

Trends in Intense Heat and Cold Conditions in Cuba

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INTRODUCTION & AIM

Climate change represents one of the main global challenges, manifesting itself primarily through rising temperatures and the intensification of extreme weather events. Among these extreme events, heat and cold waves are particularly significant, characterized by prolonged periods of exceptionally high or low temperatures that can persist for five days or more. Trend analysis is essential to assess these climate changes, allowing for the identification of patterns in time series of meteorological data over extended periods. In this context, our study focuses specifically on trend analysis of extreme heat and cold events during the period 1981–2023, using indicators such as Intense Cold Conditions and Intense Heat Conditions. This research contributes to the understanding of how climate change affects our region, providing crucial information for future planning and adaptation.

METHOD

The study covered the entire country and used 67 meteorological stations belonging to the Meteorological Institute's network of stations. Initially, the climate data were validated and verified. The existence of trends was determined primarily using the Mann-Kendall statistic, both direct and inverse, and the change points using the Pettitt test. The Spearman and Wald-Wolfowitz tests were used as alternative tests. A significance level of 0.05 was chosen, given that the 95th percentile yields a good result in meteorology.

The assessment of bioclimatic extremes associated with heat and cold was carried out using the Intense Heat Condition (CCI by its acronym in Spanish) and Intense Cold Condition (CFI by its acronym in Spanish) indicators.

TE/TEE 1:00 pm	Comfortable	Warm	Very Warm
TE/TEE 7:00 am			
Comfortable			CCI ₁
Warm		CCI ₂	CCI ₃
Very Warm		CCI ₃	CCI ₄

TE/TEE 1:00 pm	Comfortable	Slightly Cold	Cold	Very Cold
TE/TEE 7:00 am				
Comfortable				CFI ₁
Slightly Cold				CFI ₂
Cold			CFI ₃	CFI ₄
Very Cold	CFI ₁	CFI ₂	CFI ₄	CFI ₅

Which are calculated from the combination of thermal sensations at 7am and 1pm because they are contrasting times of the day, which in turn depend on the bioclimatic indices Effective Temperature (temperature and humidity) and Equivalent Effective Temperature (temperature, humidity and wind).

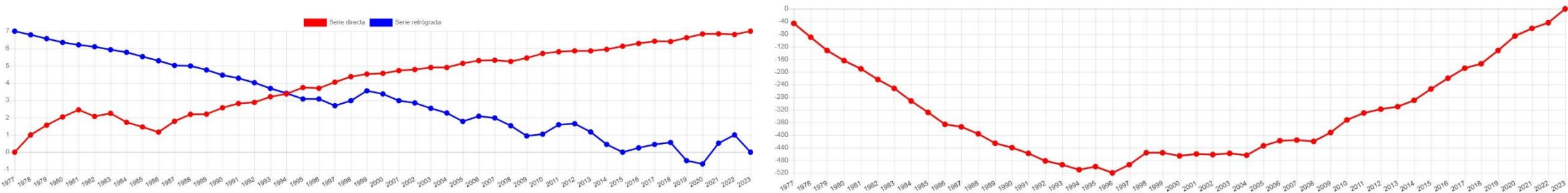
$$TE = t - G(0.00439T^2 + 0.456T + 9.5$$

$$TEE = TE + W[(0.11T - 0.13) - 0.002TG]$$

RESULTS & DISCUSSION

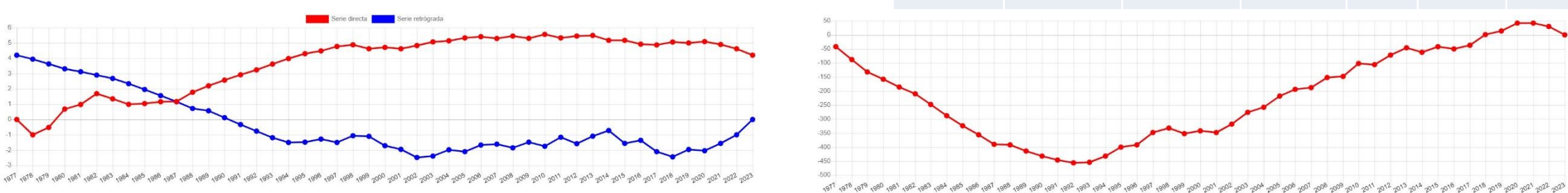
The existence of highly significant increasing trends was verified in the series corresponding to CCIsv and CCIcv in Cuba.

Pettitt's statistic shows that the change point is in 1996. Regarding the serial correlation (Wald-Wolfowitz test) and the Sperman test, they showed correlation for the annual series of days with CCI in both variants.



In the trend analysis of each of the categories of the CCI indicator for the windless variant, the existence of highly significant upward trends was verified in the series corresponding to the four categories in Cuba.

By category, Pettitt's statistics show that the turning point for these series was 1996 for categories 1 and 3, 1992 for category 2, and 1994 for category 4, all in the 1990s.



This indicated that, in all cases, extreme heat conditions have been increasing in Cuba, either without taking into account the cooling effect of the wind, or taking it into account.

The existence of trends in the series corresponding to CFIsv and CFIcv in Cuba ($\alpha_1 > \alpha_0$) could not be verified; however, Pettit shows a change point in the 2010-2011 season for both series.

Statistical tests for trend and change points in series						
Condition	Significance level $\alpha=0,05$					
	Wald-Wolfowitz	Spearman	Kendall-Mann	Trend . Sg	Pettitt	Trend. Sg
CFIsv	0.0042172701	0.9314587564	1.838486681532	NO HAY	0.0282940	2011
CFIcv	0.0001776248	0.9407136552	1.916369724772	NO HAY	0.0104353	2011

CONCLUSION

Overall, highly significant upward trends were observed in the CCIsv and CCIcv series in Cuba, as well as in each of their categories. No trends were observed in the CFIsv and CFIcv series, or in any of their categories.

FUTURE WORK / REFERENCES

Velázquez, B.; Guevara, A.; Hernández, D. & Armas, O. 2019. *La Condición de Frío Intenso como nuevo indicador de extremos bioclimáticos*. Tesis de Licenciado, La Habana: Universidad de la Habana.

Guevara, A., 2006. *Las condiciones de calor intenso como indicador de extremos bioclimáticos en Ciudad de La Habana*.