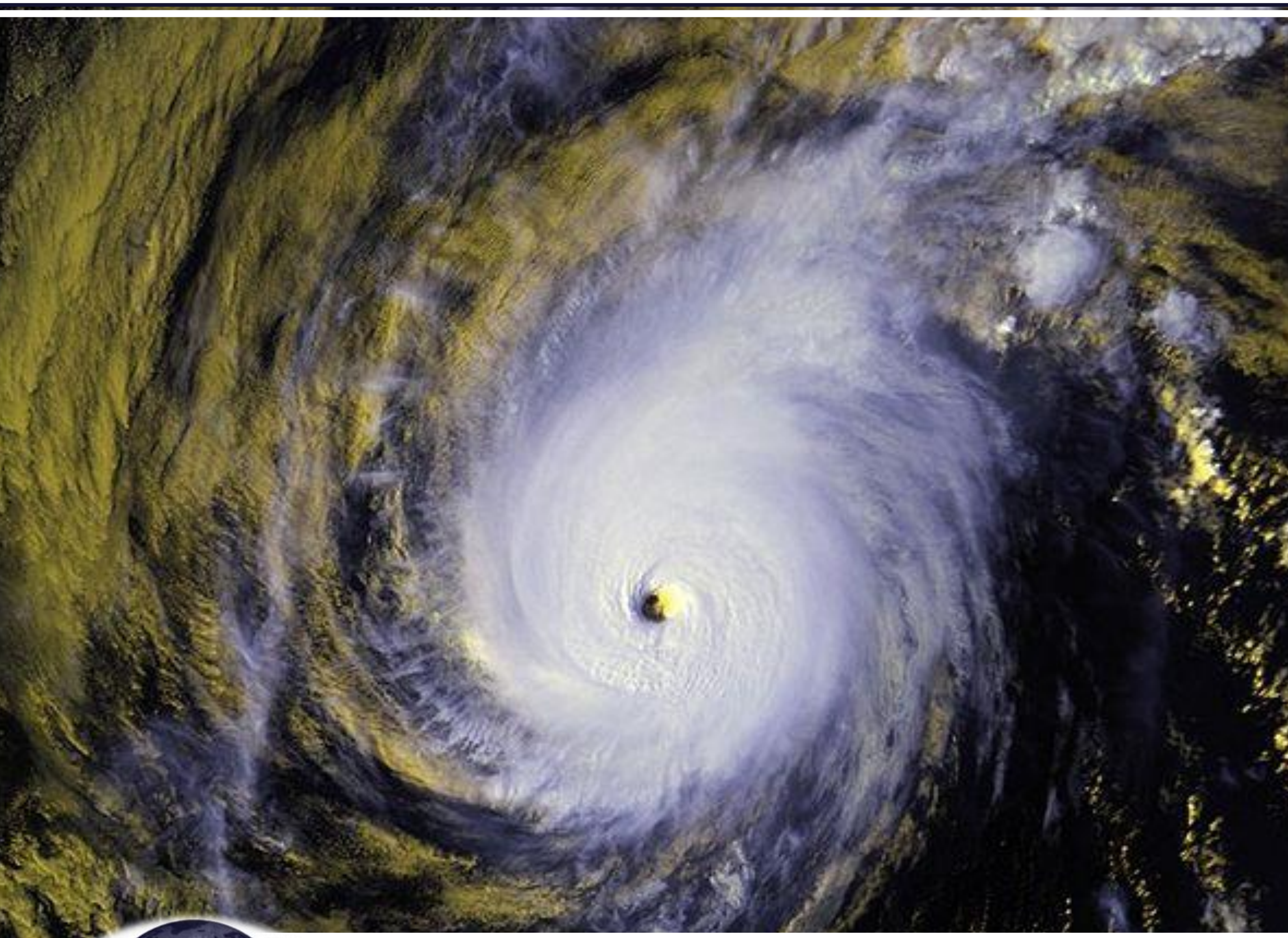
GLOBAL HURRICANE TRENDS



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GLOBAL HURRICANE TRENDS

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Climate models have long suggested that the intensity and frequency of hurricanes or *tropical cyclones* (TCs) may be significantly increased in response to global warming, as noted by Free *et al*. (2004), who have written that "increases in hurricane intensity are expected to result from increases in sea surface temperature and decreases in tropopause-level temperature accompanying greenhouse warming," citing in support of this statement the studies of Emanuel (1987), Henderson-Sellers *et al*. (1998) and Knutson *et al*. (1998). Before accepting this climate-*model*-based projection, however, it is important to see what the world of *nature* has to say about the issue.

