Hurricanes/Cyclones/Typhoons Energy Increasing with Yearly Seasons

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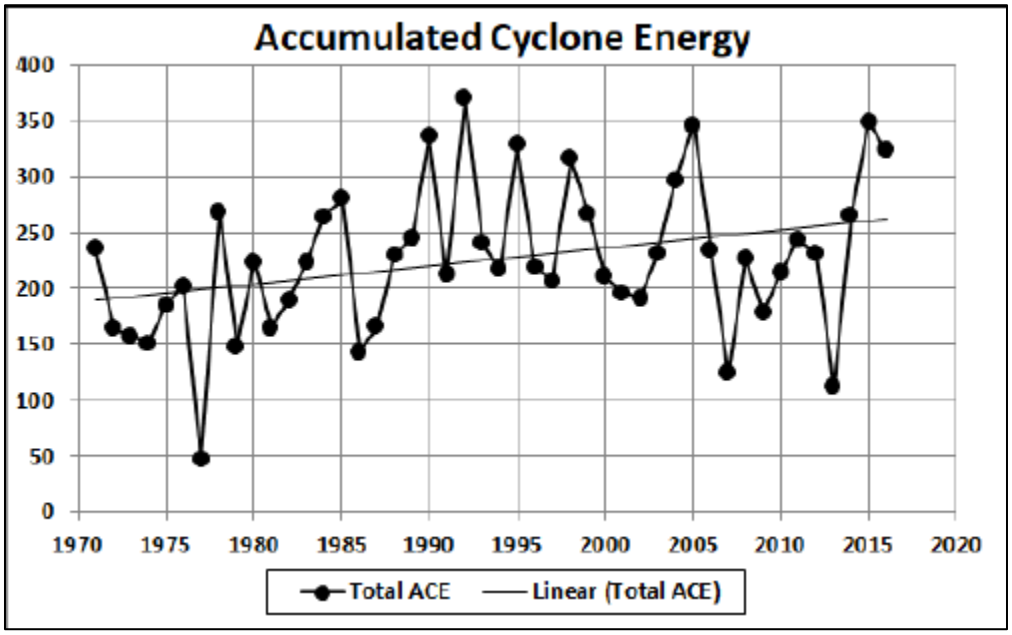
24 September 2017

http://www.roperld.com/science/GlobalTempDueToCarbon.pdf

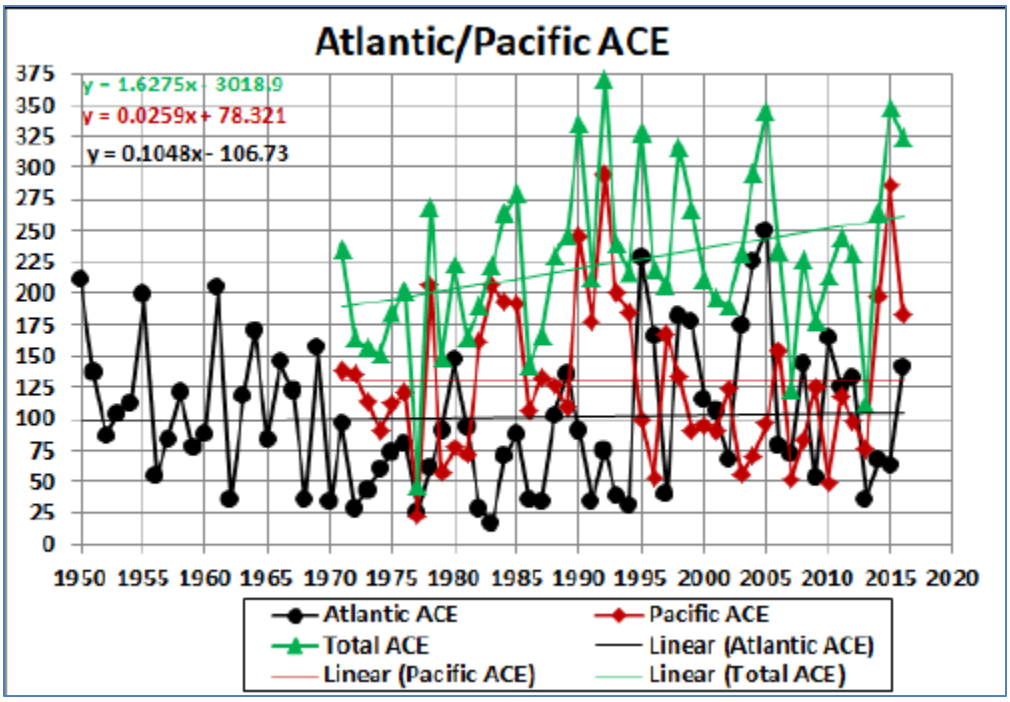
The web page https://en.wikipedia.org/wiki/Accumulated_cyclone_energy lists the yearly Accumulated Cyclone Energy (ACE) for Atlantic-Ocean hurricanes and Pacific-Ocean cyclones/typhoons. The sum for both oceans is:



