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# Behavior of the Days with SLS Reports in the Cuban Regions and Its Relationship with the Phases of ENSO Events in the Period 1990–2020†

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**Abstract:** Severe Local Storms (SLS) affect Cuba at any time of the year and constitute one of the main variations in the climate. These variations appear to be associated with very low frequency oscillations or cycles, such as the El Niño-Southern Oscillation (ENSO) event. In this research, the objectives are: to find the monthly distribution of SLS in Cuba, as well as its relationship with the ENSO phases and to analyze the relationship between the days with SLS reports and the intensity of the ENSO phases in the rainy season. and little rainy.

**Keywords:** El Niño; La Niña; SLS; rainy season; dry season

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## 1. Introduction

Severe Local Storms (SLS) frequently affect the Cuban territory at any time of the year and are considered one of the most dangerous phenomena within the mesoscale, since they are capable of causing great economic damage and loss of human life. Alfonso (1994) defined SLS as those storms that present at least one of the following phenomena: waterspouts, tornadoes, hail and gusts of linear winds not associated with tornadoes of more than 25 m/s (92 km/h).

Studies carried out in Cuba by Centella (2001) and Naranjo (1994) have shown that since the 1970s there has been a significant change in the climate of the largest of the Antilles, associated with changes in circulation patterns on the region of the Caribbean and the Gulf of Mexico, that is, to very low frequency oscillations or cycles in background climatic conditions, within processes of natural climate variability. In addition, they stated that one of the main climate variations is the increase in the frequency of affectation of extreme meteorological events such as Severe Local Storms, which seem to be related to the changes observed in the atmospheric circulation in the region and with the increase in the influence of the El Niño - Southern Oscillation event, which plays an important role as a forcing element of climate variability in Cuba.

This work has as objectives: to find the monthly distribution of Severe Local Storms (SLS) in the regions of Cuba, finding the months of greatest severity, as well as their relationship with the phases of the ENSO event and to analyze the relationship of the days with reports of SLS with the intensity of the ENSO phases in the rainy and dry season.

## 2. Results and Discussion

Between the years 1990-2020, a total of 2092 days with SLS reports were reported in Cuba, of which 812 occurred in the western region, 695 in the central region and 585 in the eastern region.

*2.1. Monthly Distribution of the Days with SLS Reports in the Regions of Cuba*

The monthly distribution of the days with reports of Severe Local Storms behaved in a very similar way in the months of January and December in the three regions of Cuba. As of February, a sustained increase in them can be seen in the west and center, reaching the maximum value in July, and then experiencing a gradual decrease. While, in the eastern zone, the largest number of SLS reports is in the month of June.

Figure 1 shows that the months that presented a greater number of days with SLS reports were May, June, July and August, which correspond to the rainy season in Cuba (May - October), which is consistent with the seasonal march of Electric Storms (Álvarez et al., 2006). In addition, it can be seen that the month of maximum severe activity was July, in the western and central regions, and June in the eastern region, which is consistent with the meteorological conditions that prevail in the rainy season, on the one hand, the behavior of the vertical shear in this month, together with the diurnal heating typical of this period, supposes favorable conditions for the development of the SLS (Aguilar et al., 2005). On the other hand, it is observed that in the dry season (November - April) severe phenomena occur to a lesser extent, with the months of January, February, November and December having the fewest days with SLS reports.

