical Everglades. The October set of data, shown in figure 1b, is from the latter part of the wet season, which typically occurs between May and October. Data from these time periods are presented because they are representative of the range of meteorological conditions that occurs within the Everglades and because several interesting phenomena are evident in the contrasting sets of temperature data.

For the time period in January, shown in figure 1a, water depth at the site, which was measured from the surface to the top of the plant-litter layer, decreased continuously from approximately 64 to 61 cm. There was very little cloudiness, winds were light, and rainfall was minimal throughout the period. The uppermost three thermistors (at 70-, 80-, and 90-cm heights) were out of the water for the entire period and, thus, recorded air temperatures at their respective intervals above the water surface. The submerged thermistors indicated that during the day, the water column became stratified and reached a maximum stratification around mid-afternoon of approximately 3° C, measured over 50 cm of depth. Air temperatures were as much as 5 to 6° C higher than water temperatures during the day. During the night, water temperatures were 2 to 3° C higher than air temperatures and convective cooling of the entire water column progressed at a rate consistent with changes in the air temperature. Throughout the night the water column

[1] The use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

cooled continuously and temperatures at the surface were always cooler than the underlying water. Data from the submerged thermistor nearest the water surface (60-cm height) (fig. 1a) indicated that the cooler boundary layer at the surface was on the order of 10 cm or less in thickness. The water column was thermally non-stratified vertically twice during the day—just after sunrise and again just after sunset. Temperatures in the plant-litter layer (thermistor at 0-cm height) were out of phase with water temperatures. A repetitive daily cyclical temperature pattern was clearly evident in this data set, which is devoid of major meteorological, i.e., storm, effects.

For the time period in October, shown in figure 1b, water depth at the site changed dramatically, as evidenced by the fact that three of the four thermistors that were in the air (60-, 70-, 80-, and 90-cm heights) at the start of the period were entirely submerged at the end. A tropical system that developed in the aftermath of Hurricane Keith brought significant rainfall to southern Florida on October 2 and 3, 2000. From a mean of 57 cm on October 1, water depth increased approximately 31 cm from October 2 to 4 and increased an additional 2-3 cm on October 5 due to local rainfall and wetland runoff. The daily cyclical temperature pattern, shown by the January data in figure 1a and clearly evident on October 1, was entirely missing on October 2 and 3 and only slowly, and weakly, redeveloped. Stratification, although evident from October 4 to 7, was minimal by comparison to the January data, being less than 0.5° C over 60 cm of depth. Water temperatures, however, decreased approximately 8° C from October 1 to 4, but returned to pre-storm levels within three days (on October 7). Temperatures in the plant-litter layer were higher than temperatures measured both in the air and in the water column during October 2 and 3. The response of water temperatures to air temperatures through meteorological forcing is clearly evident in this data set.

Summary and Conclusions

Temperatures of the water, air, and plant-litter layer were measured and recorded at a central location in the wetlands of Shark River Slough within Everglades National Park in January and October 2000. Measured data indicated that the temperature structure was highly dynamic and directly linked to meteorological conditions. Water temperatures showed a strong correlation to external meteorological forces, changing at both daily and longer frequencies. Strong thermal gradients, clearly evident during periods devoid of major meteorological events, were significantly reduced in strength and delayed in regeneration after the passage of weather fronts. The vertical temperature structure varied from both strongly and weakly stratified to well-mixed conditions. Temperature fluctuations in the plant-litter layer were out of phase and significantly smaller in amplitude than temperature dynamics within the water column. Knowledge and consideration of the complex temperature regime of the wetlands of the Everglades, as illustrated by the data presented in this paper, are fundamental to investigating and gaining insight into ecosystem processes.

Reference

Davis, S.M., Gunderson, L.H., Park, W.A., Richardson, J.R., and Mattson, J.E., 1994, Landscape dimension, composition, and function in a changing Everglades ecosystem, *in* Everglades: The Ecosystem and Its Restoration, S.M Davis and J.C. Ogden (eds.): Delray Beach, FL, St. Lucie Press, chap. 17, pp. 419-444.