From 1970 through 2016 there is a strong linear increase in hurricane/cyclone energy.

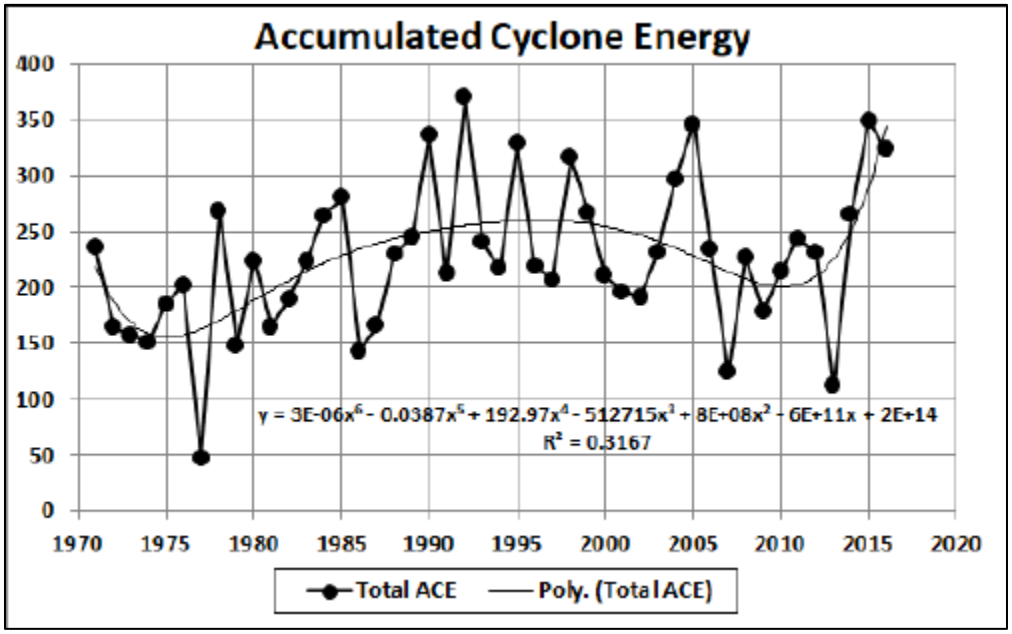
The terms “hurricane”, “cyclone” and “typhoon” are refer to the same extreme tropical storm. Often “cyclone” is use for all three terms.

It is interesting that, although both the Atlantic ACE (AACE) and the Pacific ACE (PACE) have a small linear increase, the sum of them has a much larger linear increase:



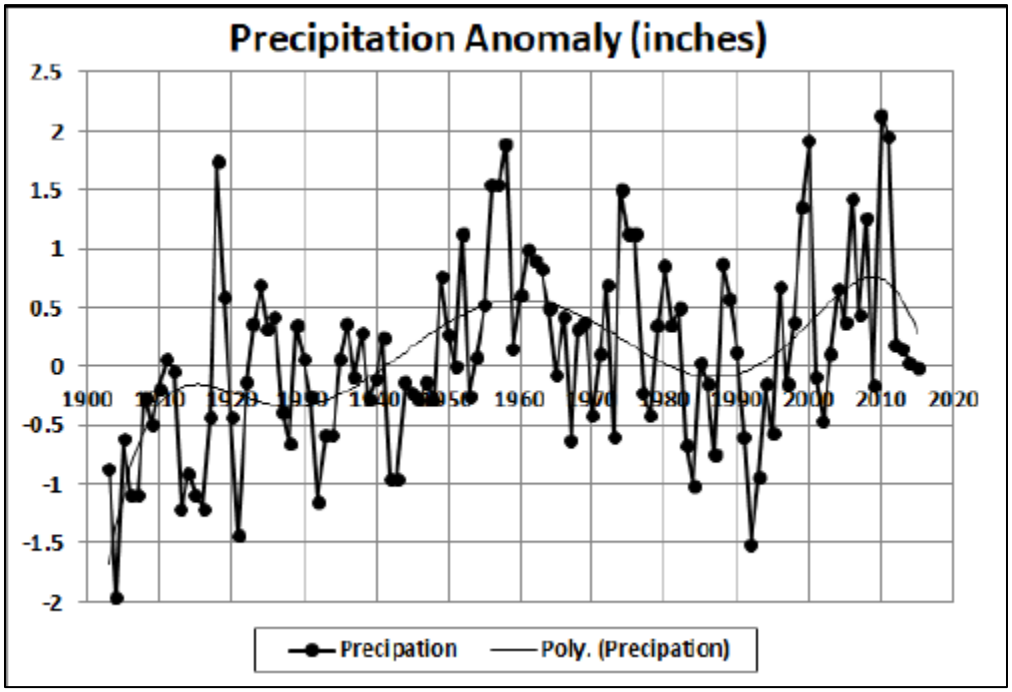
AACE slope = 0.1048, PACE slope = 0.0259 and ACE slope = 1.6275.

A better fit is a 6th-order polynomial:



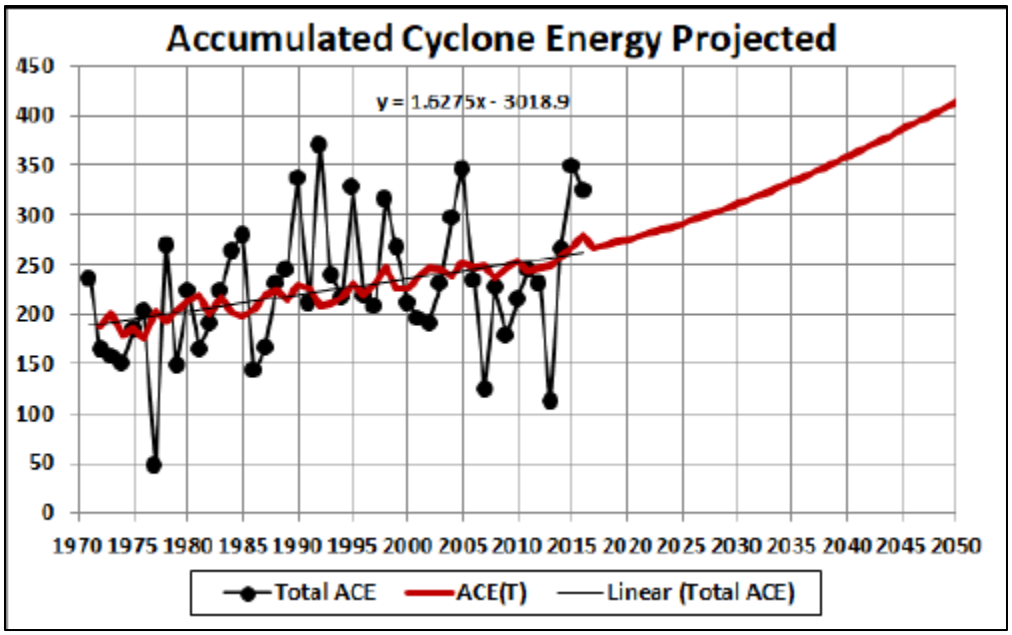
Although there is a linear increase in hurricane/cyclone increase from 1970 through 2016, there is an underlying complicated multi-decadal oscillatory and shorter-term variation. The oscillatory behavior may be currently strongly increasing.

It is interesting that the global hurricane/cyclone oscillation is approximately the inverse (~180° out of phase) with the global land-precipitation oscillation:



This phase difference is probably due to the fact that hurricanes/cyclones precipitate mostly over the oceans instead of on land.