In an early review of *empirical* evidence related to the subject, Walsh and Pittock (1998)[1] concluded that "the effect of global warming on the number of tropical cyclones is presently unknown," and that "there is little relationship between SST (sea surface temperature) and tropical cyclone numbers in several regions of the globe." Hence, they said there was "little evidence that changes in SSTs, by themselves, could cause change in tropical cyclone numbers."

In a second early analysis of the topic, Henderson-Sellers *et al*. (1998)[2] determined that (1) "there are no discernible global trends in tropical cyclone number, intensity, or location from historical data analyses," (2) "global and mesoscale-model-based predictions for tropical cyclones in greenhouse conditions have not yet demonstrated prediction skill," and (3) "the popular belief that the region of cyclogenesis will expand with the 26°C SST isotherm is a fallacy."

Six years later, in yet another futile attempt to find the long-sought global warming signal in hurricane data, Free *et al*. (2004)[3] looked for increases in *potential* hurricane intensity, because, as they put it, "changes in potential intensity (PI) can be estimated from thermodynamic principles as shown in Emanuel (1986, 1995) given a record of SSTs and profiles of atmospheric temperature and humidity." This they thus did, using radiosonde and SST data from 14 island radiosonde stations in the tropical Atlantic and Pacific Oceans, after which they compared their results with those of Bister and Emanuel (2002) at grid points near the selected stations. And what did they find?

As Free *et al*. describe it, "our results show no significant trend in potential intensity from 1980 to 1995 and no consistent trend from 1975 to 1995." What is more, they report that between 1975 and 1980, "while SSTs rose, PI decreased, illustrating the hazards of predicting changes in hurricane intensity from projected SST changes alone." In addition, in another review of what real-world data have to say about the subject, Walsh (2004)[4] acknowledged that "there is as yet

1 http://www.co2science.org/articles/V1/N2/C3.php.
2 http://www.co2science.org/articles/V3/N5/C2.php.
3 http://www.co2science.org/articles/V7/N31/C1.php.
4 http://www.co2science.org/articles/V7/N50/C2.php.

no convincing evidence in the observed record of changes in tropical cyclone behavior that can be ascribed to global warming." Nevertheless, Walsh continued to believe that (1) "there is likely to be some increase in maximum tropical cyclone intensities in a warmer world," (2) "it is probable that this would be accompanied by increases in mean tropical cyclone intensities," and (3) "these increases in intensities are likely to be accompanied by increases in peak precipitation rates of about 25%," putting the date of possible detection of these increases "sometime after 2050," little knowing that *two* such claims would actually be made the very next year.

The historic contentions came from Emanuel (2005), who claimed to have found that a hurricane power dissipation index had increased by approximately 50% for both the Atlantic basin and the Northwest Pacific basin since the mid-1970s, and from Webster *et al*. (2005), who contended that the number of Category 4 and 5 hurricanes for all tropical cyclone basins had nearly doubled between an earlier (1975-1989) and a more recent (1990-2004) 15-year period. *However*, in a challenge to *both* of these claims, Klotzbach (2006)[5] wrote that "many questions have been raised regarding the data quality in the earlier part of their analysis periods," and he thus proceeded to perform a new analysis based on a "near-homogeneous" *global* data set for the period 1986-2005.

The global Tropical Cyclone data (Klotzbach, 2006) did not support the argument that global TC frequency, intensity and longevity have undergone increases in recent years.

Klotzbach first tabulated global tropical cyclone (TC) activity using *best track data* - which he described as "the best estimates of the locations and intensities of TCs at six-hour intervals produced by the international warning centers" - for all TC basins (North Atlantic, Northeast Pacific, Northwest Pacific, North Indian, South Indian and South Pacific), after which he determined trends of worldwide TC frequency and intensity over the period 1986-2005, during which time global SSTs are purported to have risen by about 0.2-0.4°C. This work did indeed indicate, in his words, "a large increasing trend in tropical cyclone intensity and longevity for the North Atlantic basin," but it also indicated "a considerable decreasing trend for the Northeast Pacific," and combining these observations with the fact that "all other basins showed small trends," he concluded that there had been "no significant change in global net tropical cyclone activity" over the past two decades. With respect to Category 4 and 5 hurricanes, however, he found there had been a "small increase" in their numbers from the first half of the study period (1986-1995) to the last half (1996-2005); but he noted that "most of this increase is likely due to improved observational technology." Not mincing any words, therefore, Klotzbach declared that his findings were "contradictory to the conclusions drawn by Emanuel (2005) and Webster *et al*. (2005)," in that the global TC data did "not support the argument that global TC frequency, intensity and longevity have undergone increases in recent years."

