Effect of El Niño Southern Oscillation Weather Patterns on Central Florida Lake Water Budgets—Lessons from Lake Starr

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El Nino Southern Oscillation (ENSO) events between 1997 and 2003 had substantial effects on lake hydrology in central Florida. The first event (1997-1998) was one of the strongest occurrences of the warm condition of ENSO this century (Australian Government Bureau of Meteorology, 2005). In central Florida, this event came after a series of wetter than normal years, generating record high stages for many lakes and streams and causing widespread flooding. Lake Starr on the Lake Wales Ridge in Polk County reached the highest stage of the past 35 years in 1998 (Swancar and others, 2000). The 2002-2003 warm event was not as intense and generally produced less rainfall, but it provided much-needed relief from the residual effects of the drought of 1999-2001. Many rivers in the area set new record low levels during this drought (Stoker and others, 2002), which was associated with a La Nina (cold) ENSO event.

ENSO warm events (El Ninos) originating in the Pacific Ocean generate higher than average winter rainfall in Florida and other states surrounding the Gulf of Mexico. During warm events, the jet stream tends to stay farther south during the winter months, driving more storm systems across central Florida (Kahya and Dracup, 1993). The additional rain occurs during the typically dry winter at a time when evaporation is low, leading to greater net precipitation and ground-water recharge. Greater net precipitation from both warm events produced greater recharge to the ground-water system. Many lakes and rivers in Central Florida are well connected to the ground-water system because the geology consists of cavernous limestone that is thinly covered by clays and sand in a karst setting characterized by sinkholes and springs. Most central Florida lakes are similar to Lake Starr; they are seepage lakes with no surface water inflows or outflows, and rely on ground-water inflow to maintain their stages. Net ground-water exchange with Lake Starr was calculated as the residual of a water budget where rainfall, evaporation, and change in stage were measured from 1996-2004.

The Southern Oscillation Index (SOI) is a monthly normalized value that reflects the magnitude of the ENSO phenomenon (National Weather Service Climate Prediction Center, 2005). The value of the SOI is more negative during warm events (El Ninos) and more positive during cold ones (La Ninas). Net ground-water flow to Lake Starr is greater during periods when the Southern Oscillation Index (SOI) is more negative, and less when the index is positive (fig. 1). Changes in the direction of the SOI from negative to positive correspond to declines in net ground-water flow to the lake (fig. 2). While the trend in net ground-water flow is related to changes in the SOI, the magnitude is not well-predicted based on the SOI. The best linear regression model (r^2=0.45) to predict net ground-water flow to the lake was based on a 6-month running average of each of the variables, with the net ground-water value lagged 3 months (fig. 3). The lag in ground-water exchange with the lake is due to the time it takes for rainfall to reach the ground-water system, which is up to 3 months at this site where depths to water can be as high as 40 m, as well as the time for water to move through the surficial sands to the lake.

The ability to predict the onsets of droughts or wetter than normal periods and their effects on lakes and rivers based on a global index is useful for residents, scientists, engineers, and water managers. Some of the variability in net ground-water flow to the lake that cannot be explained by the SOI is probably attributable to individual extreme rain events that affected ground-water inflow to Lake Starr disproportionately. Figure 3 supports this statement; variability is greater when SOI is negative. Isolated heavy rainfall events are common in Central Florida; days with rainfall between 50 and 100 mm occurred 23 times at Lake Starr between 1996 and 2004.

References

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Figure 1. Relation between net ground-water flowto Lake Starr and the Southern Oscillation Index

