BIOSYSTEMS ENGINEERING SERIES

TIMELY INFORMATION

Agriculture & Natural Resources

Department of Biosystems Engineering & Department of Agronomy and Soils, Auburn University, AL 36849-5626
August 2010

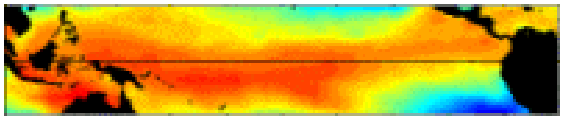
Impact of El Niño Southern Oscillation on Precipitation in Alabama

Introduction

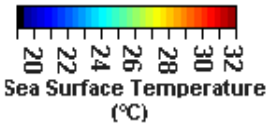
Inter-annual variations in precipitation and temperature in several regions of the world are related to oscillations of the ocean-atmosphere system in the Equatorial Pacific, known as the El Niño-Southern Oscillation (ENSO). ENSO is a natural condition that results from complex interplay among clouds and storms, regional winds, oceanic temperatures, and ocean currents along the Equatorial Pacific. It has two main phases called **El Niño** and **La Niña**.

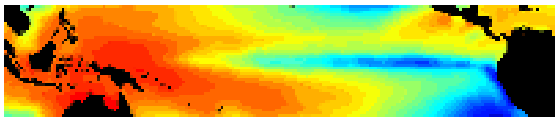
El Niño (EN) events, which occur every 2-7 years, are characterized by high sea surface temperature (SST) – ***warm temperatures*** in the Equatorial Pacific Ocean (Fig. 1a). The most recent El Niño events have been 1986-1987, 1991-1992, 1997 (April to December), 1998 (January – May), 2006, and 2009.

La Niña (LN) is just the opposite of an El Niño event. El Niño extends a "warm pool" to cover the tropics whereas shrinks to the west during La Niña. La Niña produces ***cooler than normal*** SSTs which can fall up to 7 degrees below normal along the equator (Fig. 1b). The most recent La Niña events have been 1988-1989 (strong), 1995, 1998 (September – December), 1999, and 2007.

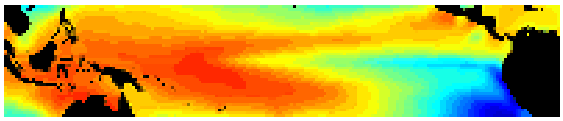


a) El Niño (warm) Conditions - December 1997





b) La Niña (cold) Conditions - December 1998



c) Normal Conditions - December 1993

Figure 1. Changes in sea surface temperature by ENSO phase.
Source: http://www.pmel.noaa.gov/tao/elnino/la-nina-story.html

ALABAMA A&M AND AUBURN UNIVERSITIES, AND TUSKEGEE UNIVERSITY, COUNTY GOVERNING BODIES AND USDA COOPERATING

The Alabama Cooperative Extension System offers educational programs, materials, and equal opportunity employment to all people without regard to race, color, national origin, religion, sex, age, veteran status, or disability.

El Niño Southern Oscillation in the Southeast

The effect of ENSO is not the same throughout the globe. Large-scale precipitation and temperature patterns influenced by ENSO have been examined in many areas of the world (Barsugli et al., 1999; McCabe and Dettinger, 1999). In the southeastern US, most climate variability can be attributed to variations in the ENSO cycle. In general, winters in the southeastern United States tend to be cooler and wetter during El Niño years and warmer and drier during La Niña years (Ropelewski and Halpert, 1986). During El Niño events, winter precipitation is anomalously high, but temperatures are low due to increased cloud cover, while summers tend to be dry along the southeastern coast. It has been demonstrated that warm ENSO events favor rain over the Southeast in winter, whereas, there is an opposite effect from cold events (Ropelewski and Halpert, 1986). Table 1 shows the seasonal differences in temperature and precipitation across the Southeast associated with ENSO phases.

Table 1. Seasonal effects of ENSO on temperature and precipitation across the Southeast.

