2C.5 *THE LENGTHIEST TROPICAL CYCLONE (TC) RECORD IN THE WORLD: Analysis of Typhoon Occurrences Since 700 AD and its Relation with Atlantic Hurricane Occurrences, Global Temperature and Solar Activity*

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1. INTRODUCTION

The following typhoon record analysis is one of a group of international research projects funded by the Inter American Institute for Global Change Research (IAI), focused on the reconstruction of Atlantic TCs (ATC) covering the last centuries (Sánchez-Sesma et al 2005; Liu et al, 2005).

2. DATA AND METHODS.

2.1 Japanese Typhoons (JT). Dr. Hatsuo Ishizaki was very motivated by the necessity to know more about the typhoon climatology that affects his native country, Japan. After searching for the Japanese keywords “strong wind” or “big wind” found in ancient writings, he reconstructed the frequency of JTs during the last thirteen centuries (Ishizaki, 1971). Figure 1 displays the number of JTs for every 12 years for the southern part of the Japanese islands.

2.2 Atlantic Tropical Cyclones (ATC). The number of hurricane system frequency record considered in this study is provided by the NOAA HURDAT file [Landsea et al, 2004].

2.3 Sunspot number (SSN). Sunspots are concentrations of strong magnetic fields piercing the solar photosphere. Modern measurements show that the "brightness" or total irradiance of the Sun fluctuates, as sunspots do, by a few tenths of a percent over the 11 year solar cycle. In addition to astronomical observations, sunspot numbers can be estimated from proxy information. Recently, Usoskin et al (2003) have reconstructed decadal SSN from cosmogenic Be-10 data in polar ice for the last 12 centuries. Figure 1 also displays a linear transformation of the reconstructed record for SSN during the last 12 centuries as a proxy of JTs. The presented series gives an approximate upper boundary of the sunspot activity.

2.4 Smooth and Lagged Linear Transformation (SLLT). The standard deviation of the climatic values was estimated through the use of the SLLT method developed by Sánchez-Sesma (2004), where, in order to identify the common low frequency oscillations and to eliminate noise and errors, the functional relation, a linear transformation (LT), was based on moving and lagged averages.

3. RESULTS

3.1 Japanese typhoons & the Sun. (JT & SSN)

When applying the SLLT without any smoothing, an expression for JT in terms of SSN was obtained. The results are displayed in Figure 1. The JT and the obtained JT (SSN) series have a 0.34 correlation coefficient. The minimum and maximum range of JT values, which for a normal distribution include 99% of decadal values, are also displayed in Figure 1.

3.2 Atlantic & Pacific Tropical Cyclones (ATC&JT).

Frequency and intensity of hurricanes can be

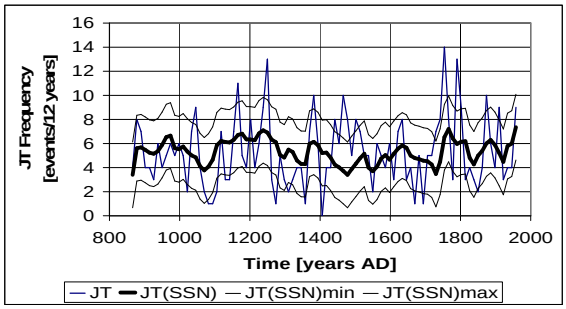

Figure 1. Comparison of Japanese Typhoon (JT) historical and reconstructed as a function of SSN

Estimated using different kinds of information. Historical information from Spanish and English navies constitutes an important source for hurricane reconstructions (e.g. Garcia-Herrera et al. 2005). Apart from this valuable regional data there is a detected climatic teleconnection between NW Pacific and Atlantic regions that allows us to also use historical information from Japan (Sanchez-Sesma, 2004).

After applying the SLLT with a 21 yr moving average, with smoothing but without lagging, an expression was obtained for ATC, from HURDAT, in terms of JT. The results are displayed in Figure 2. The observed *ATC* and the obtained *ATC(JT)* series have a correlation coefficient of 0.93.

Figure 2 also shows the mean, minima and maxima of the ATC reconstructed record which corresponds to a range of 99% of the annual values. According to this figure, the maximum values of the annual ATC occurred not only during the 20th century but also in the 13th and 18th centuries. Furthermore, this reconstruction allows us to notice the presence of periods of low hurricane activity, which appeared in the 8th, 11th, 13th, 14th and 17th centuries.

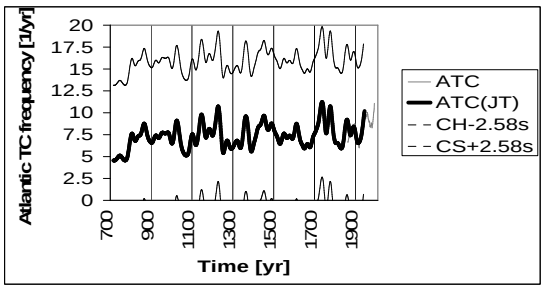

Figure 2. Atlantic Tropical Cyclone historical records based on reports, ATC and on the JT historical record ATC(JT).

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It is important to point out that the period of minimum activity of ATC is found in the 8th century and corresponds to the period of strong drought which was identified in the Yucatan Peninsula and which is considered to be an important factor in the fall of the Mayan civilization [*Hodell et al.*, 1995].

The validation of this reconstructed ATC record was made through its comparison with the Atlantic historical data of TCs published by García-Herrera et al (2005). Figure 3 illustrates this comparison.

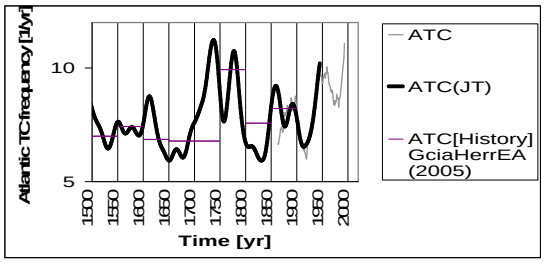

Figure 3. Atlantic Tropical Cyclone historical records based on reports, ATC and on the JT historical record ATC(JT). Constant values for 1500-1900 are LT of hurricanes historical values from the Atlantic colonial archives [García-Herrera et al 2005].

In order to analyze other relationships between the reconstructed ATC and global temperature (GT), it is compared with another reconstruction of ATC based on a reconstruction of GT (Esper, et al, 2002), as shown in Figure 4. The periods of increasing ATC for the 19th and 20th centuries correspond to a GT warming while the periods of decreasing ATC for the 16th and 17th centuries imply a cooling of GT.

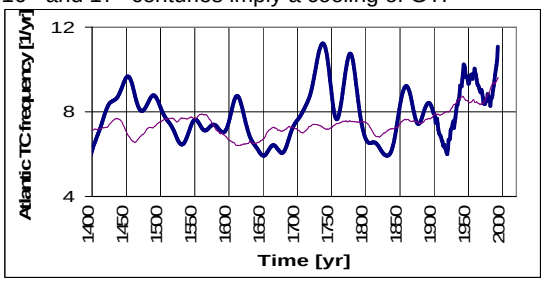

Figure 4. Atlantic Tropical Cyclone reconstruction based on JT reports (bold line), and on the reconstructed Global Temperature record ATC(GT) (thin line).

4. DISCUSSION & CONCLUSIONS. Paleo-typhoon information from Japanese imperial archives provides a source of data to document, model and shed light on the frequency and climate relations of ATC.

The modulation found in ATC by solar activity, suggests different mechanisms. The intensity of radiation from the sun, as the cold phase of ENSO has shown, may cause different ocean-atmosphere effects including: the greater amount of heat available in the tropics, and its associated Hadley cell flow increase and corresponding intensifications of the semi permanent *highs* in the Atlantic and Pacific. This ATC-SSN relation has been corroborated by observing a connection of TC activity in different oceans.

The relationship found between ATC and JT occurrences is confirmed with evaluated correlations of these variables and different indexes of ATC.

The possible impacts of ATC climate secular minimum condition on Mesoamerican societies were exemplified in the 8th century when the Maya people demise began. Recent results concerning Thermohaline Circulation permit us to suggest a peak of ATC in the present decade and a following decay to another secular minimum in the period 2030-2040 with possible drought risks for Mesoamerica.

Our analysis has also detected analog periods overlaid on warming and cooling trends.

Our results suggest a clear positive correlation between Global temperature and ATC for very low frequencies (i.e. periods greater than 140 years). For example, a warming of 0.75 °C implies an increment of ~4 of ATC; e.g. during 1800-2000, a mean increase of 0.02 [ATC/yr] occurred. These assessed long-term relations suggest that the present increase of tropical cyclones which has been occurring for the last two centuries is not unique, since an even more important period of increase happened nearly 1000 yrs before.

However, more research is needed so as to better understand, through analysis and modeling, these climate teleconnections and their low frequency variations.

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5. REFERENCES

Esper, J., Cook, E.R., Schweingruber, F.H., 2002: Low-frequency signals in long tree-ring chronologies for reconstructing pasttemperature variability. Science 295, 2250–2253.

García-Herrera R., L. Gimeno, P. Ribera, E. Hernández, 2005: New records of Atlantic hurricanes from Spanish documentary sources, J. Geophys. Res., 110, D03109, doi:10.1029/2004JD005272.

Hodell, D. A., J.H. Curtis, and M. Brenner, 1995: Possible role of climate in the collapse of Classic Maya civilization. Nature 375: 391-394

Ishizaki, H., 1971: Wind damage and wind load problems in Japan, Proceedings of USA-Japan Seminar, *Wind Loads on Structures*, Hawaii.

Landsea, C. W., et al, 2004: The Atlantic hurricane database re-analysis project: Documentation for the 1851-1910 alterations and additions to the HURDAT database. In Hurricanes and Typhoons: Past, Present and Future, R. J. Murnane and K.-B. Liu, Eds., Columbia University Press.

Liu, K-b., et al, 2005: Paleotempestology of the Caribbean Region: A Multi-proxy, Multi-site Study of the Spatial and Temporal Variability of Caribbean Hurricane. A research project to be supported by the Inter-American Institute for global change research (IAI). (A proposal approved).

Sánchez-Sesma J. 2004: Ph. D. Thesis, Universidad Nacional Autonoma de Mexico.

Sánchez-Sesma, J., 2006: Re-examining the Typhoon-Sunspot Relationship for the Last Thirteen Centuries. To be sent to J. of Climate.

Sánchez-Sesma, J. et al, 2005: Evaluation of Paleo-Hurricanes in the Intra-Americas Sea. In: Memories of the "XI Congreso Latinoamericano e Ibérico de Meteorología y XIV Congreso Mexicano de Meteorología", CD electronic document.

Usoskin I.G., et al, 2003: Millennium-Scale SSN Reconstruction, *Phys. Rev. Lett.*, v.91 (21), 211101