Using extrapolated global temperatures to year 2050 and the equation $dH = H \ln(T_f/T_i)/\ln(2)$, where dH is the yearly Accumulated Cyclone Energy (ACE) since 1970, yields for H = 935.6:

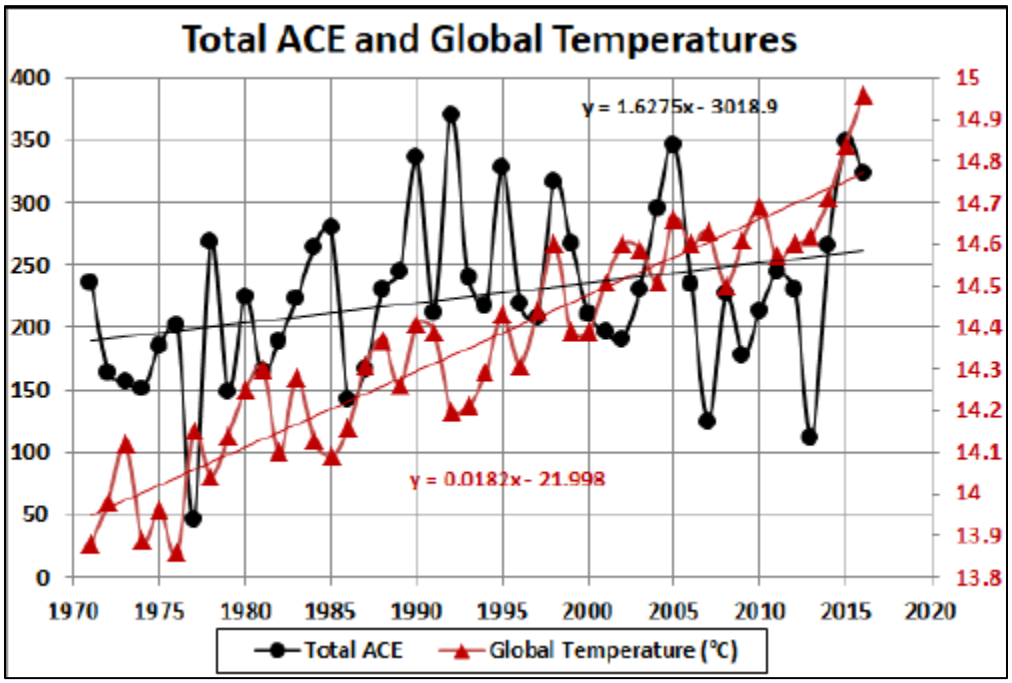


This projection is for average ACE in the future.

For a doubling of the global temperature the ACE will rise by 936. The ACE will increase ~50% by 2050.

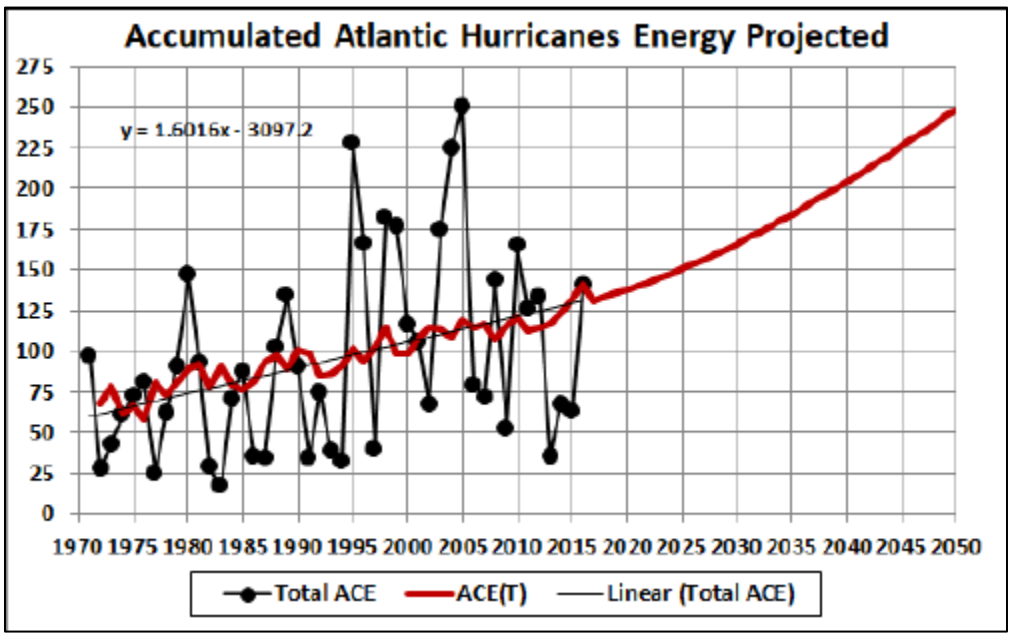
Although there is a good linear fit of global temperature to ACE, there are many ocean effects that cause complicated multi-decadal oscillatory and shorter-term variations. The oscillatory behavior appears to be currently strongly increasing similar to strongly increasing global temperatures.

