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Influence of the ENSO event on the behavior of rainfall associated with tropical waves during the period 2012–2020 in Cuba

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Abstract: Cuba presents two well-marked periods in the year, the dry one (November-April) and the rainy one (May-October); the latter is part of the tropical wave season. As they pass, tropical waves cause changes in the weather, mainly in the rainfall regime, as well as being, in some cases, precursors of tropical cyclones in the North Atlantic and in the Caribbean Sea. Regarding the variability in its quantity and intensity, recent studies suggest that it could be related to the El Niño-Southern Oscillation (ENSO) event. For this reason, the present investigation has as general objective to examine the behavior of the precipitation associated with the transit of tropical waves through Cuba during the years 2012-2020 for different phases of the ENSO (El Niño and La Niña). In order to obtain the information on the rainfall associated with the waves, the data from the meteorological stations belonging to the Institute of Meteorology of Cuba and the network of rain gauges of the National Institute of Hydraulic Resources were consulted on the dates that coincide with the passage of these systems for the country. In addition, the annual behavior of the ENSO based on the Southern Oscillation Index (ONI) was analyzed. To determine the years of greatest influence and their graphic representation, the Microsoft Excel 2019 program was used. The results showed that during the Neutral and La Niña years there are few differences in the number of cases with intense rainfall associated with waves. On the contrary, the results reveal a decrease in rainfall in the El Niño phase.

Keywords: tropical wave; El Niño-Southern Oscillation (ENSO); heavy rain

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1. Introduction

Tropical currents are subject to frequent disturbances due to the existence of isalobaric maximums and minimums. These disturbances, which travel from east to west in the form of transverse waves, within the tropical easts, are called "easterly waves" and are the best known type of tropical wave [1].

Easterly waves exist in the tropical zone of both hemispheres throughout the year. However, its presence is more marked in the tropical zone of the northern hemisphere during the period between June and September [2]. In their displacement it can be observed that they are systems of synoptic scale, of considerable latitudinal extension, in the order of 10 to 15 degrees of latitude; there are usually far from the ZITC, although they can extend to that area [3].

On their westward trajectory, these systems often pass through the Cuban geography, constituting an important source of interday variability of rainfall during the rainy season (May–October).

Recent work has shown that variability in the amount and intensity of tropical waves is associated with patterns of teleconnection, ENSO (El Niño-Southern Oscillation) [4]. During the El Niño phase, there is a decrease in the number of tropical cyclones formed

in the area of the tropical Atlantic and Caribbean Sea, which indicates a reduction in the number and intensity of tropical waves.

The objective of this work is to analyze the variability of precipitation associated with the transit of tropical waves through the Cuban archipelago between the years 2012–2020 considering the different phases of the ENSO.

2. Materials and Methods

The selected study region is the tropical North Atlantic zone, between 5 ºN and 25 ºN and 10 ºW and 100 ºW (Figure 1). This area is extremely important, since an average of 60 tropical waves a year are formed in it.

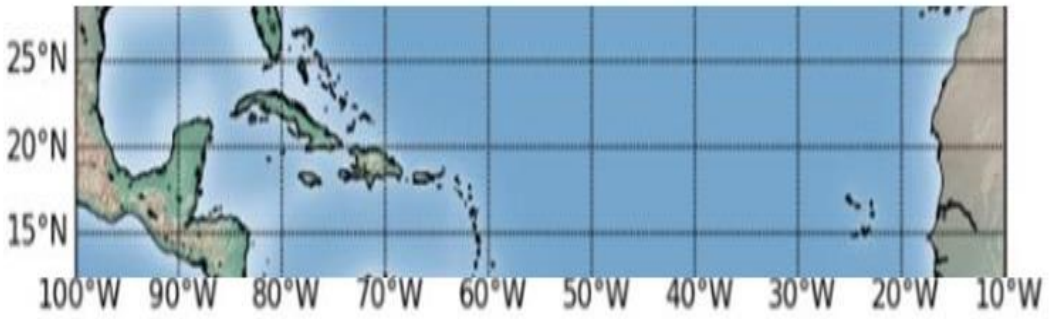

Figure 1. Study area.

Of the total number of tropical waves formed in this region from 2012 to 2020, only those that, in their westward displacement, directly or indirectly influenced Cuba, were taken into account, for a total of 323 tropical waves. The rest of the tropical waves formed in the Atlantic basin were eliminated from the considerations due to their low representation over the Cuban archipelago.