El Nino/La Nina Impacts Across the Southeast U.S.					
Phase	Region	Seasons			
		Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep
El Nino	Peninsular Florida	Wet & cool	Very wet & cool	Slightly dry	Slightly dry to no impact
	Tri-State Region	Wet	Wet	Slightly wet	No impact
	Western Panhandle	No impact	Wet	Slightly dry	No impact
	Central and North Ala. & Ga.	No impact	No impact	No impact	Slightly dry
La Nina	Peninsular Florida	Dry & slightly warm	Very dry & warm	Slightly wet	Slightly cool
	Tri-State Region	Slighly dry	Dry	Dry	No impact
	Western Panhandle	Slightly dry	Dry	Dry	No impact
	Central and North Ala. & Ga.	Dry	Dry in the south, wet in NW Ala.	No impact	Wet in NW Ala.
Neutral	All Regions	No impact	No impact	No impact	No impact

Source: http://agroclimate.org/climate/sec_climate_impacts/index.php

Seasonal changes in Alabama precipitation by ENSO phase

The effect of ENSO on precipitation in Alabama is not uniform. There appears to be significant seasonal precipitation differences between northern, central, and southern portions of Alabama. The data presented has been summarized by climate divisions in Alabama (Fig.2).

Figure 2. Climate divisions of Alabama

These divisions were adopted from the U.S. Department of Agriculture's Bureau of Agricultural Economics Crop Reporting Districts in 1949, with minor revisions later for the purpose of organizing the data based on geography, drainage basins, river districts and/or forecast areas of responsibility. The ease with which information presented by these divisions can be understood was an important consideration in summing up the weather station data into eight different climate divisions of the state.

During ***January-February-March (JFM)*** in the La Niña (LN) phase, the southern climate divisions (CD's 7 and 8) of the state get below normal precipitation (2.85-3.68 in below normal), whereas, the northwestern CD's tend to be wetter than normal (CD's 1, 2 and 3) (Fig. 3b). Dry conditions extend up to the central part of the state (lower parts of CD's 5 and 6). During El Niño (EN), there is an almost opposite trend (Fig. 3a) with wetter conditions occurring in the southern and central parts of the state and moving further up north as compared to La Niña conditions occurring during the same season.

During the ***April-May-June (AMJ)*** season, in El Niño phase, most of the state is wet except for CD 2 and northeastern part of CD 3, and, in La Niña, most of the state is dry except for south of CD 3 and the central part of CD 6 (Fig.3 (c), (d)).

Higher negative precipitation anomalies ***during October-November-December (OND)*** in La Niña phase (lesser precipitation) are observed in southern CD's 7 and 6, extending up to CD 5 (Fig. 3f). If the ENSO phase is El Niño during OND, there is no clear trend in the state. However, most of the central part of the state is wetter than normal with some parts of CD's 7, 3 and 2 being drier than normal (Fig. 3e). Therefore, we can say that during La Niña in winter months, above normal precipitation can be expected in north Alabama, which is in sharp contrast with south Alabama where a completely different pattern can be expected.

For most seasons, the effect of ENSO is more clear in the CD's closer to the Gulf and decreases as we move towards the northeastern part of the state. The seasonal precipitation anomalies due to the warm or cold ENSO phases for all climate divisions in Alabama are sumarized in Table 2. Precipitation below or above the average values (i.e., anomalies) can be expected for different climatic divisions and ENSO phases. For example, during El Niño, CD 1, that includes Lauderdale, Limestone, Madison, Colbert, Franklin, Lawrence, and Morgan counties, might receive between 1.96 and 0.25 inches of less precipitation as compared to the average values for the JFM season. In contrast, CD 8, that includes Mobile and Baldwin counties, might receive between 3.25 and 5.45 inches more precipitation as compared to the average values for the same season and ENSO phase.

The information in the Table 2 is an indication of the spatial and temporal impact of ENSO on precipitation throughout the state. Table 2 summarizes the precipitation anomalies, presented in the maps of figure 3, which occurred during each ENSO cycle for each of the different climate divisions.