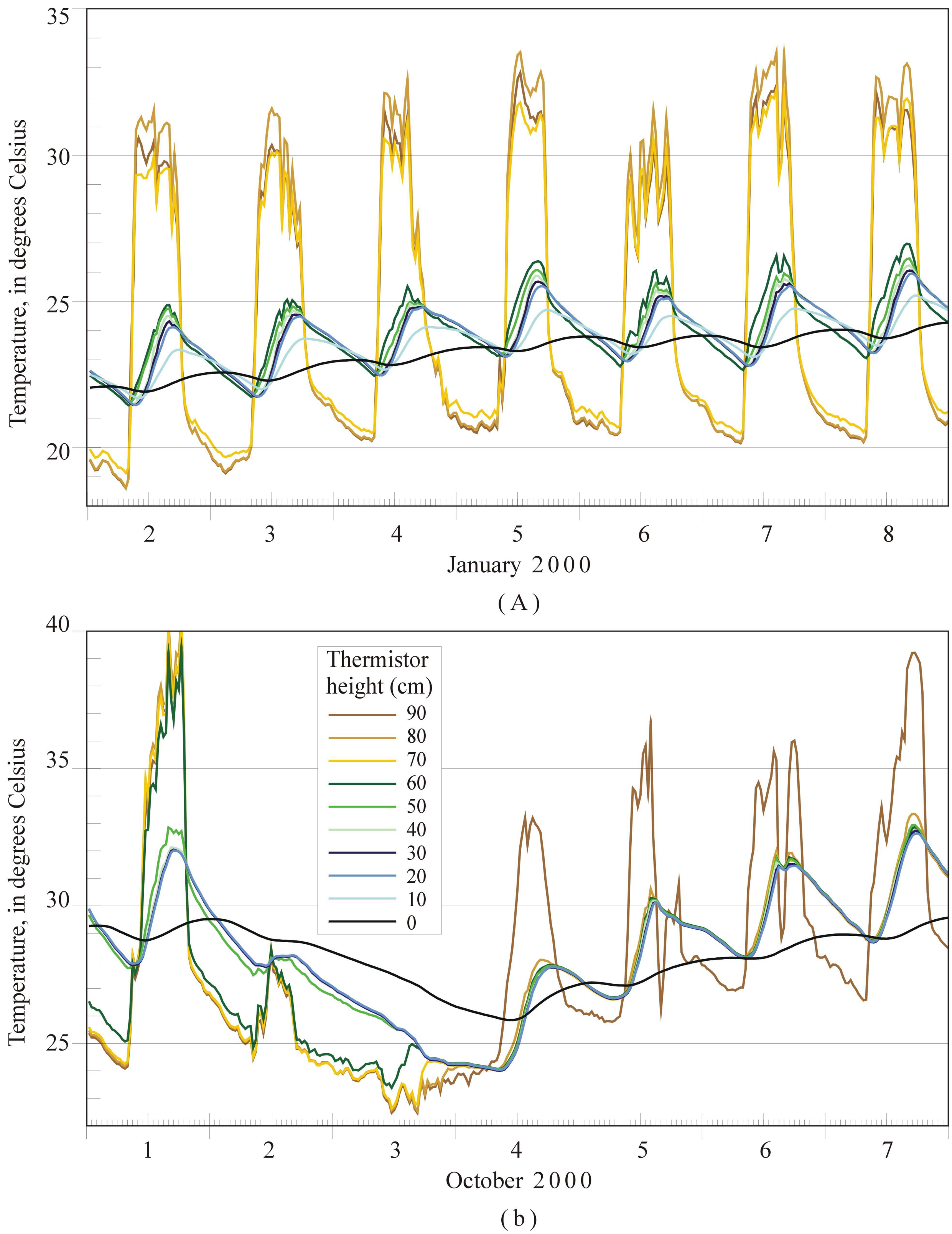

Figure 1. Water, air, and plant-litter temperatures recorded at SH1 in Shark River Slough, Everglades National Park, Florida, (a) during January 2-8 and (b) October 1-7, 2000. (Thermistor height measured from within plant-litter layer.)