# 5B.3 An Atlantic Tropical Cyclone Intensification Index for the last 2000 yr:
*A Significant ~510 yr Climate Cyclic Pulse Reconstructed*

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## 1. INTRODUCTION

Based on historical and instrumental Atlantic Tropical Cyclones (ATC) recently updated records, and hydrological proxy records from the Caribbean, this paper proposes to reconstruct an ATC intensification index (II) for the last 2 millennia (Sánchez-Sesma, 2008, SS08 hereafter)

## 2. DATA AND METHODS.

### *2.1 Data Sources.*

Three main sources of ATC information were used in this work, one is from the instrumental measurements covering the last one and a half centuries [HURDAT (Landsea, 2005), HD hereafter, see Fig. 1], a second is the reconstructed record recently updated with Spanish documentary sources for the 1500-1850 period [García-Herrera et al. (2005), GH hereafter, see Fig. 1], and a third is the oxygen-isotope monsoon rainfall record from U/Th-dated stalagmite from the Isthmus of Panama (Lachniet et al, 2004, LA07 hereafter, see Fig. 3).

### *2.2 An Intensification Index(II)*.

Although there is a possible bias due to missing ATC information, its reconstruction during the last 500 years provides important information. If we analyze the relative values of the hurricanes (HR) and tropical storms (TS) collected by GH and HD we can estimate trends and oscillations. To do that, an intensification index for TC is proposed as the following (SS08):

$$II(t)=[HR(t)-TS(t)]/[HR(t)+TS(t)] \quad (1)$$

where *II(t)* is the annual intensification index value, *HR(t)* is the annual number of hurricanes in the ATC records, *TS(t)* is the annual number of tropical storms in the ATC records, and t is the corresponding year.

The *II* values can oscillate between -1.0 and 1.0, when there are only tropical storms or hurricanes, respectively. *II* values do not change if the same factor is applied both in HR and TS.

## 3. RESULTS

### *3.1 Reconstruction of II for the last 500 yrs*

We evaluated the ATC II defined in eq. 1 over the period as 1500-2006. We applied a moving average filter (MA-21-yr) to the ATC II values to emphasize multidecadal processes. Employing GH and HURDAT archives, it is possible to evaluate the almost complete ATC II history of the last 500 years. The reconstructed ATC-II values are shown in Figure 4. An iterative process that looks for the minimum RMS error adjusted to ATC-II values a sine function with a period of 496 years; it is also shown in this Figure.

### *3.2 Reconstruction of II for the last 2000 yrs.*

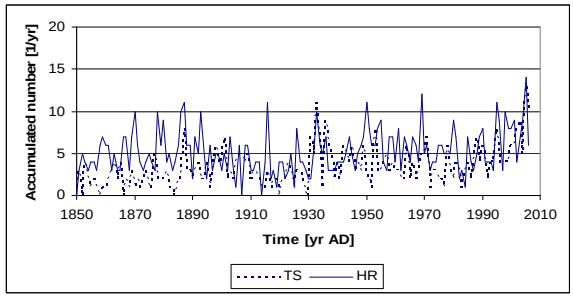


Figure 1. Annual accumulated number of Atlantic Tropical Cyclones (ATC) as recorded by NOAA in the HURDAT data base (Landsea, 2005).

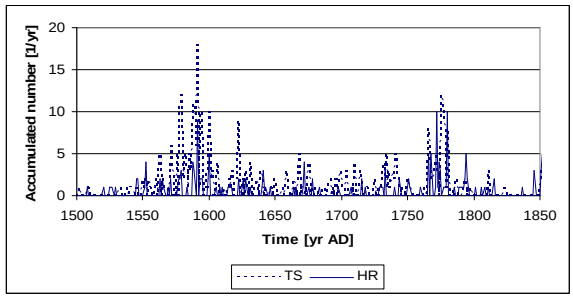


Figure 2. Annual accumulated number of Atlantic TCs (ATC) from documentary sources for the period 1500-1850. (García-Herrera et al., 2005).