Current ENSO Phase – Forecast

According to the analyses conducted by the National Oceanic and Atmospheric Administration (NOAA), NOAA's National Weather Service, and the International Research Institute for Climate and Society, ***the current ENSO*** phase (August 2010) is ***La Niña,*** forecast for the period August to October 2010 and possibly to continue through early 2011. Historic climate data by state and county for each ENSO phase is available through the Climate Risk tool (Fig. 4) developed by the Southeast Climate Consortium (http://agroclimate.org/tools/climateRisk/)

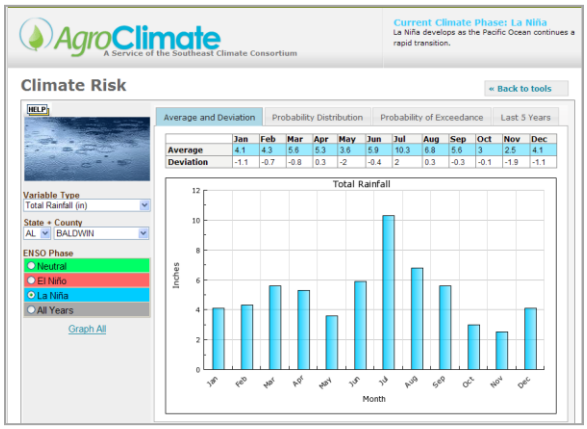


Figure 4. Output from the Climate Risk Tool

<u>The Climate Risk tool</u> allows the user to assess and forecast the monthly changes in rainfall, average minimum and maximum temperatures by each ENSO phase. Information on *Deviations* - amount by which the forecast conditions differ from the average conditions - might be a good indicator of excess (positive deviations) or deficit (negative deviations) that one would expect for a particular month.
Note: Select a state and county to get information specific for your location.

Additional Information

These websites provide further information about ENSO and its effect:

- http://agroclimate.org/
- http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/index.shtml
- http://www.elnino.noaa.gov/
- http://www.seclimate.org/

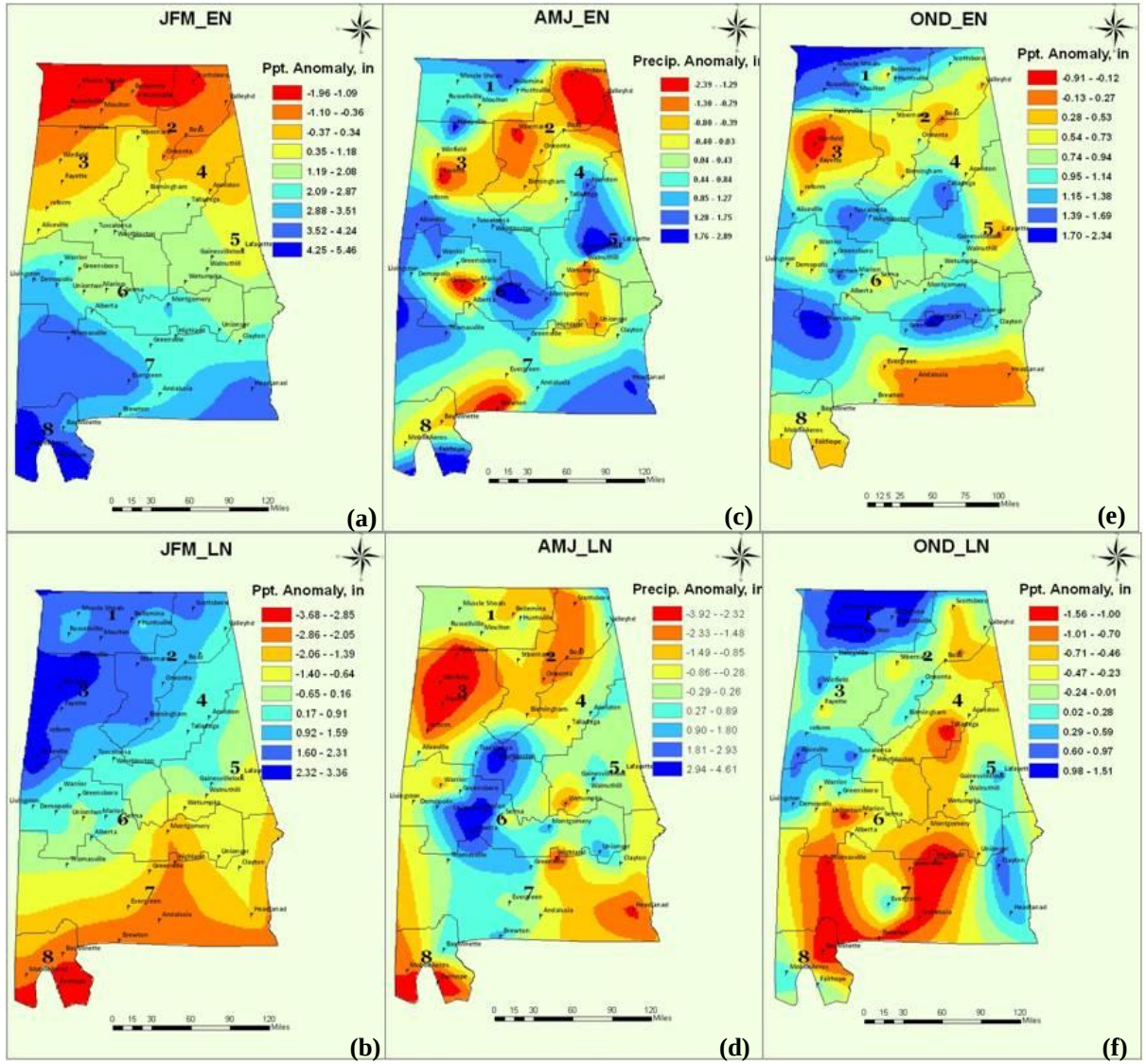


Figure 3. Precipitation Anomaly Maps of Alabama for the season JFM [(a): El Niño and (b): La Niña], AMJ [(c): El Niño and (d): La Niña], and OND [(e): El Niño and (f): La Niña]

Table 2. Expected precipitation anomalies caused by ENSO phase in Alabama.

Phase	CD	Counties	ENSO impact on precipitation (anomaly in inches)		
			JFM	**AMJ**	**OND**
El Niño	1	Lauderdale, Limestone, Madison, Colbert, Franklin, Lawrence, Morgan	Dry [(-1.96) to (-0.25)]*	Wet (0.03-2.89)	Wet (0.5-2.34)
	2	Jackson, Marshal, Dekalb, Blount, Cullman, Jefferson	Dry [(-1.96) to (-0.01)]* Cullman, Jefferson & Blount slightly wet	Dry [(-2.39) to (-0.39)]*	Slightly wet (0.25-1.15)
	3	Marion, Winston, Lamar, Fayette, Walker, Pickens, Tuscaloosa, Bibb, Chilton, Autauga	Marion, Lamar & Fayette slightly dry, rest wet (2.1-0.01)	Fayette and Walker dry [(-2) to (-0.03)]*, rest wet (0.04-1.75)	Marion dry [(-0.91) to (-0.01)]*, rest wet (0.01-1.65)
	4	Cherokee, Etowah, Calhoun, St. Clair, Talladega, Shelby	Mostly dry [(-1.1) to (-0.01)]* Shelby & Talladega wet (0.3-2.05)	Wet (0.03-1.28), Cherokee-dry [(-1.30) to (-0.40)]*	Wet (0.5-1.65)
	5	Cleburne, Clay, Randolph, Coosa, Tallapoosa, Chambers, Elmore, Lee	Slightly wet (0.01-2.1)	Wet (0.03-2.89) South Tallapoosa-dry	Slightly wet (0.01-1.35)
	6	Sumter, Greene, Hale, Perry, Marengo, Dallas, Lowndes, Montgomery, Macon, Bullock	Wet (1.19-4.2)	Mostly wet with parts of Hale, Marengo, Macon. Bullock dry [(-1.30) to (-0.4)]*	Wet (0.5-2.0)
	7	Choctaw, Clarke, Washington, Monroe, Wilcox, Conecuh, Escambia, Butler, Crenshaw, Covington, Pike, Coffee, Geneva, Russell, Barbour, Dale, Henry, Houston	Wet (2.85-4.25)	Wet (0.03-1.8) except for Escambia dry [(-2.39) to (-0.4)]*	Mostly wet (0.01-2.3), Covington, Geneva. Houston slightly dry [(-0.1) to (-0.01)]*
	8	Mobile, Baldwin	Very Wet (3.25-5.45)	Southern part wet and north dry	Wet (0.25-1.05)

Table 2. Continuation

Phase	CD	Counties	ENSO impact on precipitation (anomaly in inches)		
			JFM	**AMJ**	**OND**
La Niña	1	Lauderdale, Limestone, Madison, Colbert, Franklin, Lawrence, Morgan	Wet (1.0-2.3)	Dry [(-2.33) to (-0.01)]*	Wet (0.1-1.5)
	2	Jackson, Marshal, DeKalb, Blount, Cullman, Jefferson	Wet (0.15-2.3)	Mostly Dry [(-2.33) to (-0.01)]*	Mostly dry [(-0.5) to (-0.01)]*
	3	Marion, Winston, Lamar, Fayette, Walker, Pickens, Tuscaloosa, Bibb, Chilton, Autauga	Marion, Winston, Lamar, Fayette, Walker very wet (1.0-3.35), Autauga dry	Marion to Tuscaloosa very dry [(-3.92) to (-0.01)]*, rest wet	Bibb, Chilton & Autauga dry [(-0.71) to (-0.01)]* . The rest of the area wet (0.01-0.95)
	4	Cherokee, Etowah, Calhoun, St. Clair, Talladega, Shelby	Moderately wet (0.15-1.0)	Slightly dry [(-1.4) to (-0.01)]*, Shelby wet (0.26-2.6)	Dry [(-1.00 to (-0.01)]*
	5	Cleburne, Clay, Randolph, Coosa, Tallapoosa, Chambers, Elmore, Lee	Mostly slightly dry [(-1.4) to (-0.01)]*	Dry [(-2.25) to (-0.01)]*	Dry [(-1.0) to (-0.01)]*, Lee & Chambers slightly wet
	6	Sumter, Greene, Hale, Perry, Marengo, Dallas, Lowndes, Montgomery, Macon, Bullock	Sumter, Greene, Hale slightly wet; rest dry [(-2.85) to (-0.01)]*	Mostly wet (0.25-4.5), Green and Sumter slightly dry	Mostly dry [(-1.56) to (-0.01)]*. Green & Sumter slightly wet
	7	Choctav, Clarke, Washington, Monroe, Wilcox, Conecuh, Escambia, Butler, Crenshaw, Covington, Pike, Coffee, Geneva, Russell, Barbour, Dale, Henry, Houston	Dry [(-2.85) to (-0.01)]*	Mostly dry [(-3.5) to (-0.01)]*, Wilcox, Monroe, Conecuh & Escambia slightly wet (2.00-0.01)	Mostly dry [(-1.56) to (-0.01)]*, Houston, Henry & Barbour slightly wet (0.01-0.95 in)
	8	Mobile, Baldwin	Very dry [(-3.68) to (-1.5)]*	Dry [(-3.9) to (-0.01)]*	Dry [(-1.56) to (-0.01)]*

*For all the dry conditions, the values in parentheses correspond to expected less precipitation with respect to average values.

Note: *The values presented in this table correspond to the ranges of values used on Figure 2 to represent the seasonal precipitation anomalies by ENSO phase. The precipitation values for different locations in Alabama were derived from spatial interpolation of data collected at different weather stations throughout the state*.

References

1. Barsugli J. J., J. S. Whitaker, A. F. Loughe, P. D. Sardeshmukh and Z. Toth. (1999), Effect of the 1997-98 El Niño on Individual Large-Scale Weather Events. Bulletin of American Meteorological Society 80: 1399-412
2. McCabe, G. J. and M. D. Dettinger (1999), 'Decadal variations in the strength of ENSO teleconnections with precipitation in the western United States'. International Journal of Climatology 19(13): 1399-1410.
3. Ropelewski, C. F., and M. S. Halpert (1986), North American precipitation and temperature patterns associated with the El Niño/Southern Oscillation. Mon. Weather Rev., 114, 2352– 2362.

Prepared by

Vaishali Sharda, Graduate Research Assistant, Biosystems Engineering Department;

Brenda Ortiz, Assistant Professor and Extension Specialist, Agronomy and Soils Department; Puneet Srivastava, Associate Professor, Biosystems Engineering De

ALABAMA A&M AND AUBURN UNIVERSITIES, AND TUSKEGEE UNIVERSITY, COUNTY GOVERNING BODIES AND USDA COOPERATING

The Alabama Cooperative Extension System offers educational programs, materials, and equal opportunity employment to all people without regard to race, color, national origin, religion, sex, age, veteran status, or disability.