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Estimation of predictive potential of El Nino (La Nina) for long-term precipitation forecast in Iraq

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ABSTRACT

The El Nino- Southern Oscillation (ENSO) phenomenon is the most important form of tropical climate change. By modifying the distribution of rainfall and temperatures, it sometimes engenders devastating effects in many tropical regions and even in high latitudes. The aim of this study was to choose the El Nino event as a potential predictor for long-term precipitation forecast in Iraq in the presence of opposite patterns in Iraq's precipitation distribution at different phases of the El Nino event. The results indicate that calculating the frequency of occurrence of precipitation gradations in Iraq during the warm and cold phases of ENSO are presented in Tables 2 and 3.

Keywords: El Nino, Long-Term, Phenomenon, Climate change.
Article type: Research Article.

INTRODUCTION

El Nino (La Nina) phenomenon and the Southern Oscillation

The El Nino (La Nina) phenomenon has been greatly influences the precipitation regime of the globe. The El Nino and La Nina phenomena are long-term sea surface anomalies of water temperature greater than 0.5 ºC observed in the Pacific Ocean in its central tropical part. El Nino (La Nina) condition is classified when there is an anomaly in the water surface temperature of the Pacific Ocean above 0.5 ºC (or below -0.5 ºC) for over five months. The latter occurs at irregular intervals of 2-7 years. It is usually lasts for one or two years. El Nino (La Nina) events disrupt the normal circulation cycle in the ocean-atmosphere system. The El Nino- Southern Oscillation (ENSO) phenomenon is the most important form of tropical climate change, as it occurs, develops in the wide Pacific basin, and its consequences extend to extra tropical regions (Repolewsky & Halpert 1986; Wang 2001). The first signs of El Nino are as follows: At first, increase in air pressure over the Indian Ocean, Indonesia and Australia; second, drop in air pressure over Tahiti and in the central and eastern parts of the Pacific Ocean; and third, trade winds in the equatorial Pacific Ocean are weakened or directed to the east; fourth, warm air appears near Peru, causing rains in the deserts; and fifth, warm water spreads from the western part of the Pacific Ocean to the east. It carries with rain, causing it in areas where it is usually dry (Nikolaev 1998). ENSO consists of the relationship between the ocean (El Niño: EN) and the atmosphere (Southern Oscillation: SO), and its presence in the Pacific have been documented in many historical documents describing plant and animal life (Baker *et al.* 2001; Baker *et al.* 2001). Worker in 1923 first coined the term "Southern Oscillation" in order to describe, on a multiyear scale, the alternation of the high and low pressure systems observed in the Pacific Ocean. The Southern Oscillation Index (the difference in pressure anomalies between Tahiti and Darwin) is a characteristic index of the ENSO change (Saravanan & Chang 1999). At the beginning, the word “El Nino” meant a warm coastal current along the coast of Peru and Chile, which brought "wonderful" fish of unusual shapes and colours to the cold waters of these regions. Each time with a period of 2 to 7 years, this warm current took place for several months, as a result of

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which there was a threat of destruction or migration of many species of commercial fish. Moreover, this warming brings significant local bad weather and changes in the drought boundary between the tropical zone of northern Peru and arid regions in the south. There are also some reports about climate change and drought in the world (Boundi & Ait Yacine 2021; Attafi *et al.* 2021; Omidvar *et al.* 2022; Hosseini *et al.* 2022). The first mention of the term "El Nino" dates back to 1892, when Captain Camilo Carrilo reported at a congress of the Geographical Society in Lima that Peruvian fishermen named the warm northern current "El Nino", as it was observed on Christmas Eve. "El Nino" is Spanish for "baby". The names of these phenomena were first introduced into scientific circulation in 1923 by Gilbert Thomas Walker. Only as a result of research by the Norwegian physicist and meteorologist Wilhelm Freeman Koren Bjerknes in 1969, it was possible to establish a relationship between this warm coastal anomaly with the southern oscillation, equatorial ocean surface temperature anomalies, and transport reaching the Pacific Ocean. The ENSO index is determined by the average value of the water surface temperature anomaly in the central part of the Pacific Ocean.

There are several areas for monitoring El Niño. Niño 1 + 2 from 90° W to 80° W; from 10° N to 0°, Niño 3 from 150° W to 90° W; from 5° N to 5° S, Niño 3.4 from 170° W to 120° W; Nino 4 from 160 ° E to 150 ° W; from 5 ° N to 5 ° S. A graphic represent the four El Nino monitoring regions in Fig. 1.