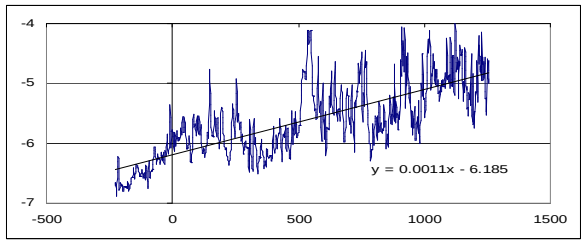


Figure 3. A Raw $\delta^{18}O$ values of speleothem calcite from Chilibrillo, Panama (LA04)

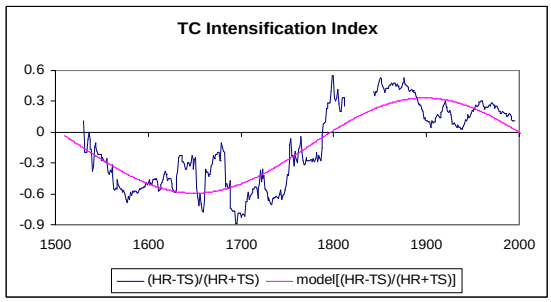


Figure 4. ATC intensification index (ATC II) for the Atlantic Ocean defined as [(HR-TS)/(HR+TS)] annual accumulated values filtered with a 21-yr moving average. An adjusted sine function with a 496 yr period is also displayed.

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In order to evaluate the stability of the 500 yr oscillation Fourier series with N=2 was applied both to the detrended Caribbean proxy isotope-based (LA04) and to the directly evaluated ATC-II record. Figure 5 displays ATC-II linearly transformed and 81-yr moving-average proxy record for the speleothem-based Central America monsoon record over 1500 yr (180 B.C.-1310 A.D.) obtained by LA04, with the historical and instrumental reconstruction, based on GH and HD data, using a 41-yr moving average on the ATC-II data as previously made. Also, in this figure two adjusted Fourier series models with period of 508 yrs are displayed. Model 0 was based on all data from 231 BC to 1985 A.D. In contrast, model 1 began in the same initial year, 231 BC, but ended in 1310 A.D. The models 0 and 1, explained 67.7 and 65.4% of variance for all the reconstructed period.

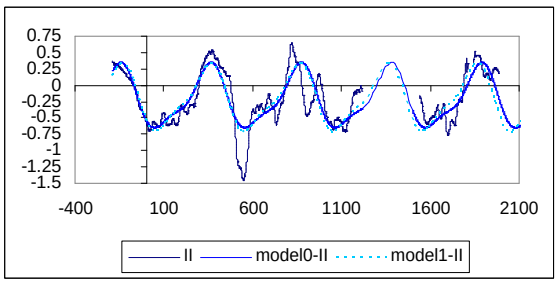


Figure 5. Comparison of smoothed ATC-II reconstructed record (thin line) based on historical and Central American Monsoon (CAM) records, with two Fourier Series models (thick [model 0] and dotted lines [model 1]).

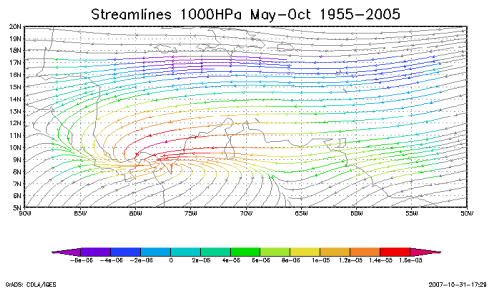


Figure 6. Surface streamlines for the May-October season during the past 51 years (1955-2005 period) based on the reanalysis information (Kalnay et al 1996).

### *4. DISCUSSION and CONCLUSIONS.*

The importance of the Panamanian stalagmite record for ATC is shown, when the mean streamlines at 1000 mb level are displayed for the Caribbean. Based on the reanalysis information (Kalnay et al 1996), Figure 6 displays these streamlines for the May-October season during the past 51 years (1955-2005 period). This graphical result shows the influence of the Caribbean (or the main development region of ATC) in the Panamanian zone in which a semipermanent "low" center is located.

Based on instrumental and proxy (historical and CAM) records, the ATC-II reconstructed record has shown an oscillation of ~510 yrs, which has been detected in several reconstructed and simulated climate related processes, such as Northern Hemisphere temperatures, and other North Atlantic and central European atmospheric and oceanic phenomena (SS08).

Although there are no explanations and mechanisms for this ~510 yr oscillation, it shows how nature works in the ocean-atmosphere climate system with long-term trends and oscillations. This ~510 yr ATC natural oscillation puts forward the potential for predicting ATC II trends at least for several decades into the future.

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