This graph shows Total ACE and global temperatures:



Atlantic Hurricanes

An analysis similar to the one above for just Atlantic-Ocean Hurricanes yields:

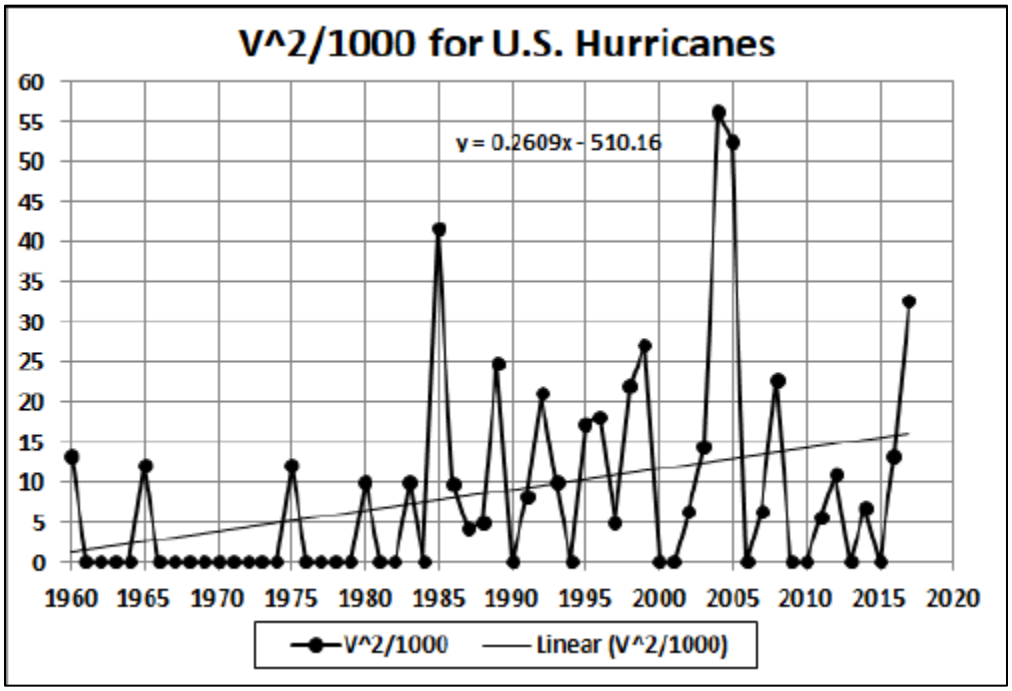


Hurricanes in the United States

The web page https://web.archive.org/web/20140210221648/http://www.aoml.noaa.gov/hrd/hurdat/All_U.S._Hurricanes.html lists the U.S. hurricanes and their maximum wind speed, V, in knots. The 2017 season is still underway, but it is included because it is a very active. For this analysis a measure of the hurricanes' seasonal "energy" is