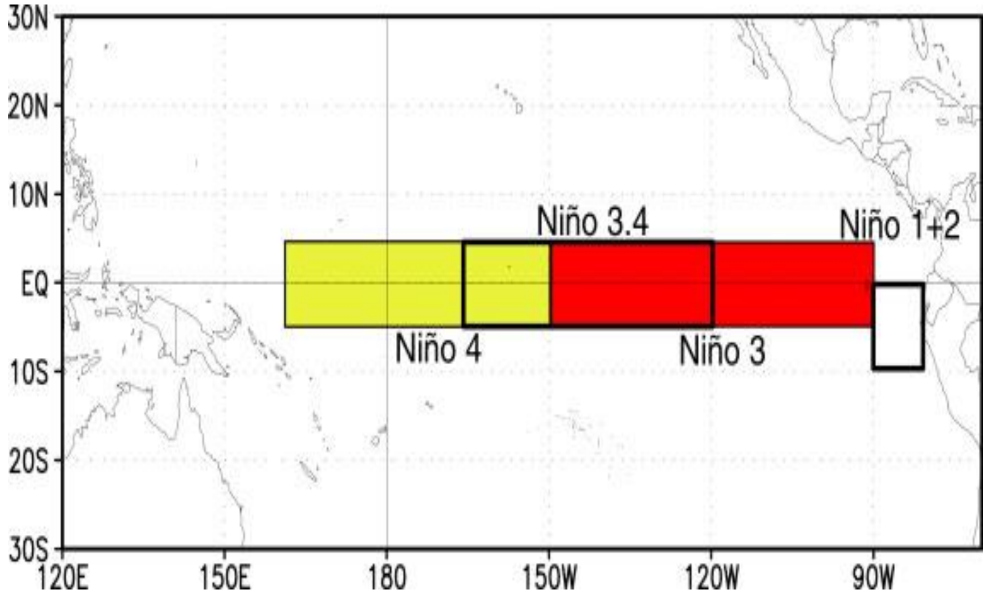

Fig. 1. El Nino monitoring regions in the Equatorial Pacific Ocean.

In general, the ENSO phenomenon is determined by its differences from the normal conditions under which the eastern transports in the Pacific Ocean lead to the rise of deep cold waters along the equator; the temperature jump layer (thermocline) approaches the surface and cools the surface water. Moreover, these eastern transports push back warm waters into the western Pacific Ocean, which is a source of convective activity. At the same time, warm and humid air rises, gradually loses its moisture. Then it is carried upward by western transports and then sinks into the Pacific Ocean atmosphere and joins the dry regions of South America to the Walker Cell. Fig. 2 shows the normal conditions for the ocean-atmosphere system in the Equatorial Pacific Ocean and the conditions for the El Nino event. Under normal conditions, warmer waters (27-28 °C) are located in the west of the Pacific Ocean, and colder (22-23 °C) in the east. Under normal conditions, the thermocline is tilted from east to west above the warm water in the west of the Pacific Ocean, powerful convective clouds develop and precipitation falls. During the El Nino period, warm waters move to the east, the thermocline rises in the west and deepens in the east and the zone of convection and precipitation moves after warm water to the central and eastern regions of the Pacific Ocean. In the La Nina period, on the contrary, the tilt angle increases, precipitation intensifies over the western Pacific Ocean, and the trade winds intensify. During El Niño, the warm waters of the Pacific Ocean spread over the entire equatorial basin and carry convective zones with them. This phenomenon develops and often peaks in the month of December, and then gradually decreases. It may be followed by the La Nina phenomenon, which is characterized by an intensification of the seasonal cycle and intensification of transports and an equatorial cold tongue, which penetrates more to the west. Notably, ENSO affects the inter-annual course of the general atmospheric circulation (Gustoev 2005; Gustoev 1991). By modifying the distribution of rainfall and temperatures, it sometimes engenders devastating effects in many tropical regions and even in high latitudes. Intermittent rains and weakening of the south-eastern circulation are noted over East Africa. Thus, there is a net ENSO effect and therefore Iraq's precipitation is the result of complex reconciliation and interactions between several potential sources of climate variability. In recent years, an increase in the intensity associated with global warming can significantly shift the delicate balance between various sources of climatological variability in East Africa during the ENSO (Sodem 2000).

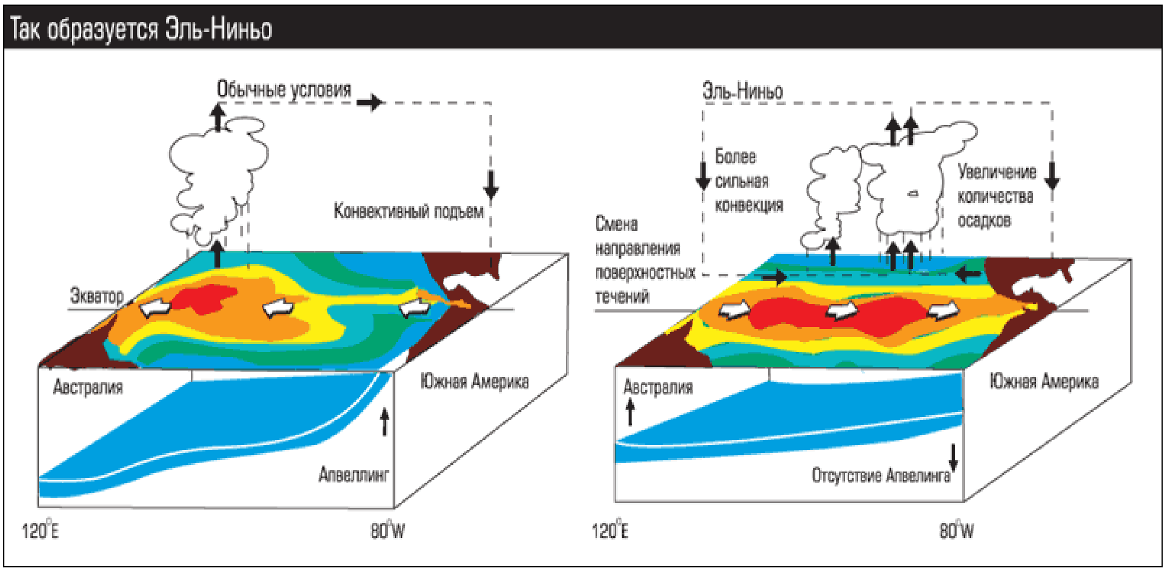

Fig. 2. Conditions for the formation of the El Nino phenomenon.

Fig. 3 shows the 6-month precipitation anomalies for the 1997/98-El Nino event. Some of the global impacts associated with ENSO are increasing rainfall in the southern United States and Peru, causing devastating flooding and aridity in the western Pacific, sometimes associated with devastating wildfires in Australia and the Indonesian continent.

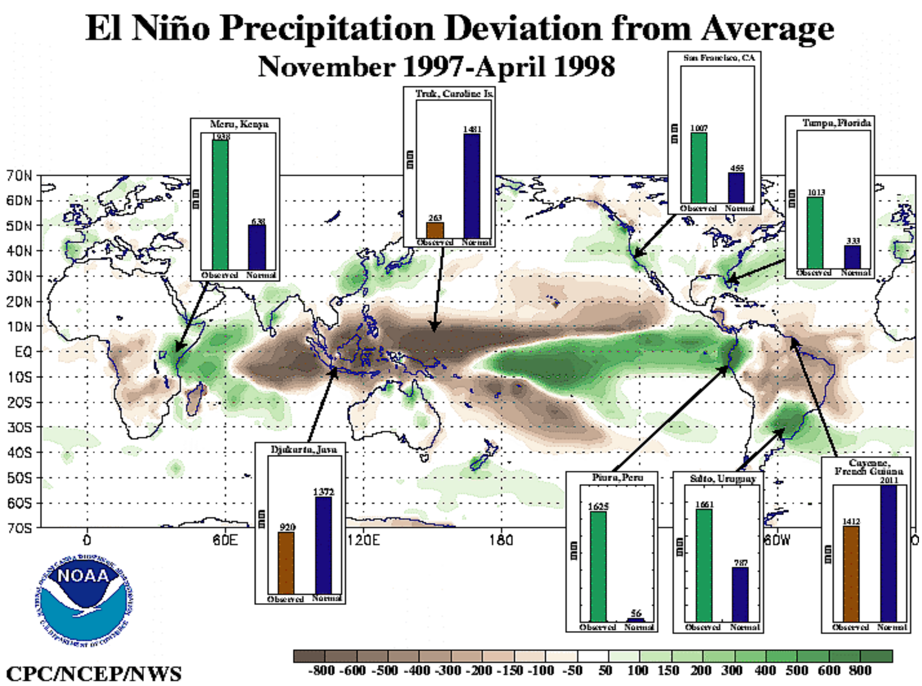

Fig. 3. ENSO and global precipitation deviations from November 1997 to April 1998.

ENSO in 1982/83, a strong record prior to the current events of 1997/98, was responsible for widespread occurrences of aridity, flooding and hurricanes around the world, resulting in several hundred deaths and significant damage.

RESULTS AND DISCUSSION

Significant changes in precipitation regime during the El Nino event are noted in eastern and southern Africa. It causes significant damage to the economies of these countries. In particular, the losses incurred in eastern and southern Africa were in 1982/83. The ENSO event is valued at more than $ 3 billion (about one third of the total global estimate). Losses associated with 1997/98-ENSO event, were higher than in 1982/83. As a result, the socio-economic infrastructure was destroyed in many countries of the world, including in equatorial East Africa (Ngongol 2011). In 2015/2016, one of three powerful El Nino was observed in the past 65 years. Ocean surface temperatures in the central and eastern tropical Pacific Ocean exceeded + 2.0 °C above average between October 2015 and February 2016.

The predictive potential of the El Nino event in the long-term precipitation forecast for Iraq was estimated from the frequency of occurrence of opposite precipitation patterns at different phases of the El Nino event. To assess the precipitation regime in Iraq, the monthly precipitation totals were ranked with the allocation of five equally probable gradations: B - significantly below the norm; b - below normal; N - near the norm; a - above the norm; A - significantly higher than the norm. According to the El Nino and La Nina calendar, the frequency of the gradations of monthly precipitation amounts in Iraq was calculated: Bb, identified as dry years, and the frequency of Aa gradations, defined as wet years, at different phases of the El Nino phenomenon. Iraq's rainfall was estimated by the prevalence of dry or wet years in the El Nino and La Nina years. The recommendation for choosing the El Nino event as a potential predictor for long-term precipitation forecast in Iraq is the presence of opposite patterns in Iraq's precipitation distribution at different phases of the El Nino event. The results of calculating the frequency of occurrence of precipitation gradations in Iraq during the warm and cold phases of ENSO are presented in Tables 2 and 3. To illustrate, the reduced distribution of Iraq precipitation gradations at different ENSO phases is presented in Figs. 4 and 5.

Table 1. Precipitation gradations for Iraq in El Nino years.

Years	Months							
	1	2	3	4	5	10	11	12
1896	A	B	A	b	B	-	B	B
1899	B	B	B	b	B	b	a	N
1900	B	N	N	-	-	B	a	a
1902	B	B	a	A	-	a	A	B
1905	B	B	a	B	B	-	B	B
1911	A	b	A	N	N	-	N	a
1912	b	B	b	B	-	b	B	N
1914	N	a	b	A	b	-	-	-
1918	b	N	N	A	N	B	A	N
1919	A	N	B	A	A	-	-	N
1925	b	b	N	b	b	A	N	b
1926	A	A	a	N	N	B	A	a
1929	b	a	B	N	b	B	b	N
1930	a	a	B	a	B	-	a	a
1939	a	A	A	A	B	N	A	A
1941	B	A	a	a	-	B	B	A
1953	b	A	a	a	b	N	a	N
1957	N	N	A	A	A	b	A	b
1958	a	B	B	B	B	-	a	a
1965	A	B	b	a	B	a	b	b
1972	a	b	A	-	a	-	-	-
1973	-	-	-	b	-	B	-	a
1976	N	N	N	a	b	b	-	b
1982	A	N	a	A	A	A	a	b

1983	N	N	N	N	A	-	b	b
1997	a	N	A	a	a	A	A	A
1998	A	N	A	N	a	-	B	B
2009	B	B	b	b	B	A	N	N

Table 2. Gradations of precipitation for Iraq in the years of La Nina.

Years	**Months**							
	1	**2**	**3**	**4**	**5**	**10**	**11**	**12**
1946	a	a	A	A	a	B	N	N
1948	B	N	b	a	b	-	B	A
1955	N	B	N	a	a	-	N	A
1963	b	a	b	A	A	a	b	a
1973	-	-	-	b	-	B	-	a
1975	A	-	B	a	a	-	-	-
1977	a	b	B	a	N	b	b	N
1979	a	b	b	B	N	a	b	N
1980	b	A	a	N	N	-	N	B
1986	b	A	a	a	A	a	A	b
1988	A	A	A	A	-	a	b	A
1990	N	A	N	N	b	N	b	b
1991	a	A	A	B	B	A	a	A
1993	a	a	N	A	A	A	a	n