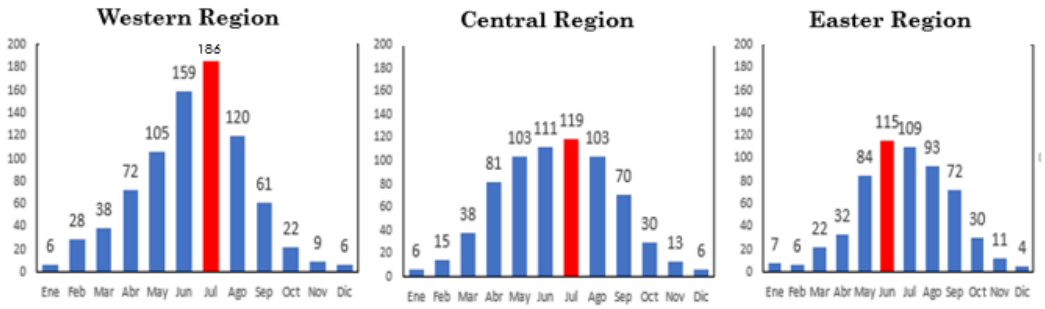


**Figure 1.** Monthly distribution of the days with SLS reports in the Cuban regions in the period 1990 - 2020.

Starting from the previous analysis, the months that had the greatest number of days with SLS reports (May, June, July and August) were selected and the phases of the ENSO event that were present were analyzed, taking into account the values of the ENSO Index (EI). The results showed that neutral conditions are the ones that prevail in these months, that is, the Sea Surface Temperature (SST) oscillates between -0.5ºC and 0.5ºC with respect to the average in the Equatorial Pacific, which resembles patterns normal time (site www.onemi.gov.cl). In addition, it was shown that, in the years 1991, 1992, 1993, 1997, 1998, 2002 and 2015, the El Niño phase was present in the months of maximum severe activity; while the La Niña phase was present only in 2010, in the months of July and August, and in 2013, in the month of July.

Table 1 shows that in Cuba the total number of days with SLS reports in the months with the highest frequency of severe activity is 1407, of which 570 occurred in the western region (40.5%), 436 in the central region ( 31%) and 401 in the eastern zone (29%). In addition, it can be seen that, for the month of May, in the years that there were a greater number of severe events, the Neutral phase of the ENSO event was present. On the other hand, in the months of June, July and August there was no homogeneity in terms of the phases, since the maximum values occurred both in the warm and in the neutral phase in the three regions of Cuba. Therefore, it can be argued that the phases that most favored severe activity in the archipelago were Neutral and El Niño.

**Table 1.** Number of days with SLS reports in the months of greatest severe activity in Cuba. (The numbers in red indicate that the ENSO phase that is present is El Niño, in blue that La Niña influences, and the rest of the values indicate the influence of the Neutral phase).

| Number of Days with SLS Reports | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Western Region | | | | Central Region | | | | Eestern Region | | | |
| Years/Months | May | Jun | Jul | Aug | May | Jun | Jul | Aug | May | Jun | Jul | Aug |
| 1990 | 4 | 2 | 9 | 1 | 2 | 6 | 5 | 7 | 0 | 0 | 0 | 0 |
| 1991 | **8** | **5** | **10** | 4 | **0** | **3** | **6** | 6 | **0** | **1** | **0** | 3 |
| 1992 | **3** | **5** | 9 | 0 | **3** | **6** | 8 | 8 | **1** | **3** | 0 | 1 |
| 1993 | **5** | **6** | 3 | 4 | **4** | **5** | 2 | 0 | **0** | **0** | 0 | 1 |
| 1994 | 1 | 5 | 1 | 7 | 3 | 2 | 4 | 1 | 1 | 3 | 2 | 2 |
| 1995 | 2 | 1 | 5 | 4 | 2 | 2 | 1 | 0 | 4 | 9 | 4 | 1 |
| 1996 | 5 | 5 | 3 | 1 | 2 | 1 | 2 | 0 | 2 | 3 | 1 | 3 |
| 1997 | **3** | **4** | **4** | **4** | **3** | **3** | **1** | **4** | **0** | **0** | **2** | **1** |
| 1998 | **5** | 1 | 1 | 0 | **1** | 2 | 0 | 5 | **1** | 7 | 3 | 3 |
| 1999 | 10 | 4 | 5 | 2 | 5 | 3 | 2 | 0 | 5 | 5 | 4 | 4 |
| 2000 | 3 | 8 | 7 | 11 | 2 | 5 | 6 | 5 | 1 | 3 | 4 | 2 |
| 2001 | 0 | 6 | 6 | 1 | 4 | 4 | 8 | 2 | 5 | 5 | 3 | 2 |
| 2002 | 1 | 4 | **8** | **3** | 0 | 3 | **2** | **5** | 4 | 4 | **2** | **7** |
| 2003 | 5 | 7 | 3 | 3 | 2 | 4 | 5 | 5 | 9 | 7 | 2 | 2 |
| 2004 | 0 | 11 | 7 | 7 | 1 | 6 | 4 | 6 | 0 | 0 | 5 | 3 |
| 2005 | 1 | 10 | 10 | 9 | 4 | 2 | 2 | 2 | 1 | 1 | 0 | 3 |
| 2006 | 7 | 3 | 5 | 7 | 3 | 2 | 4 | 1 | 0 | 4 | 2 | 2 |
| 2007 | 6 | 5 | 8 | 2 | 3 | 4 | 0 | 3 | 3 | 4 | 7 | 4 |
| 2008 | 3 | 10 | 4 | 2 | 3 | 1 | 9 | 1 | 2 | 4 | 6 | 6 |
| 2009 | 2 | 7 | 2 | 5 | 3 | 3 | 5 | 2 | 7 | 3 | 2 | 1 |
| 2010 | 1 | 2 | **4** | **6** | 2 | 1 | **4** | **4** | 3 | 4 | **7** | **3** |
| 2011 | 5 | 3 | 5 | 4 | 8 | 2 | 2 | 2 | 4 | 4 | 6 | 4 |
| 2012 | 2 | 1 | 10 | 4 | 4 | 5 | 2 | 2 | 3 | 9 | 5 | 2 |
| 2013 | 6 | 7 | **6** | 6 | 3 | 3 | **7** | 2 | 2 | 3 | **4** | 4 |
| 2014 | 3 | 9 | 7 | 1 | 2 | 5 | 5 | 1 | 4 | 5 | 2 | 6 |
| 2015 | 3 | **4** | **8** | **6** | 6 | 11 | 4 | 6 | 6 | **6** | **8** | **1** |
| 2016 | 3 | 2 | 7 | 5 | 8 | 8 | 1 | 5 | 6 | 2 | 8 | 6 |
| 2017 | 1 | 3 | 9 | 2 | 0 | 0 | 7 | 9 | 1 | 3 | 5 | 7 |
| 2018 | 0 | 7 | 10 | 7 | 4 | 1 | 3 | 2 | 2 | 5 | 4 | 4 |
| 2019 | 4 | 5 | 5 | 2 | 9 | 4 | 4 | 7 | 0 | 7 | 8 | 5 |
| 2020 | 3 | 7 | 5 | 0 | 7 | 4 | 4 | 0 | 7 | 1 | 3 | 0 |
| Total | **105** | **159** | **186** | **120** | **103** | **111** | **119** | **103** | **84** | **115** | **109** | **93** |

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### *2.2. Intensity of the ENSO Phases in the Distribution of Days with SLS Reports in the Rainy and Dry Season*

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The rainy season in Cuba extends from the month of May to October. Table 2 shows the number of months and days with SLS reports in the rainy season throughout the Cuban archipelago, as well as the intensity of the El Niño and La Niña phases. In this period it is observed that when weak EI values occur, in both phases, there are a greater number of days with reports of severe events. On the other hand, when the La Niña phase presents moderate and very strong EI values, no SLS report occurs.

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***Table 2.*** Number of months and days with SLS reports in the rainy season in Cuba between the years 1990 - 2020.

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| | | | Days with SLS Reports | | |
|---|---|---|---|---|---|
| | Index | Months | Western Region | Central Region | Eestern Region |
| El Niño Phase | Weak EI (50 - 150) | 21 | 107 | 85 | 57 |
| | Moderate EI (150 - 300) | 3 | 15 | 15 | 8 |
| | Strong EI (300 - 400) | 3 | 10 | 6 | 8 |
| | Very Strong EI (over 400) | 4 | 6 | 10 | 8 |
| La Niña Phase | Weak E (-35 to -150) | 4 | 12 | 10 | 12 |
| | Moderate EI (-150 to -190) | 0 | 0 | 0 | 0 |
| | Strong EI (-190 to -290) | 2 | 3 | 1 | 4 |
| | Very Strong EI (less than -290) | 0 | 0 | 0 | 0 |

In the dry season (November - April) it was observed that the greatest number of reports of severe phenomena occurs when the La Niña phase presents weak EI values. When the El Niño phase presents moderate EI values, more SLS reports occur in the western and eastern region, while in the center of the country the highest reports occur when El Niño is weak. On the other hand, no severity events were reported in the central region when La Niña had moderate values and in the eastern region when it presented moderate and very strong values (table 4).

***Table 4.*** Number of months and days with SLS reports in the dry season in Cuba between the years 1990 - 2020.

| | | | Days with SLS Reports | | |
|---|---|---|---|---|---|
| | Index | Months | Western Region | Index | Months |
| El Niño Phase | Weak EI (50 - 150) | 16 | 13 | 9 | 5 |
| | Moderate EI (150 - 300) | 10 | 17 | 8 | 6 |
| | Strong EI (300 - 400) | 5 | 6 | 4 | 5 |
| | Very Strong EI (over 400) | 6 | 4 | 0 | 1 |
| La Niña Phase | Weak E (-35 to -150) | 25 | 16 | 24 | 14 |
| | Moderate EI (-150 to -190) | 3 | 1 | 0 | 0 |
| | Strong EI (-190 to -290) | 4 | 4 | 5 | 1 |
| | Very Strong EI (less than -290) | 4 | 2 | 1 | 0 |

## 3. Conclusions

1. In the study period, a total of 2092 days with SLS reports were recorded, of which 812 corresponded to the western region, 695 to the central region and 585 to the eastern zone.
2. The months with the highest number of days with SLS reports were May, June, July and August, which coincide with the rainy period of the year, highlighting July as the month of maximum severe activity for western and central Cuba, and the month of June for the eastern zone.
3. The months of greatest involvement of SLS in the western zone represented more than 70% of the cases, registering a total of 570, while in the central zone it is equivalent to 62.7% and 68.3% in the eastern region, with 436 and 401 cases. respectively.

4. The phase that most favored the occurrence of SLS was the Neutral phase of the ENSO event, followed by the warm phase and to a lesser extent the cold phase.
5. In the rainy season, the greatest number of reports of severe phenomena occur when weak EI values occur during the El Niño and La Niña phases.
6. In the dry season, the greatest number of severe phenomena occurs when the La Niña phase is weak. In addition, a greater number of SLS reports were reported when the El Niño EI presents moderate values in the western and eastern region, while in the center of the country they occur when El Niño is weak.

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**Data Availability Statement:** EI of the months with the highest number of days with SLS reports in the period 1990-2020.

| Years | May | Jun | Jul | Aug |
|---|---|---|---|---|
| 1990 | 1.69 | 13.44 | 12.27 | 0.71 |
| 1991 | **94.47** | **109.33** | **72.84** | 36.98 |
| 1992 | **178.93** | **67.02** | 13.33 | -0.44 |
| 1993 | **133.47** | **111.60** | 49.94 | 39.56 |
| 1994 | 15.40 | 13.98 | -2.88 | -7.50 |
| 1995 | -11.02 | -10.00 | -3.67 | 0.00 |
| 1996 | -15.24 | -21.34 | -12.47 | -9.78 |
| 1997 | **100.33** | **226.67** | **341.91** | **461.07** |
| 1998 | **325.07** | 37.89 | 26.37 | -14.00 |
| 1999 | -28.27 | -22.40 | -7.72 | -10.33 |
| 2000 | -2.67 | -1.60 | -6.04 | -6.67 |
| 2001 | 3.16 | 5.78 | 3.47 | -0.50 |
| 2002 | 29.72 | 40.38 | **57.49** | **66.27** |
| 2003 | -8.22 | -28.47 | -13.83 | -0.13 |
| 2004 | 1.93 | 0.00 | -0.73 | 8.70 |
| 2005 | 34.67 | 40.37 | 20.41 | 10.19 |
| 2006 | -3.98 | 2.74 | 18.68 | 35.35 |
| 2007 | -9.20 | -6.84 | -12.34 | -4.79 |
| 2008 | -2.32 | 3.05 | 2.61 | 23.89 |
| 2009 | 0.67 | 0.00 | 16.88 | 23.36 |
| 2010 | 11.93 | 10.10 | **-42.16** | **-104.89** |
| 2011 | -24.03 | 12.55 | 15.33 | 4.05 |
| 2012 | 3.53 | 40.76 | 37.38 | 48.17 |
| 2013 | 0.69 | -24.24 | **-49.18** | -30.95 |
| 2014 | 7.26 | 22.75 | 13.03 | 24.46 |
| 2015 | 43.25 | **60.93** | **149.65** | **227.23** |
| 2016 | 31.91 | 3.17 | 0.03 | -12.21 |
| 2017 | 27.00 | 21.57 | 12.79 | 7.97 |
| 2018 | -14.67 | 4.44 | 6.40 | 2.89 |
| 2019 | 18.60 | 20.89 | 23.54 | 8.56 |
| 2020 | 7.44 | 0.58 | -3.91 | -15.28 |

**Conflicts of Interest:** "The authors declare no conflict of interest.

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