SP and Hydrologic Monitoring of Shallow Groundwater Flow in Covered Karst Terrain

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For monitoring complex patterns of shallow groundwater flow it can be useful to supplement hydrogeologic measurements (piezometers, soil moisture and matric potential sensors) with SP data. Because SP readings are sensitive to moisture flux both locally and at a distance, the data are inherently complementary to point-readings of the hydrogeologic instruments.

In the covered karst of west-central Florida, USA, shallow groundwater flow patterns can be extremely heterogeneous in both space and time. At sinkholes, the shallow clay-rich confining unit is breached and sand-filled conduits form. These conduits serve as points of locally concentrated recharge to underlying aquifers. Shallow flow is thus very different when the water table is above the top of the clay-rich unit and when the water table is below this level. As a result seasonal differences in rainfall infiltration and recharge patterns are quite pronounced. In addition to the seasonal variability and the hour-to-day infiltration times for rainfall events there are significant evapotranspiration-driven diurnal variations in the unsaturated zone.

We present results from a combined set of semi-continuous measurements on piezometers, soil moisture and matric potential sensors, and SP electrodes, for many months over two small sinkholes in a small area (600 m^2) in covered karst. The SP measurements are clearly sensitive to the rainfall infiltration events, producing distinctive responses as large as 50 mV. The timing of the SP signals at different electrodes can be used to map canopy interception. Electrodes buried at 10 cm depth show diurnal variability of ~1-3 mV with the temporal patterns expected for evapotranspiration. These results show that for monitoring shallow infiltration and evapotranspiration fluxes, SP electrodes can function as at least qualitative sensors. However interpretation of piezometer and soil moisture and matric potential sensor data is more reliable and straightforward. Where the SP data really add to system understanding is their sensitivity to flow beneath the sensor. This is especially valuable in studying sinkholes, where it can be difficult or disruptive to install deep piezometers. At our test site, against the background of the other temporal variability the SP data show positive and negative anomalies episodically over the sinkhole conduits, suggesting that conduit flow is dynamic, not static. We postulate that distinct SP anomalies can be related to distinct flow regimes in the conduits: fast flow to the aquifer, slow flow to the aquifer, and a conduit plugged high enough that flow rates essentially match those through the regional confining layer. Numerical simulations of such flow regimes show that each produces distinct SP anomalies. Ongoing data collection is being used to test this hypothesis and to better understand the controls on SP response.