[5] http://www.co2science.org/articles/V9/N23/C1.php.

About this same time, Landsea *et al*. (2006)[6] asked themselves an important question: "Are the global tropical cyclone databases sufficiently reliable to ascertain long-term trends in tropical cyclone intensity, particularly in the frequency of extreme tropical cyclones (categories 4 and 5 on the Saffir-Simpson Hurricane Scale)?" And in an attempt to answer this question, they proceeded to analyze the history of a number of operational changes at various tropical cyclone warning centers, which they felt might have led to "more frequent identification of extreme tropical cyclones," as well as an unreal "shift to stronger maximum sustained surface wind," investigating in particular the Dorvak Technique for estimating tropical cyclone intensity. And what did they find?

In the words of the four researchers, "trend analyses for extreme tropical cyclones are unreliable because of operational changes that have artificially resulted in more intense tropical cyclones being recorded [with the passing of time], casting severe doubts on any such trend linkages to global warming." In addition, they note that "data from the only two basins that have had regular aircraft reconnaissance - the Atlantic and Northwest Pacific - show that no significant trends exist in tropical cyclone activity when records back to at least 1960 are examined (Landsea, 2005; Chan, 2006)," while additionally citing the fact that "Klotzbach (2006) has shown that extreme tropical cyclones and overall tropical cyclone activity have globally been flat from 1986 until 2005, despite a sea surface temperature warming of 0.25°C."

Following close on the heels of Klotzbach's study came the paper of Kossin *et al*. (2007)[7], who wrote that "the variability of the available data combined with long time-scale changes in the availability and quality of observing systems, reporting policies, and the methods utilized to analyze the data make the best track records inhomogeneous," and who thus stated that this "known lack of homogeneity in both the data and techniques applied in the post-analyses has resulted in skepticism regarding the consistency of the best track intensity estimates." Consequently, as an important first step in resolving this problem, Kossin *et al*. "constructed a more homogeneous data record of hurricane intensity by first creating a new consistently analyzed global satellite data archive from 1983 to 2005 and then applying a new objective algorithm to the satellite data to form hurricane intensity estimates," after which they analyzed the resultant homogenized data for temporal trends over the period 1984-2004 for all major ocean basins and the global ocean as a whole.

In describing what they learned from this exercise, the five scientists who conducted the work said that "using a homogeneous record, we were not able to corroborate the presence of upward trends in hurricane intensity over the past two decades in any basin other than the Atlantic." Therefore, noting that "the Atlantic basin accounts for less than 15% of global hurricane activity," they concluded that "this result poses a challenge to hypotheses that directly relate globally increasing tropical sea surface temperatures to increases in long-term mean global hurricane intensity," delivering another major blow to the contentions of Emanuel (2005) and Webster *et al*. (2005), while stating that "the question of whether hurricane intensity is globally trending upwards in a warming climate will likely remain a point of debate in the foreseeable future."

6 http://www.co2science.org/articles/V9/N43/C2.php.

7 http://www.co2science.org/articles/V10/N21/C1.php.

And so it *did* remain a point of debate. Vecchi and Soden (2007)[8], for example, used both climate models and real-world observations "to explore the relationship between changes in sea surface temperature and tropical cyclone 'potential intensity' - a measure that provides an upper bound on cyclone intensity and can also reflect the likelihood of cyclone development." And in doing so, they concluded that "changes in local sea surface temperature are inadequate for characterizing even the sign of changes in potential intensity."

Also, reporting on the *International Summit on Hurricanes and Climate Change* that was held in May of 2007 on the Greek island of Crete, where 77 academics and stakeholders from 18 countries participated in a free-ranging discussion of hurricanes and climate change, Elsner (2008)[9] wrote that "the question of whether we can ascribe a change in tropical cyclone intensity to anthropogenic climate change is still open." And on the question of a warming-induced increase in hurricane *frequency*, the science was even *more* unsettled. Although "most models," in his words, indicate "an overall decrease in the number of storms," he noted that not even all *models* agree on the change in individual basin tropical cyclone numbers, "with some models showing an increase in the Atlantic and others a decrease."