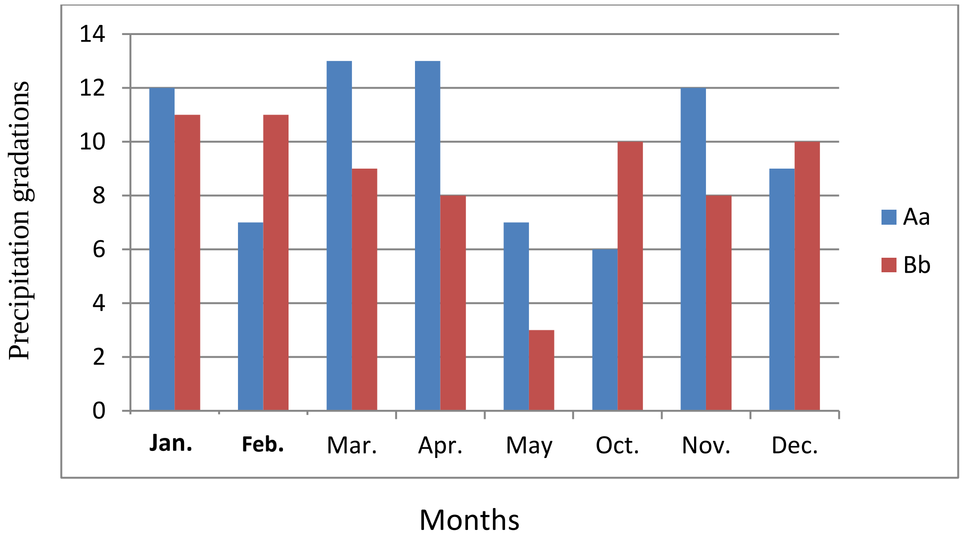

Fig. 4. Repeatability of gradations of monthly amounts of precipitation in Iraq in El Nino years.

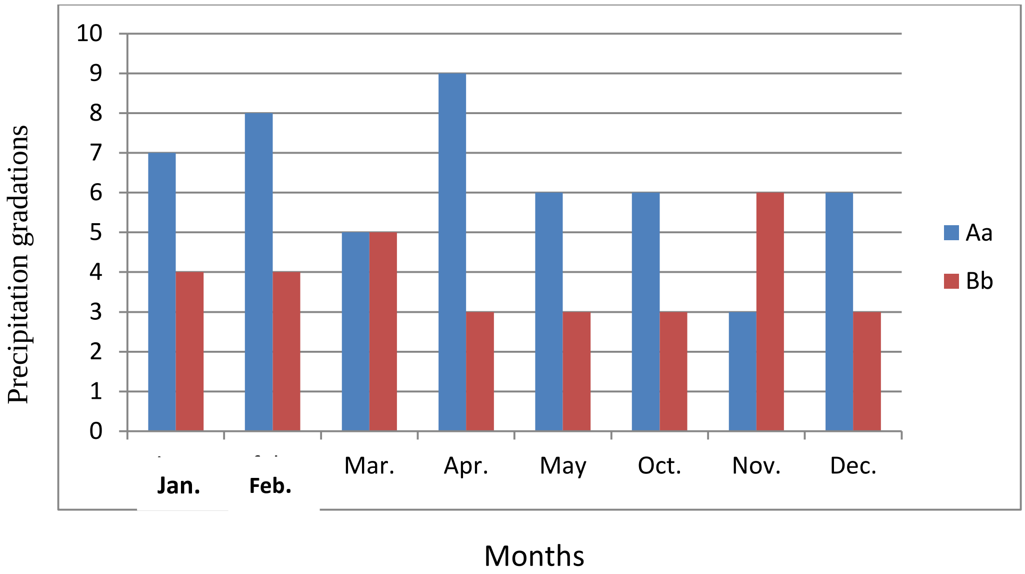

Fig. 5. Repeatability of gradations of monthly sums of precipitation in Iraq in La Nina years.

The results of comparing the frequency of occurrence of gradations of monthly sums of precipitation in Iraq at different ESC phases are shown in Table 3.

Table 3. Frequency of precipitation gradations in Iraq in the years La Nina and El Niño.

Years	Gradation	Months							
		1	2	3	4	5	10	11	12
El Niño	Aa	12	7	13	13	7	6	12	9
	Bb	11	11	9	8	3	10	8	10
La Nina	Aa	7	8	5	9	6	6	3	6
	Bb	4	4	5	3	3	3	6	3

Note - bold type indicates values in months at which opposite precipitation levels are observed at different phases of phenomena.

CONCLUSION

This study was focused on estimation of predictive potential of El Nino (La Nina) for long-term precipitation forecast in Iraq. Iraq's rainfall was estimated by the prevalence of dry or wet years in the El Nino and La Nina years. The recommendation for choosing the El Nino event as a potential predictor for long-term precipitation forecast in Iraq is the presence of opposite patterns in Iraq's precipitation distribution at different phases of the El Nino event. The results of calculating the frequency of occurrence of precipitation gradations in Iraq during the warm and cold phases of ENSO were presented in tables and figures.

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