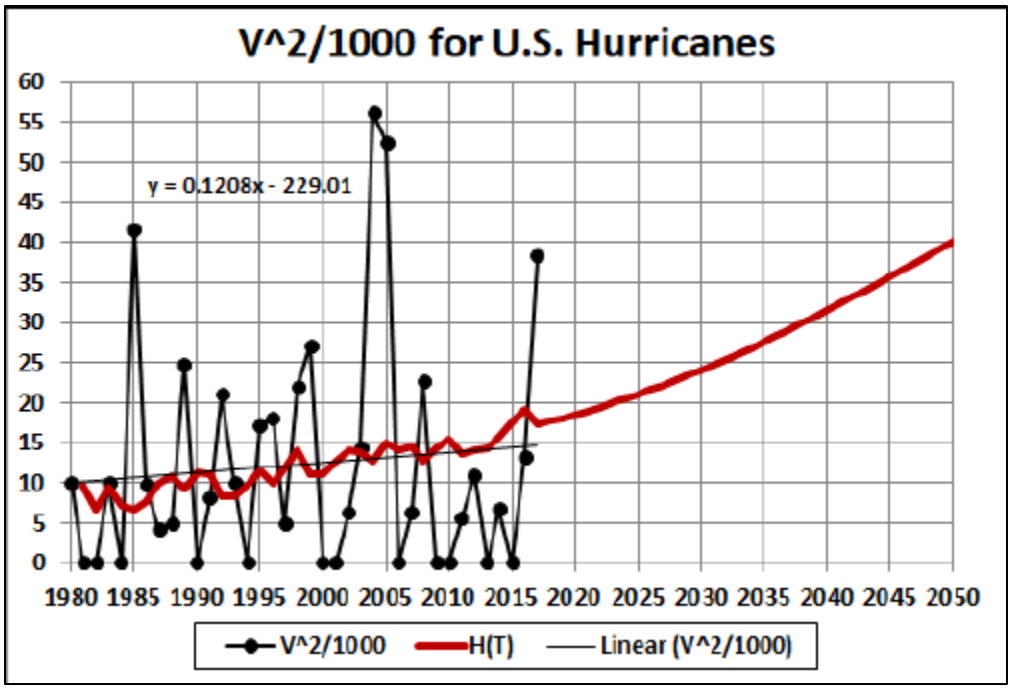
$$E = \Sigma V^2/1000 \text{ where } \Sigma V^2 = \text{sum over all hurricanes in a season}$$

The result is:



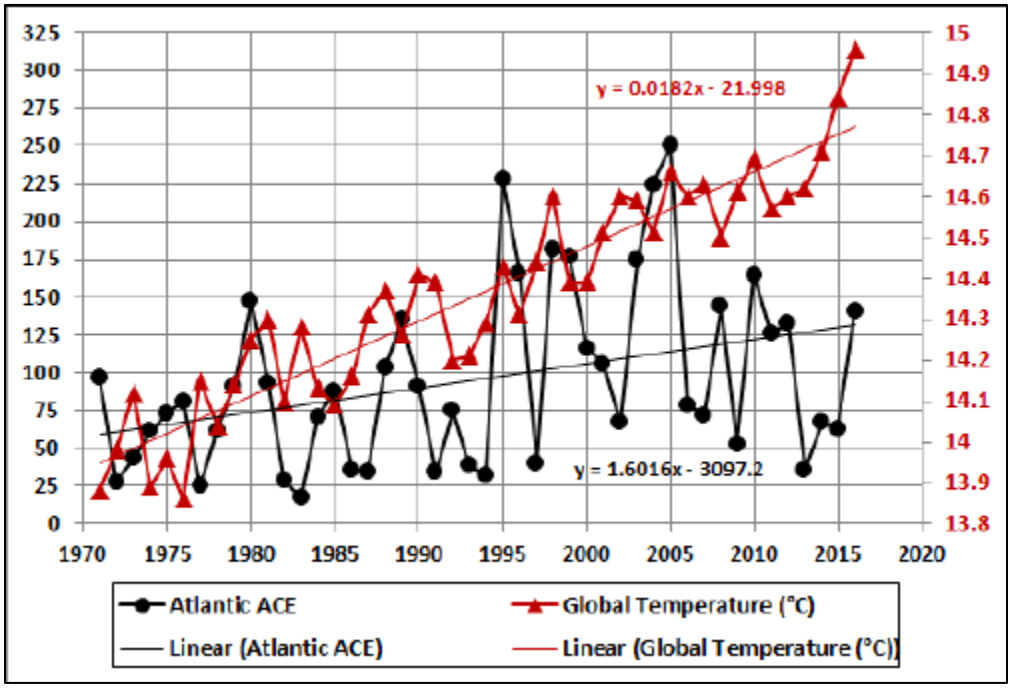
Only data from 1980 on are used because global temperature did not start its fast rise until then.