Further confusion was raised by the study of Nolan and Rappin (2008)[10], who extended the methodology of Nolan *et al*. (2007) to include a prescribed wind as a function of height that remains approximately constant during the genesis of tropical cyclones in environments of radiative-convective equilibrium that are partially defined by sea surface temperature (SST), which they then employed to explore what happens when SSTs rise. This approach revealed that "increasing sea surface temperature does not allow TC genesis to overcome greater shear." In fact, they say that "the opposite trend is found," and that "the new and surprising result of this study is that the effect of shear in suppressing TC genesis actually increases as the SST of the radiative-convective equilibrium environment is increased."

This new *model*-based result was eerily analogous to the *observation*-based result of Vecchi and Knutson (2008), who found that as the SST of the main development region of North Atlantic TCs had increased over the past 125 years, certain aspects of climate changed in ways that may have made the North Atlantic, in their words, "more favorable to cyclogenesis, while at the same time making the overall environment less favorable to TC maintenance." Hence, it is *doubly* interesting that Nolan and Rappin conclude their paper with the intriguing *question*: "Do these results explain recent general circulation modeling studies predicting fewer tropical cyclones in a global warming world (e.g., Bengtsson *et al*. 2007)?"

Changing gears just a bit, Fan and Liu (2008)[11] presented a brief review and synthesis of the major research advances and findings of *paleotempestology*, which they described as "a young science" that "studies past typhoon activity spanning several centuries to millennia before the instrumental era through the use of geological proxies and historical documentary records." And in doing so, they determined that "there does not exist a simple linear relationship between typhoon frequency and Holocene climate (temperature) change," especially of the

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8 http://www.co2science.org/articles/V11/N7/C1.php.

9 http://www.co2science.org/articles/V11/N32/EDIT.php.

10 http://www.co2science.org/articles/V11/N44/C1.php.

11 http://www.co2science.org/articles/V12/N2/C3.php.

type suggested by the world's climate alarmists. They report, for example, that "on the contrary, typhoon frequency seemed to have increased at least regionally during the coldest phases of the Little Ice Age." And they also note that "more typhoons and hurricanes make landfalls in China, Central and North America during [cooler] La Niña years than [warmer] El Niño years." Consequently, and following their own advice about the need "to extend the time span of typhoon activity records" to help resolve the debate over the nature of climate change effects on this important weather phenomenon, Fan and Liu were able to demonstrate that the world's climate alarmists likely have even the *sign* of the temperature effect on typhoon activity wrong, as global warming seems to *reduce* tropical cyclone activity over both the long-term *and* the short-term.

> **Fan and Liu were able to demonstrate that the world's climate alarmists likely have even the *sign* of the temperature effect on typhoon activity wrong, as global warming seems to *reduce* tropical cyclone activity over both the long-term *and* the short-term.**

Moving ahead one year, Chan (2009)[12] studied five ocean basins - the Atlantic (1960-2007), the Western North Pacific (1960-2007), the Eastern North Pacific (1960-2007), the South Indian Ocean (1981-2007), and the South Pacific (1981-2007) - examining the relationship between the seasonally-averaged *maximum potential intensity* (MPI, an index of thermodynamic forcing) over each basin and the frequency of occurrence of intense TCs within that basin. This work revealed, in Chan's words, that "only in the Atlantic does the MPI have a statistically significant relationship with the number of intense TCs, explaining about 40% of the [observed] variance," while "in other ocean basins, there is either no correlation or the correlation is not significant." The People's Republic of China's researcher also indicates that even in the Atlantic, where a significant correlation exists between thermodynamic or temperature related factors and the frequency of intense TCs, it is not clear whether global warming will produce a net increase in TC frequency, because model projections also suggest that the increase in vertical wind shear associated with an increase in sea surface temperature tends to work *against* intense TC development. And, therefore, Chan concluded that "it remains uncertain whether the frequency of occurrence of intense TCs will increase under a global warming scenario."

Simultaneously, Wang and Lee (2009)[13] wrote that in the Western Hemisphere, tropical cyclones "can form and develop in both the tropical North Atlantic (NA) and eastern North Pacific (ENP) Oceans, which are separated by the narrow landmass of Central America," and that "in comparison with TCs in the NA, TCs in the ENP have received less attention, although

12 http://www.co2science.org/articles/V12/N51/C1.php.
13 http://www.co2science.org/articles/V13/N44/C2.php.

TC activity is generally greater in the ENP than in the NA (e.g., Maloney and Hartmann, 2000; Romero-Vadillo *et al*., 2007)." Therefore, in exploring how the TC activities of the NA and ENP ocean basins might be related to each other over the period 1949-2007, as well as over the shorter period of 1979-2007, they employed a number of different datasets to calculate the index of *accumulated cyclone energy* (ACE), which accounts for the number, strength and duration of all TCs in a given season. And when this was done, they discovered that "TC activity in the NA varies out-of-phase with that in the ENP on both *interannual* and *multidecadal* timescales," so that "when TC activity in the NA increases (decreases), TC activity in the ENP decreases (increases)." In addition, they found that "the out-of-phase relationship seems to [have] become stronger in the recent decades," as evidenced by the fact that the interannual and multidecadal correlations between the NA and ENP ACE indices were -0.70 and -0.43, respectively, for the period 1949-2007, but -0.79 and -0.59, respectively, for the period 1979-2007. As a result, and in terms of the *combined* TC activity over the NA and ENP ocean basins *as a whole*, there is little variability on either interannual or multidecadal timescales; and the real-world empirical data thus suggest that the variability that *does* exist over the *conglomerate of the two basins* has grown slightly *weaker* as the earth has *warmed* over the past six decades, which runs counter to climate-alarmist claims that earth's hurricanes or tropical cyclones should become more numerous, stronger and longer-lasting as temperatures rise.

Noting that the impact of rising sea surface temperatures (SSTs) on tropical cyclone activity is one of the great societal and scientific concerns of our day, Wang *et al*. (2010)[14] examined cross-basin spatial-temporal variations of TC storm days for the Western North Pacific (WNP), the Eastern North Pacific (ENP), the North Atlantic (NAT), the North Indian Ocean (NIO), and the Southern Hemisphere Ocean (SHO) over the period 1965-2008, for which time interval pertinent satellite data were obtained from the U.S. Navy's Joint Typhoon Warning Center for the WNP, NIO and SHO, and from NASA's U.S. National Hurricane Center for the NAT and ENP. And after analyzing these data, they report that "over the period of 1965-2008, the global TC activity, as measured by storm days, shows a large amplitude fluctuation regulated by the El Niño-Southern Oscillation and the Pacific Decadal Oscillation, but has no trend, suggesting that the rising temperature so far has not yet [had] an impact on the global total number of storm days," which further implies that "the spatial variation of SST, rather than the global mean temperature, may be more relevant to understanding the change of the global storm days."

Moving one year closer to the present, Maue (2011)[15] obtained *global* TC life cycle data from the IBTrACS database of Knapp *et al*. (2010), which contains six-hourly best-track positions and intensity estimates for the period 1970-2010, from which he calculated the *accumulated cyclone energy* (ACE) metric (Bell *et al*., 2000), which is analogous to the *power dissipation index* (PDI) used by Emanuel (2005) in his attempt to convince the world of the truth of the climate-alarmist claim. This work revealed, in his words, that "in the pentad since 2006, Northern Hemisphere and global tropical cyclone ACE has decreased dramatically to the lowest levels since the late 1970s," and he also finds that "the global frequency of tropical cyclones has reached a historical low." Some details of note also include the fact that "a total of 69 TCs were counted during calendar year 2010, the fewest observed in the past 40 years with reliable

[14] http://www.co2science.org/articles/V13/N25/C1.php.
[15] http://www.co2science.org/articles/V14/N37/C1.php.

frequency data," as well as the fact that over that same four-decade period, "12-month running-sums of the number of global TCs of at least tropical storm force has averaged 87," while "the minimum number of 64 TCs was recently tallied through May 2011." Therefore, and in view of the fact that "there is no significant linear trend in the frequency of global TCs," in agreement with the analysis of Wang *et al*. (2010), plus the fact that the earth is experiencing "this current period of record inactivity," as Maue describes the situation in the final six words of his paper, it would appear that the long-held climate-alarmist contention that global warming increases the frequency and intensity of tropical storms is simply not true.