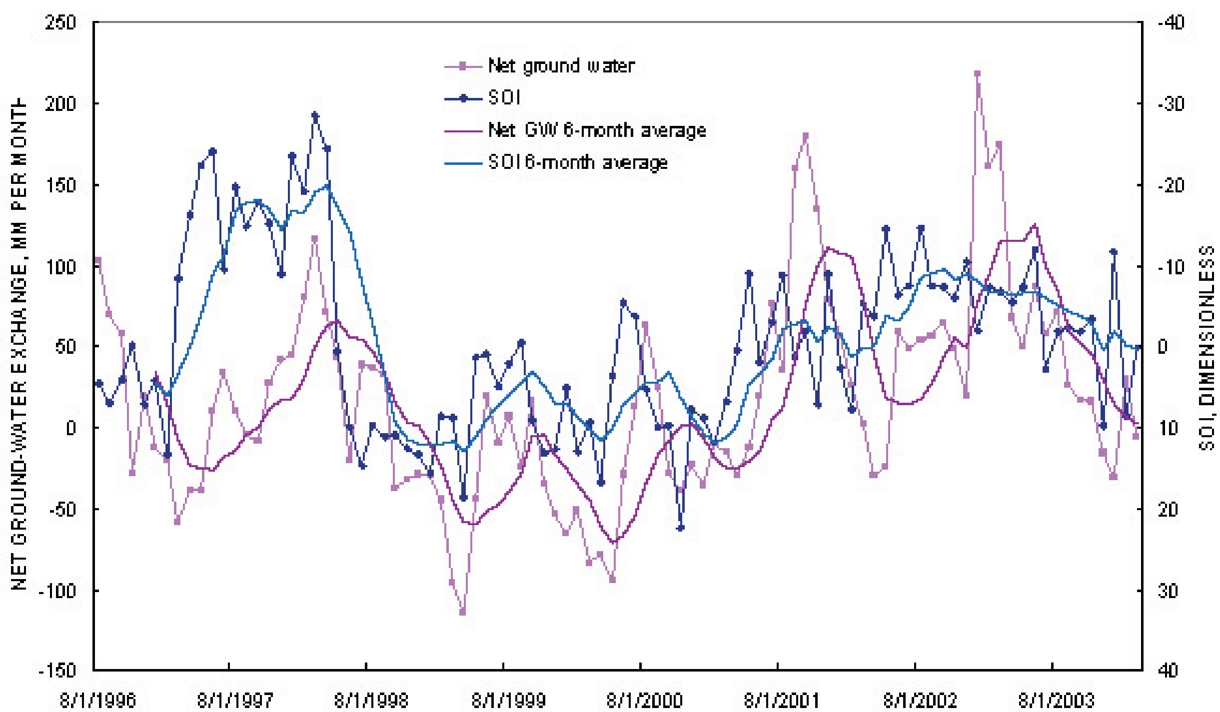

Figure 2. Relation between cumulative net ground-water flow and cumulative Southern Oscillation Index

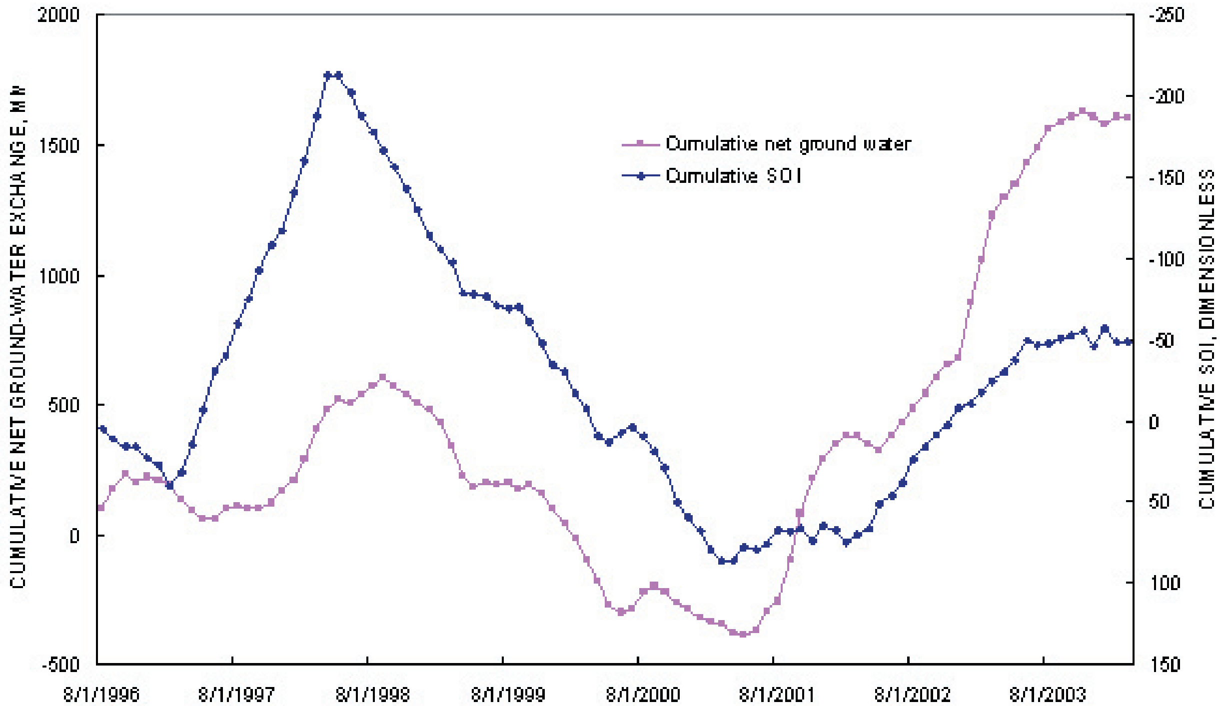

Figure 3. Relation between average of previous 6 months net ground-water exchange (lagged 3 months) and 6-month average Southern Oscillation Index (SOI)