Using extrapolated global temperature to year 2050 and the equation $dH = H \ln(T_f/T_i)/\ln(2)$, where dH is the yearly Accumulated Cyclone Energy (ACE) since 1970, yields for H = 178.8:



For a doubling of the global temperature the U.S. hurricanes' "energy" will rise by 179. The "energy" will increase ~185% by 2050.

This graph shows Atlantic ACE and global temperatures:



Because of increasing ocean-surface temperatures the total energy of seasonal cyclones will increase as either more cyclones or greater energy per cyclone, most likely the latter because special conditions are required to form cyclones.

Ocean Niño Index (ONI) and Cyclones

The ONI is given in http://ggweather.com/enso/oni.htm. It is a measure of the deep-water upwelling in the Pacific Ocean. Negative ONI (La Niña) indicates upwelling and positive ONI (El Niño) indicates essentially no upwelling, which corresponds to warmer ocean surface and, thus, warmer atmosphere.

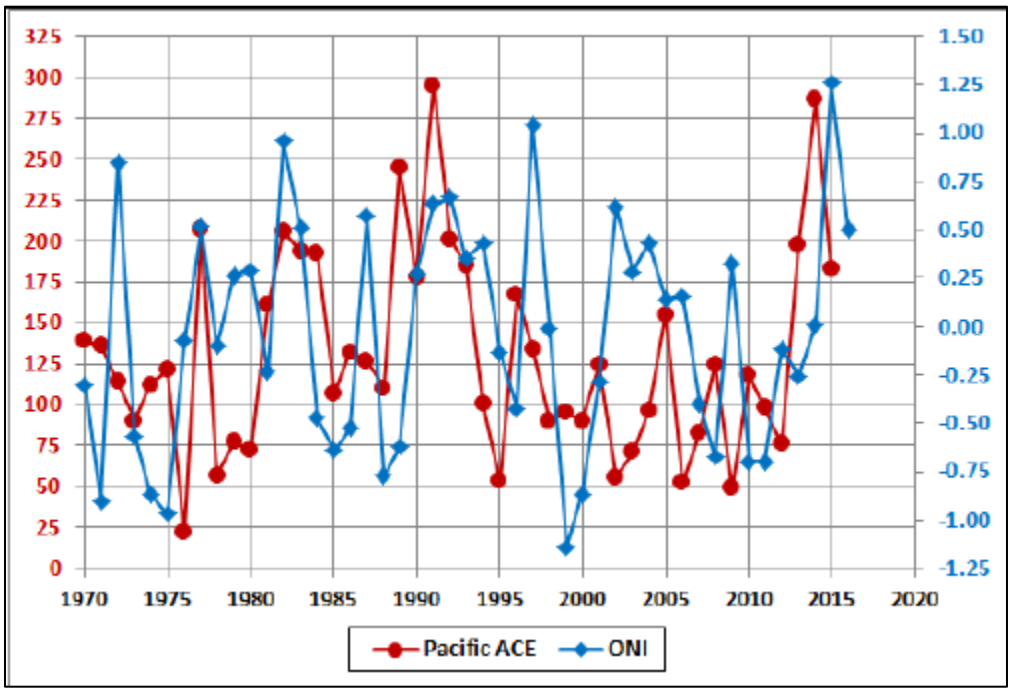
Since warmer surface water causes more energetic hurricanes, it is expected that ONI would correlate with Pacific cyclones' energy.

Here are correlation coefficients for ONI with the Pacific ACE (PACE), Atlantic ACE (AACE), total ACE, global temperature (T) and other cross correlations:

ONI/PACE	ONI/AACE	ONI/ACE	PACE/AACE	ONI/T	PACE/T	AACE/T	ACE/ONI	ACE/T
0.417	-0.224	0.125	-0.378	0.218	-0.007	0.375	0.125	0.322

Indeed, ONI has a positive correlation, 0.417, with the Pacific ACE and a slight negative correlation, -0.224, with the Atlantic ACE. The ONI correlation with the total ACE is barely positive. Note that PACE and AACE slightly anti-correlate.

Here is a graph of ONI and PACE:



Appendix

The projected global temperatures due to carbon-dioxide and methane emissions are: