ENSO Forecasts to Plan Water Withdrawals for Irrigation

► During growing seasons, irrigation can help farmers offset the impact of dry spells on crops. While farmers make large investments to employ irrigation systems in their fields, careful planning of irrigation water withdrawals from streams is a must to take full advantage of these systems.

The withdrawal of irrigation surface water from streams can be based on El Niño Southern Oscillation (ENSO) forecasts. This method can help farmers plan sustainable water withdrawals from streams based on forecasted climatic conditions.

Introduction

Alabama averages approximately 56 inches of rainfall annually. However, this rainfall is highly variable and insufficient to meet crop water requirements during the growing season. Stream flows are frequently lower during crop growing months, which limits the amount of water a farmer can pump from streams to irrigate crops. The water withdrawals made from streams during this time would likely affect the ecological integrity of the streams.

Climate variability can affect the hydrological processes within a watershed. One such climate variability phenomenon is ENSO, which governs climate variability in the southeastern United States—and the state of Alabama is no exception. ENSO influences temperature, precipitation, and streamflow patterns in this region. Understanding the effects of ENSO can help farmers plan water withdrawals from streams. El Niño and La Niña are two phases based on contrasting extremes in the ENSO cycle. El Niño refers to the ENSO cycle's warm phase when trade winds, usually blowing from east to west along the equator, weaken or are reversed in the opposite direction because of the warming of the sea surface in the Pacific. La Niña, on the other hand, is the ENSO cycle's cold phase and is characterized by lower-than-average sea surface temperatures. In this phase, the typical eastward winds along the equator become even stronger. The neutral phase refers to periods when neither El Niño nor La Niña is present and sea surface temperatures are close to the long-term average. While the variations in sea surface temperatures are measured in the Pacific, the impacts

of these events in the form of floods, droughts, and hurricanes are observed worldwide. In Alabama, the droughts of 2000–2001 and 2007–2008 showed a direct connection to the La Niña phase of ENSO. A specific phase of ENSO affects the amount of precipitation in different seasons in a specific year, and, therefore, the volume of streamflow alters depending on the ENSO phase.

While the impacts of ENSO can be catastrophic, the occurrences of such events can be predicted. The National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center provides detailed information regarding the current ENSO status, including a lookout for the upcoming months. The capability to forecast the occurrence of these ENSO events allows growers to make informed decisions related to irrigating their fields.

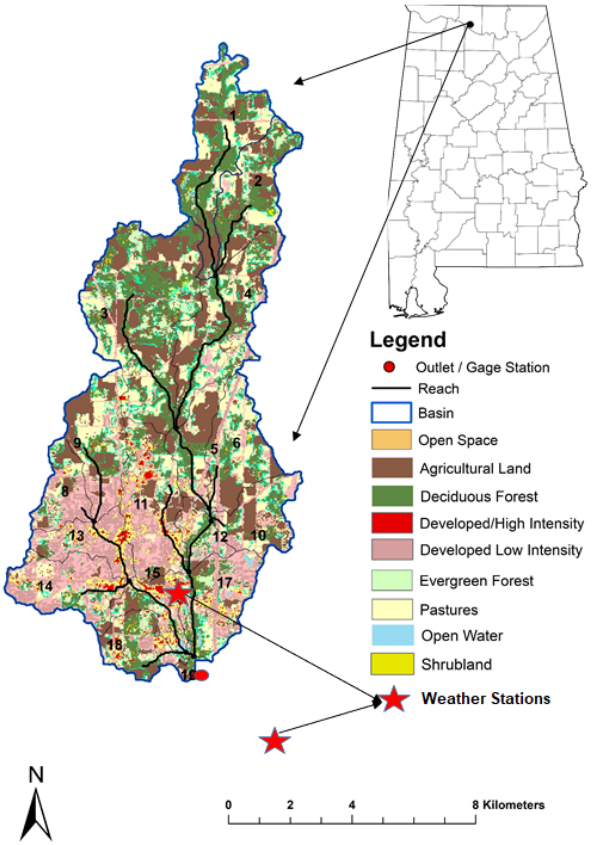

Figure 1. Swan Creek watershed in northwest Alabama

To understand the effect of ENSO on streamflows, a study was conducted in the Swan Creek watershed (97 km^2) in north Alabama (figure 1) where streamflows were simulated using the Soil and Water Assessment Tool (SWAT) simulation model.

Relationship between ENSO and Precipitation

Results show that from 1950 to 2018 winters were wetter during the La Niña phase than during the El Niño phase, especially from January to March (figure 2). However, during the summer, the precipitation was lower during the La Niña phase than during the El Niño phase. Regardless of the phase, the precipitation was higher in the winter months than in the summer months. In another study conducted in south Alabama, higher precipitation was observed in the El Niño phase during the winter season. This higher precipitation continued through the summer months. Therefore, the results of this study show that the impact of ENSO on precipitation can vary in different parts of Alabama.

Understanding precipitation trends based on location is extremely important for a farmer in planning irrigation water withdrawals. For example, if drier conditions are predicted during the growing season, a farmer may plan irrigation withdrawals in advance when the water availability is higher. Additionally, the precipitation trends may also be used by a farmer to choose the type of crop for irrigated and non-irrigated fields. When drier conditions are expected during the growing season, farmers may sow a drought-tolerant crop in non-irrigated fields and water-sensitive crops in irrigated fields. Overall, such choices based on forecasted precipitation trends would help farmers better manage crops and irrigation and, therefore, increase crop productivity.

Relationship between ENSO and Streamflow

Like precipitation, higher streamflow levels were observed from January to April in the study watershed (figure 3). For the remaining year, except October, the streamflows were higher in the El Niño phase than in the La Niña phase. These results indicated that growers who need to withdraw water from streams in the summer, especially during the La Niña season, might not have enough water in the streams to make ecologically sustainable withdrawals or they might have to resort to other sources of water to fulfill crop needs. However, higher precipitation and streamflows in the winter months during the La Niña phase allow harvesting water from on-farm ponds in the winter months for

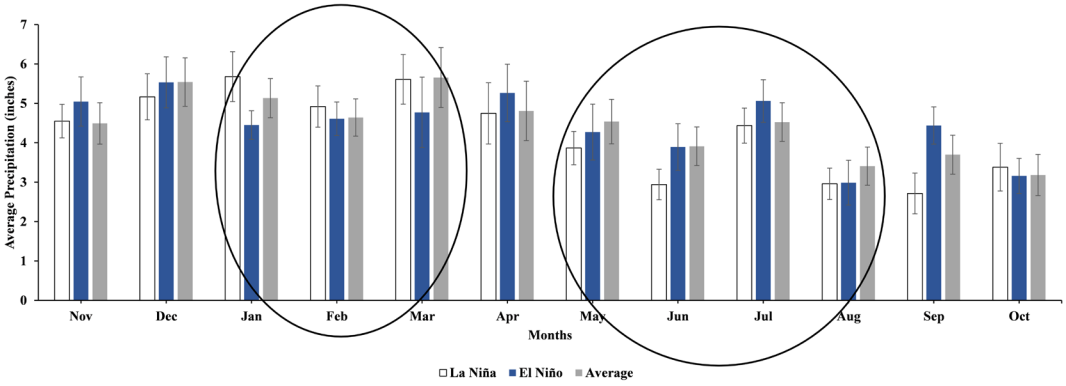

Figure 2. Average monthly precipitation (January 1950 to June 2018) trends in northwest Alabama for different ENSO phases

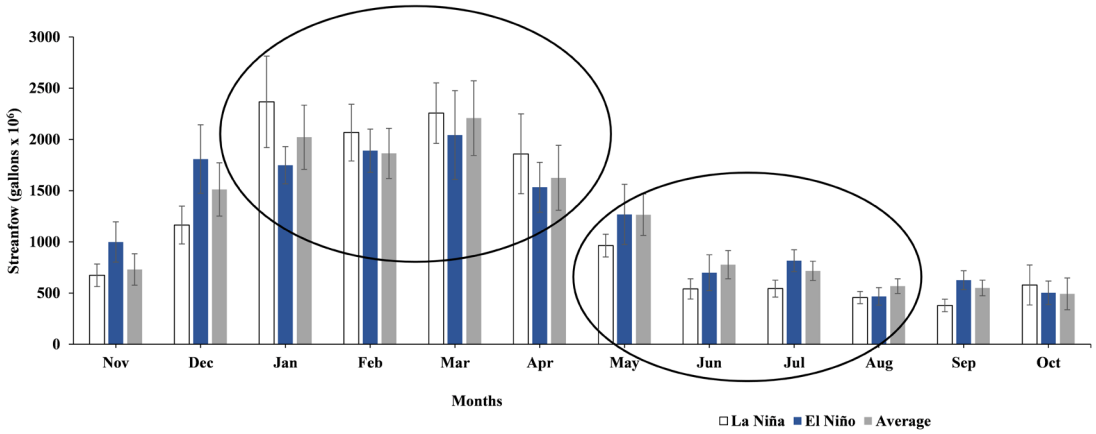

Figure 3. Average monthly (January 1950 to June 2018) streamflow (gallons x 10^6) trends in northwest Alabama for different ENSO phases.

use during the summer months. In southern Alabama, streamflows were higher in the El Niño phase than in the La Niña phase from January through August. Therefore, unlike north Alabama, growers in the southern region of the state would not have higher flows during the winter months in the La Niña phase. Location-specific forecasts must be used for water withdrawal planning in both north and south Alabama.

Relationship between ENSO and Water Withdrawals

As areas under irrigation increase in the state, irrigation planning by farmers is essential to ensure stream water availability for irrigation and to maintain the ecological sustainability of the streams. Many farmers making simultaneous withdrawals from streams during a short time would result in an ecological imbalance in streams, especially during periods of low flows. Therefore, understanding ENSO trends in a given area is important for farmers to better manage water withdrawals for irrigation. An analysis was performed to study the amount of ecologically sustainable water withdrawals that could be made under different scenarios. Similar to precipitation and streamflow trends, a greater amount of water was available for withdrawal in the winter months regardless of the ENSO phase. However, the winter withdrawals are more critical during the La Niña phase as the withdrawals substantially reduce during the summer months (figure 4). Withdrawals made during such times of low flows would be ecologically harmful. The amount of water that can be sustainably withdrawn is reduced by half if withdrawals are made in the crop growing season than in the non-crop growing season (figure 5).

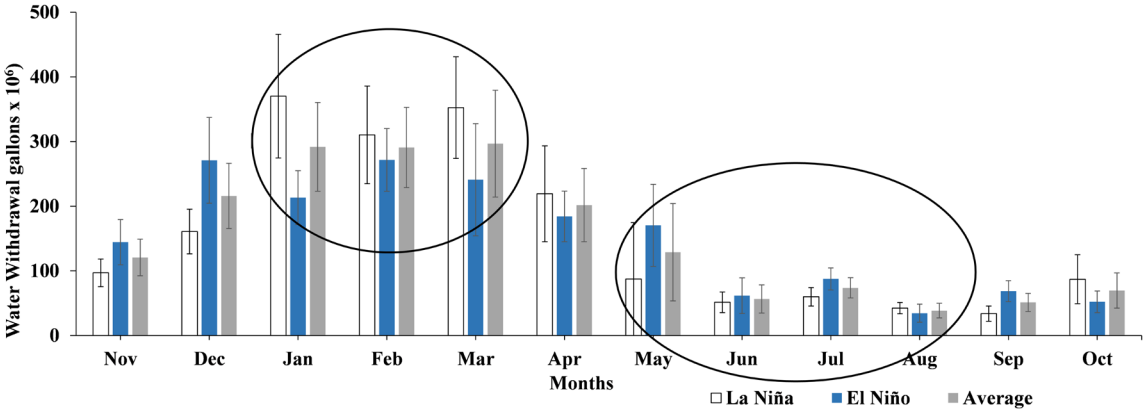

Figure 4. Average monthly (January 1950 to June 2018) water withdrawals (gallons x 10^6) as a function of months in different ENSO phases.

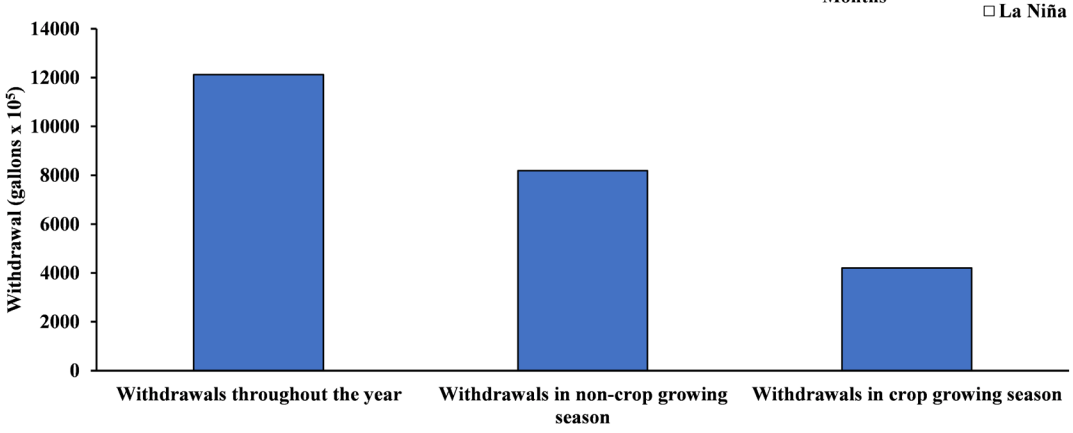

Figure 5. Average monthly (January 1950 to June 2018) withdrawal (gallons × 10^5) amount

Conclusions

In Alabama, precipitation and streamflows highly depend on the ENSO phase. Growers can use ENSO phase predictions to plan water withdrawals for irrigation and make decisions regarding the crops they will plant in irrigated and non-irrigated fields during the growing season. The relationship between the El Niño phase and streamflow can vary between north and south Alabama. In north Alabama, more water withdrawals could be made in the winter months during the La Niña phase. However, the La Niña phase results in lower precipitation in the summer months, which limits water withdrawals during this time.

The trends are opposite in southern Alabama. Additionally, in the event of predicted dry conditions during the growing season (La Niña in north Alabama), farmers could make water withdrawals from streams during the winter months and store it in on-farm ponds to be used during the growing season. The carefully planned irrigation management strategy based on ENSO forecasts would help farmers ensure water availability and make ecologically sustainable water withdrawals, which is vital for regions like Alabama where irrigated areas are gradually increasing.

Related Resources

Alabama Extension publication “El Niño-Southern Oscillation and Its Impact on Alabama’s Climate,” ANR-2091, on the Extension website at www.aces.edu

Alabama Extension publication “ABCs of Climate Variability,” ANR-1437, on the Extension website at www.aces.edu

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