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Analysis of Some Properties of the Intense Cold Conditions in Havana †

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Abstract: In the article, statistical characteristics such as gusts, persistence and the conditioned probabilities of days with Intense Cold Condition in Havana are analyzed. The bioclimatic indicator used is generated from thermal sensations at contrasting times of the day (07:00 and 13:00 h), depending on the presence or absence of wind. The climatic data belongs to the meteorological stations of Casablanca and Santiago de las Vegas, in the period 1981–2018. Through the study it was possible to obtain additional information on the behavior and manifestations of the Intense Cold Condition in the province of Havana, laying the foundations for later extending its use to the entire country. The persistence values of the phenomenon are lower as the gusts increase, showing that these events are generally limited to periods of a few days.

Keywords: bioclimatic indicator; intense cold; persistence; gusts; conditioned probability

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1. Introduction

Bioclimatic extremes, specifically those related to heat and cold, are rare events. The difference with respect to extreme climatic phenomena lies in the fact that they are expressed in terms of indicators of comfort, thermal stress, epidemiological, economic, etc., all related to bioclimatology (Castillo and Barcia, 2016). These events are of great importance, because their occurrence implies an affectation to the living being.

In countries located at medium and high latitudes, bioclimatic extremes cause high mortality figures, mainly in older people and those with pre-existing diseases (Hernández, 2011). In tropical countries, research has been directed mainly to the study of heat extremes, which is related to the climate of these countries. However, this does not mean that under certain circumstances and during a certain period of the year, known in Cuba as the dry season, extreme cold conditions occur in the country, which sometimes cause extreme thermal sensations associated with the intense cold perceived by the population. Therefore, Velázquez et al., 2019 following this methodology of Guevara, 2006, which analyzed the bioclimatic extremes due to heat, studied the bioclimatic extremes due to cold in Havana, through the use of a new indicator: the Intense Cold Condition (ICC), based on the effective temperature (ET) and equivalent effective temperature (EET). This research shows the low frequency registered by this indicator, presenting only in 8% of the total days analyzed, and confirms that they are typical of the dry season in Cuba, including October as the transition month, since these months are in the 99.8% of the cases studied.

Despite this, there is still a need for greater knowledge of the impact of these conditions in the country, especially in the analysis of other aspects of the indicator, such as the persistence of the phenomenon, because its influence for several days can cause a greater discomfort in the population, as it prevails for a longer period of time, and may increase the risk, conditioned by less adaptation to these conditions. Therefore, the article intends to broaden the knowledge about the ICC in the territory, based on the determination and analysis of certain statistical characteristics such as gusts, persistence and the conditioned probabilities of days with the presence of the indicator.

2. Materials and Methods

The study period comprised a series of 38 years, from 1980 to 2018. The climatological data used included the following parameters: air temperature, relative humidity and wind speed, measured at 07:00 and 13:00 h of the 75° W meridian in the months of the winter period in Cuba. In general, it is considered that the first schedule characterizes with a good approximation the coldest period and the second, the hottest within the day, in Cuba. These data were extracted from two meteorological stations: Casablanca and Santiago de las Vegas (Figure 1), belonging to the network of meteorological stations of the Institute of Meteorology (INSMET). Both stations are located in the province of Havana: located in western Cuba, a region in which there is a marked drop in temperatures during the winter period (Gil, 2019).

Figure 1. Meteorological stations in the province of Havana.

The Intense Cold Condition (ICC) was enunciated by Velázquez (2019) who defined it as "that condition where, subjectively, thermal sensations due to excessive cold prevail throughout the day or in a considerable part of it, either due to its intensity, duration or by a combination of both characteristics".

The ICC without wind illustrates the presence of thermal sensations from Very Cold to Comfortable, based on the TE values at 7 and 13 h, which take into account only the combined effect of relative humidity and air temperature.

The ICC with wind represent the occurrence of Very Cold to Comfortable sensations, starting from the EET values at 7 and 13 h, based on air temperature, relative humidity and wind intensity.

The indicator has 5 categories that go from the least intense to the most intense, in ascending order, shown in Table 1.

Table 1. Classification of the CFIs (without wind and with wind) by categories.

