Sunspot Activity and Atlantic Tropical Cyclones

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Abstract

A hurricane season is affected by several oceanic-atmospheric variables that all influence the number and intensity of tropical cyclones. Tropical cyclones have been heavily studied to find information about their thermodynamics and also to be able to accurately forecast an entire hurricane season. Sunspots have also been examined to determine if a link is present between solar irradiance and hurricanes.

The research builds on previous work in the study between sunspots and hurricanes and focuses on different variables during a hurricane season and correlating those variables to sunspots. It is found that the entire sunspot cycle does not play a major role in hurricane activity. A correlation of only 0.0235 between number of storms and sunspot activity was found.

Other yearly variables and the extremes of the sunspot cycle were correlated to discover if the sunspot cycle influenced hurricane frequency or intensity. The correlations in sunspot extreme years (maximum and minimum) increased from those over the entire cycle, with minimum years having the highest correlations (-0.6121 for storms) to a hurricane season. F-tests revealed that the variance in storm number is the same in all phases of the sunspot cycle. Regression models showed that minimum year sunspots can describe 37.5% of the climatology of tropical cyclones and 27.5% of tropical cyclone days. Sunspots should be considered for increased pre-seasonal hurricane forecast accuracy and the inter-annual variability of tropical cyclones.

Methodology

- Hurricane seasons and sunspots from 1958 – 2008
  - Total number of storms and days
  - Average wind speed and pressure
- Spearman correlation coefficients, f-tests, and linear regression models

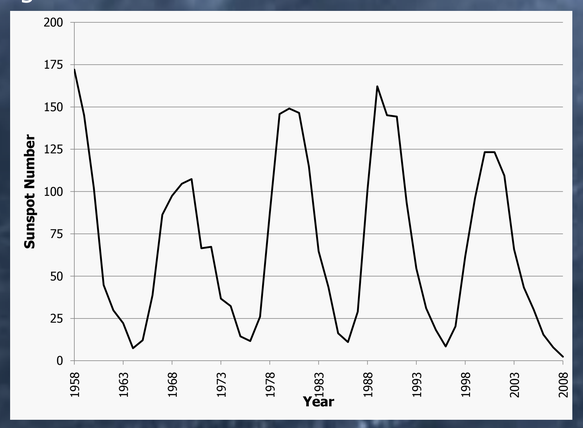

Fig. 1. Sunspot cycle from 1958-2008.

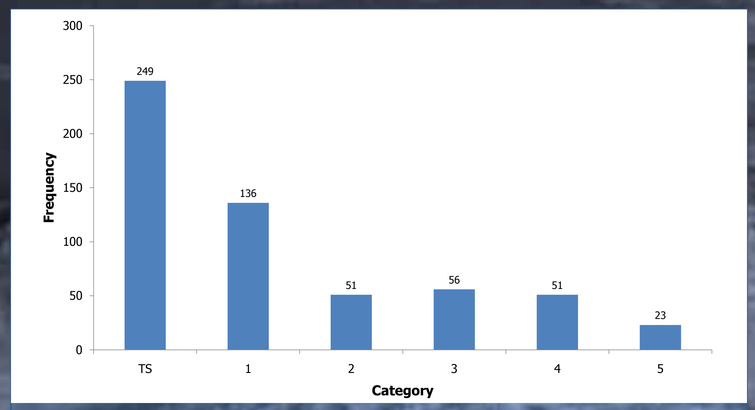

Fig. 2. Histogram showing frequency of tropical storms and hurricanes from 1958 – 2008.

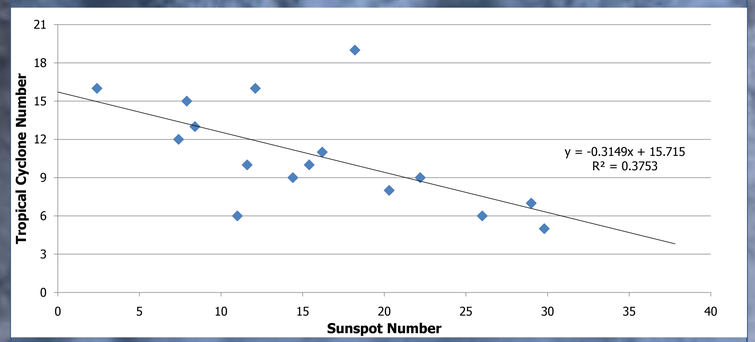

Fig. 3. Linear regression of minimum sunspots and number of tropical cyclones. The R-squared is 0.3753 with a RMSE of 3 storms.

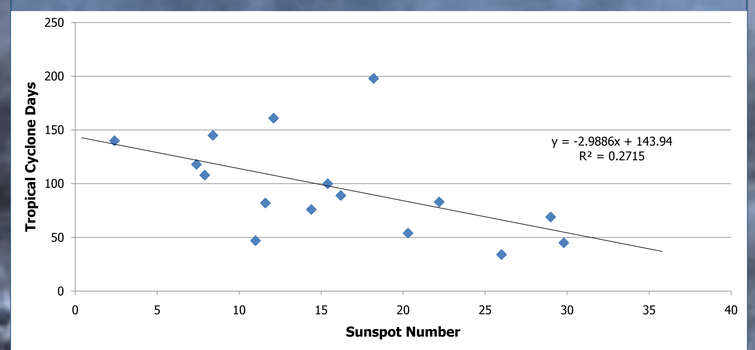

Fig. 4. Linear regression of minimum sunspots and total tropical activity days. The R-squared is 0.2715 and the RMSE is 41 days.

Table 1. Spearman correlation statistics for the entire sunspot cycle and different variables of a hurricane season.

Variables	Total	Sunspot Max (Over 100)	Sunspot Min (Under 30)
Storms	0.0235	-0.0934	-0.6121
Days	-0.0643	0.0898	-0.5618
Wind	0.0424	0.2703	-0.2
Pressure	0.0239	-0.0265	0.2706

Table 2. F-test comparing the variances of sunspots for maximum and minimum sunspots and the variance of number of storms in each portion of the sunspot cycle.

Variable	F-Stat	Upper Limit	Lower Limit	Reject
Max vs. Min Sunspots	0.1227337	2.862093	0.3493947	TRUE
Max vs. Min Storms	1.729546	2.862093	0.3493947	FALSE
Total vs. Max Storms	1.803835	2.5488	0.4741558	FALSE
Total vs. Min Storms	1.042953	2.5488	0.4741558	FALSE

Results

Evidence shows the sunspot cycle in its entirety has little correlation to a hurricane season. However, maximum sunspot years had a strong correlation to maximum wind speed and minimum sunspot years had a strong correlation in all categories. An f-test demonstrated that the variances in number of tropical cyclones are the same in all phases of the sunspot cycle, suggesting that sunspot activity does not affect the natural variability of tropical cyclones.

Regression models done on the minimum sunspot year variables are the only models that showed significance. Minimum year storms and sunspots are modeled with an R-squared of 0.3753 and a root mean square error (RMSE) of 3 storms. Likewise, the minimum year tropical cyclone days and sunspots model produced a R-squared of 0.2715 with a RMSE of 41 days.

Conclusions

- The total sunspot cycle has a weak overall correlation
  - Extreme years have a stronger correlation
  - Minimum years have the strongest correlation
- Decreased sunspots actually increased tropical cyclone frequency
  - -0.61 correlation to storms
  - -0.51 correlation to days
  - Intensity was marginally correlated
- Sunspots have an influence on a hurricane season and should be considered for improving pre-seasonal hurricane forecasts and understanding inter-annual hurricane variability

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