Precipitation data, associated with the passage of tropical waves, from the meteorological stations belonging to the Cuban Institute of Meteorology and the network of rain gauges of the National Institute of Hydraulic Resources were also used from May 2012 to November 2020.

Based on the information provided by the Southern Oscillation Index (ONI), downloaded from the website https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web .ppt, it was possible to divide the period into years with an El Niño event, years with the La Niña phase and years where the Neutral phase predominated. Similarly, Table 1 shows the information collected.

Table 1. Evolution of the ENSO based on the ONI during 2012-2020.

Year	DEF	EFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDE	Phases
2012	-0,9	-0,7	-0,6	-0,5	-0,3	0	0,2	0,4	0,4	0,3	0,1	-0,2	Neutral
2013	-0,4	-0,4	-0,3	-0,3	-0,4	-0,4	-0,4	-0,3	-0,3	-0,2	-0,2	-0,3	Neutral
2014	-0,4	-0,5	-0,3	0	0,2	0,2	0	0,1	0,2	0,5	0,6	0,7	Neutral
2015	0,5	0,5	0,5	0,7	0,9	1,2	1,5	1,9	2,2	2,4	2,6	2,6	El Niño
2016	2,5	2,1	1,6	0,9	0,4	-0,1	-0,4	-0,5	-0,6	-0,7	-0,7	-0,6	La Niña
2017	-0,3	-0,2	0,1	0,2	0,3	0,3	0,1	-0,1	-0,4	-0,7	-0,8	-1	Neutral
2018	-0,9	-0,9	-0,7	-0,5	-0,2	0	0,1	0,2	0,5	0,8	0,9	0,8	Neutral
2019	0,7	0,7	0,7	0,7	0,5	0,5	0,3	0,1	0,2	0,3	0,5	0,5	Neutral
2020	0,5	0,5	0,4	0,2	-0,1	-0,3	-0,4	-0,6	-0,9	-1,2	-1,3	-1,2	La Niña

For the graphic representation, the Microsoft Excel 2019 program was used.

3. Results and Discussion

3.1. Associated precipitation

During the study period, 323 tropical waves passed through Cuba, which were examined taking into account those that caused rain, and another amount without associated or very little precipitation. Figure 2 exemplifies the aforementioned, showing the waves divided into two groups: active and not very active. In most years, active waves predominated, those that generated rain because they had sufficient energy or due to interaction with other surface or upper air synoptic systems, as is the case of cold lows.

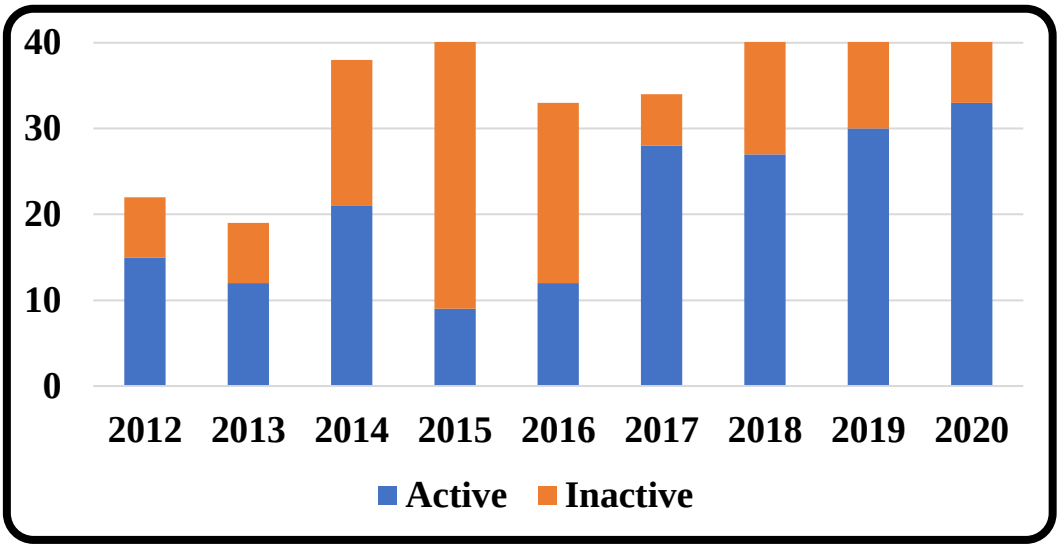

Figure 2. Rainfall associated with the transit of tropical waves.

3.2. Relationship between ENSO and precipitation variability.

Table 2 shows that the period of greatest transit of tropical waves through the national territory coincides with the periods where the Neutral phase predominates, followed by the La Niña phase, for an annual average of 23 and 9 waves, respectively. It can also be observed that in El Niño years there is a considerable decrease in the amount of tropical waves that reach Cuba. These results coincide with the studies of [5] in which it is stated that during the extreme phases of ENSO the number of easterly waves is reduced.

Table 2. Variability of tropical waves taking into account the ENSO phases.

Phases	Total	Mean
Neutral	204	23
La Niña	78	9
El Niño	41	5

Figure 3 shows the variability of rainfall associated with tropical waves and its relationship with the different phases of the ENSO, it has been possible to establish that there are few differences between years with the La Niña phase and years with the Neutral phase. On the contrary, the results for the El Niño phase reveal a drastic reduction in rainfall in Cuba, which corresponds to a decrease in the number of active tropical waves through the national territory. Therefore, during El Niño events, the tropical waves that pass most frequently over the Cuban archipelago are the inactive waves.

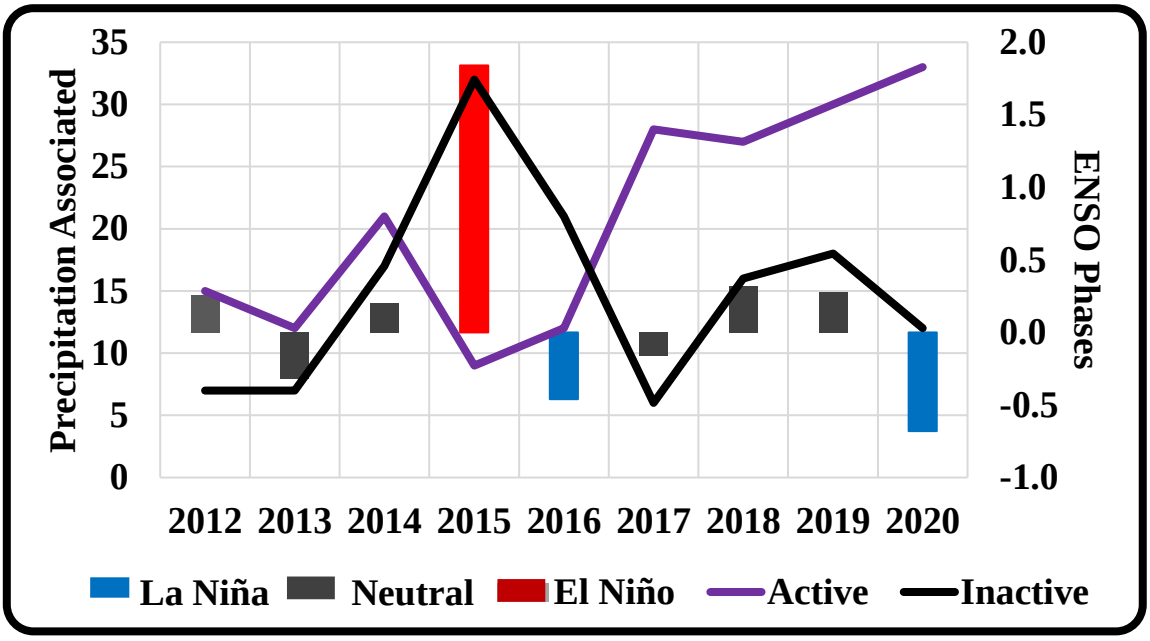

Figure 3. Precipitation variability in relation to ENSO phases.

4. Conclusions

During the study period, 323 tropical waves passed through Cuba, of which 187 were classified as active waves. The results obtained allow us to establish that the periods associated with the greatest transit of tropical waves through the Cuban archipelago coincide with Neutral years followed by La Niña years, being lower during El Niño. The variability of precipitation associated with the transit of tropical waves through Cuba during the years 2012-2020 is similar during the Neutral and La Niña phases, however, during the warm phase of the ENSO there is a noticeable decrease in rainfall.

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Conflicts of Interest: The author declares no conflicts of interest.

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