ET/EET 1:00 pm / ET/EET 7:00 am	Comfortable	Slightly Cold	Cold	Very Cold
Comfortable				ICC_1
Slightly cold				ICC_2
Cold			ICC_3	ICC_4
Very Cold	ICC_1	ICC_2	ICC_4	ICC_5

Source: Velazquez (2019).

For each weather station, the frequency of days with ICC in its two variants was determined, also counting the number of events of consecutive days with these conditions (gusts). The intensity of the gusts was also determined taking into account the number of consecutive days that made it up.

As a final step, series of days with ICC without wind/with wind were formed for each meteorological station, with which the desired statistical characteristics were determined. Persistence was selected, which shows how repetitive a phenomenon is from the point of view of its occurrence (Hernández, 2011). The absolute and empirical probabilities of the occurrence of days with ICC were also calculated for the 2 study stations, in order to obtain the coefficient of persistence of days with ICC in its two modalities, without wind and with wind.

3. Results and Discussion

The highest number of gusts of days with ICC occurred in the months of January and February, both for ICC without wind and ICC with wind. Values of up to 7 consecutive days (G7) were reached with the presence of IFC, although gusts of 1 day (G1) predominated, that is, the manifestation of the event in isolation over time, shown in Figure 2.

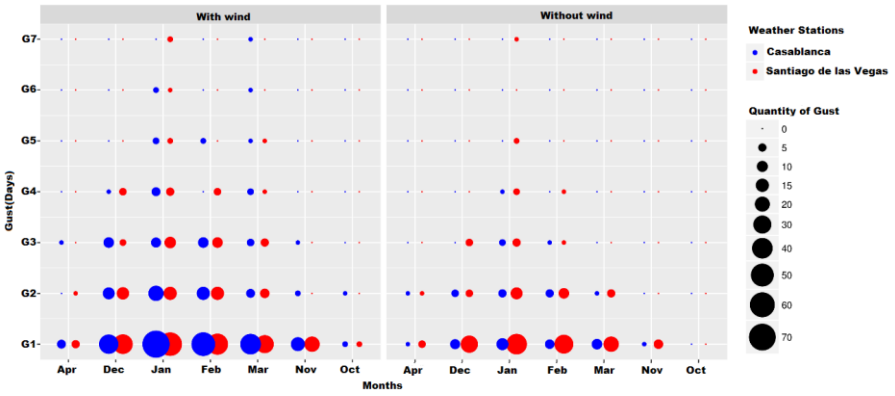

Figure 2. Gusts of days with ICC in the two study stations.

In the 38 years analyzed, the ICC without wind in the coastal station presented a greater quantity in the two-month period of January and February, with the month of January standing out with a total of 21 gusts. For its part, in Santiago de la Vegas there was a greater number of gusts, although they presented similarity in the months of greatest occurrence, January being the one with the highest number of cases, with a total of 63 gusts. The highest value of consecutive days with the presence of ICC without wind was reached in January 2010 with 7 days for the Santiago de las Vegas station.

It is valid to point out that with the influence of the wind, not only the number of gusts increased in the two variants for both seasons, but also their appearance in the month of October. A higher number of gusts occurred for both seasons in January, as in

the variant without wind, with 112 cases in Casablanca and 89 in Santiago de las Vegas, this month being the most representative of the appearance of these events.

On the other hand, the gust that most prevailed in both seasons and variants was that of 1 day, which shows that isolated and non-consecutive events occurred in most cases, while those greater than 3 days are fewer cases. It also highlights that category 5 only presented gusts of 1 day in the windy variant, while categories 2 and 3 are the ones that presented the highest number of events both with and without wind. (Figure 3).

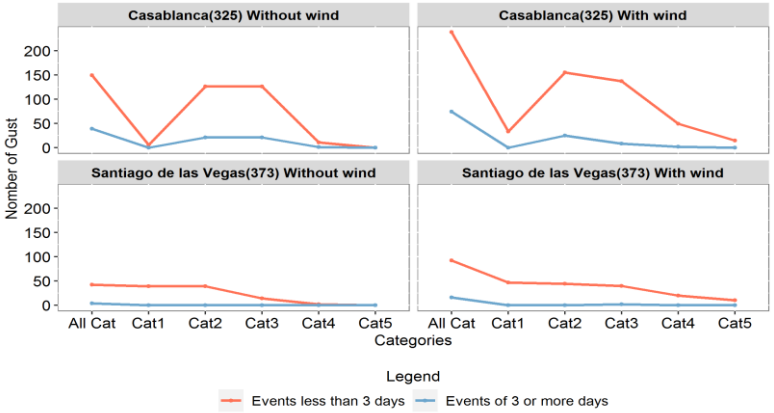

Figure 3. Number of gusts in more than 3 days or not: without wind (**left**), with wind (**right**).

The absolute probability of occurrence of ICC with wind reached its maximum amount in Casablanca, while in the windless modality the maximum occurred in Santiago de las Vegas, occurring in both modalities and in both seasons in the month of January. The lowest probability was reported in the month of October in the windless variant with 0% occurrence in both stations, while in the windy variant, they occurred for both the coastal and inland stations in October with 0. 0.37% and 0.19%, respectively (See Tables 2 and 3).

Table 2. Absolute probability of days with ICC without wind and ICC with wind in %, for the two seasons studied.

Months	Absolute Probability of Days with CFIwithout Wind and CFIwith Wind in %			
	Casablanca		Santiago de las Vegas	
	ICCwithout Wind	ICCwith Wind	ICCwithout Wind	ICCwith Wind
January	3.41	17.52	10.06	15.54
February	2.07	12.04	6.02	11.65
March	0.99	8.6	2.87	6.27
April	0.28	0.83	0.56	0.74
October	0	0.37	0	0.19
November	0.1	2.29	0.67	2
December	1.47	8.29	4.33	8.02

Table 3. Persistence coefficient (K) of the days with ICC without wind and with wind in the selected stations. (1980–2018).

Months	Absolute Probability of Days with CFIwithout Wind and CFIwith Wind in %			
	Casablanca		Santiago de las Vegas	
	ICCwithout Wind	CFIcv	CFIsv	CFIcv
January	0.65035287	0.76579721	0.71548007	0.82507113
February	0.5649143	0.59479541	0.45485101	0.66596613
March	0.17519831	0.69140341	0.29584833	0.6355284
April	0.5567927	0.55928254	0.30710652	0.23600659
October	0	0.4388919	0	0
November	0	0.31204439	0	0
December	0.44309872	0.59484749	0.46253483	0.56095983

In Casablanca, the probability of occurrence of days with ICC in the windless mode was 1.1%. For the years 1980–2018, there were a total of 28 days preceded by days in this modality, which is equivalent to a 31.1% probability of occurrence of ICC the day after this situation occurred. For the modality with wind during a season, the probability of occurrence is 7.16%. In the 1980–2018 seasons, 199 days preceded by days of the same modality were observed, resulting in a 36.8% probability of occurrence of these conditions the day after they occurred. Resulting in a greater possibility of finding isolated days with ICC than consecutive days with this condition.

In Santiago de las Vegas, the probability of occurrence of days with ICC in the windless mode was 3.5%. For the period 1980–2018, a total of 80 days preceded by days in this modality occurred, which is equivalent to a 30.1% probability of occurrence of ICC the day after this situation occurred. For the windy modality during a season, the probability of occurrence was 6.3%. In the period 1980–2018, 183 days preceded by days of the same modality were observed, resulting in a 38.2% probability of occurrence of these conditions the day after they occurred. It is valid to emphasize that something similar occurs in Casablanca where it is more frequent to find isolated days with ICC for both variants.

Figure 4 shows many of the aforementioned characteristics, however, the difference between the two variants (with and without wind) is notorious, reaffirming how decisive the role of the wind was when it came to increasing the probability of occurrence of storms. days with ICC, in addition to being evident the greater persistence of the phenomenon in the January-February two-month period.

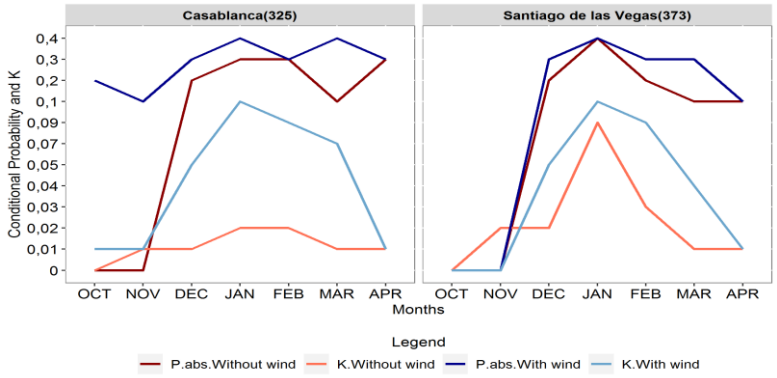

Figure 4. Persistence and probabilities in the variant without wind and with it, for the two study stations.

The previous results reflect that there are high values of persistence of the phenomenon in Havana during the months of December to February. This indicates that in these months the occurrence of ICC days is more likely, as well as the condition being

maintained for more than 1 day, and this is more likely in windy ICC, representative of the worst bioclimatic conditions, although this phenomenon is characteristic. to appear in isolation.

When comparing the results obtained by (Hernández, 2012) in the analysis of gusts and persistence of days with IHC (extremes due to heat), with the analysis of persistence and gusts of days with ICC (extremes due to cold), it is observed that there is a lower number of gusts of days with intense cold than with intense heat, in addition, the duration of days with ICC is also lower than the days with IHC, situations typical of tropical climates. However, it is interesting that for both indicators the persistence values of the phenomenon become less appreciable as the gusts increase, being more noticeable for the ICC, in which persistence is not a predominant characteristic, which shows that these events are generally limited to periods of a few days.

However, the foregoing statement does not presuppose a total absence of cold temperatures or their extreme manifestations, but rather with the increase in climatic variability and the scarce presence of cold extremes, the risk may increase due to the different vulnerabilities present in each region or country, conditioned by a lower adaptation to these conditions, product of the prevailing climatic tendencies. So we are faced with the need to deal with phenomena whose intensity and frequency are changing, or will change, in too short a time for humanity to successfully adapt and continue its development as a species. This knowledge would serve as the basis for the execution of actions that guarantee greater well-being in the populations.

4. Conclusions

- Through the selected statistical characteristics, it was possible to obtain additional information on the behavior and manifestations of the Intense Cold Condition in the province of Havana, laying the foundations for later research to extend its use to other provinces of the country.
- The persistence values of the phenomenon become less appreciable as the gusts increase, which shows that these events are generally circumscribed to periods of a few days.
- There are high values of persistence of the phenomenon in Havana during the months of December to February, being more likely in the windy ICC, representative of the worst bioclimatic conditions, although this phenomenon is characteristic of occurring in isolation.

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References

1. Castillo, C.; Barcia, S. Condiciones de calor intenso en la provincia de Cienfuegos, Cuba. *Rev. Cuba. Meteorol.* **2016**, *22*, 26–38.
2. Gil, L.; Gonzales, I.; Hernández, D. Las temperaturas extremas de la temporada invernal en la región occidental de Cuba en el período 1981–2016. *Rev. Climatol.* **2019**, *19*, 17–26.
3. Guevara, A. Las condiciones de calor intenso como indicador de extremos bioclimáticos en Ciudad de La Habana. *Rev. Territ.* **2006**, *16*.
4. Hernández, Y.; Guevara, A.V.; Santana, M.; León, A. Caracterización de las Condiciones de Calor Intenso (CCI) en la provincia de Mayabeque, Cuba. In Proceedings of the 6to Congreso Cubano de Meteorología, La Habana, Cuba, 29 December 2011.

5. Hernández, Y. Rachas, probabilidad de ocurrencia y persistencia de días con Condiciones de Calor Intenso en Mayabeque, Cuba. *Rev. Cuba. Meteorol.* **2012**.
6. Velázquez, B.; Guevara, A.; Hernández, D.; Armas, O. La Condición de Frío Intenso como Nuevo Indicador de Extremos Bioclimáticos. Licentiate Thesis, Universidad de la Habana: La Habana, Cuba, 2019.