Contemporaneously, and stating that "Quaternary data have not figured prominently in recent debates concerning TC natural variability versus potential anthropogenic global warming-induced changes, nor have the Quaternary data been used to any substantial degree in numerical model projections concerning the future behavior of TCs," Nott (2011)[16] provided a brief review of the subject, noting that there are "at least 15 different methods for reconstructing long-term records of TCs."

Exploring this body of work, the Australian researcher reports that "recent analyses of corrected historical TC records suggest that there are no definitive trends towards an increase in the frequency of high-intensity TCs for the Atlantic Ocean region (Knutson *et al*., 2010), the northwest Pacific (Chan, 2006; Kossin *et al*., 2007) and the Australian region, South Pacific and south Indian oceans (Kuleshov *et al*., 2010)." He does note, however, that "over multi-century to millennial timescales, substantial change has occurred in virtually all TC-generating regions of the globe," with "alternating periods of lesser and greater activity," writing that "the longer, coarser-resolution records display periods from multi-century to over a millennium in length, whereas the higher-resolution records register multi-decadal to centennial-length periodicities."

In some of these cases, Nott says that (1) "different climate states, such as periods dominated by El Niños and La Niñas, appear to be responsible for the TC variability," while in other cases, he says the responsible factor seems to be (2) shifts in the position of the jet stream, (3) solar variability, or (4) some unknown cause. And, therefore, Nott states "there is still considerably more data needed before causes of the long-term variability of TCs can be comprehensively identified," and he says that "a better understanding of this long-term variability will be critical to understanding the likely future behavior of TCs globally and especially so when attempting to detect and attribute those future changes." Thus, one ought not get too excited about climate-alarmist claims that global warming leads to increases in either the frequency or intensity of tropical cyclones and hurricanes, as there is as yet no comprehensive set of real-world data that point in that direction.

In a related study designed to explore "the question of whether and to what extent global warming may be changing tropical cyclone activity," Grossmann and Morgan (2011)[17] reviewed the scientific literature related to the possible effects of climate-model projected consequences of continued atmospheric greenhouse gas enrichment on TC frequency and intensity; and in

[16] http://www.co2science.org/articles/V14/N41/C1.php.
[17] http://www.co2science.org/articles/V14/N51/C2.php.

doing so, they found that "while Atlantic TCs have recently become more intense, evidence for changes in other basins is not persuasive, and changes in the Atlantic cannot be clearly attributed to either natural variability or climate change." More specifically, they say that "the presence of a possible climate change signal in TC activity is difficult to detect because inter-annual variability necessitates analysis over longer time periods than available data allow," and because "projections of future TC activity are hindered by computational limitations and uncertainties about changes in regional climate, large-scale patterns, and TC response."

Therefore, while concluding that "scientific uncertainty about whether and how climate change will affect TCs in the future may not be resolved for decades," Grossmann and Morgan go on to suggest that even if climate change "does not result in any significant increase in the intensity or frequency of future tropical cyclones" nor "lead to significant sea-level rise," human vulnerability in areas prone to land-falling hurricanes "will likely continue to increase significantly due to the continuing growth of populations and capital stock in high risk areas," citing Pielke *et al*. (2008). Thus, they say it would be wise "to induce greater protective action," stating that "there is a need to act now to reducing the existing high vulnerability to these storms," which will continue to constitute a real and present danger to people and infrastructure in coastal areas whether or not the frequency and degree of that danger increases or decreases, as it takes only *one* severe TC to lay waste to the works of man and snuff out the lives of many.

There is a need to act now to reduce the existing high vulnerability to these storms, which will continue to constitute a real and present danger to people and infrastructure in coastal areas whether or not the frequency and degree of that danger increases or decreases.

Although many and diverse are the studies that have explored both real and imagined impacts of changes in sea surface temperature (SST) on various properties of tropical cyclones (TCs), much less discussed is the *reverse* phenomenon of the impacts of TCs on SSTs. It has been known for *decades*, however - as reported by Dare and McBride (2011)[18] - that strong winds associated with TCs tend to reduce SSTs beneath such storms, as described (in chronological order) by Fisher (1958), Leipper (1967), Brand (1971), Price (1981), Bender *et al*. (1993), Hart *et al*. (2007), Price *et al*. (2008), Jansen *et al*. (2010) and Hart (2011). This *cold surface wake*, as they describe it, "may extend for hundreds of kilometers adjacent to the storm track (Nelson, 1996; Emanuel, 2001)," and it can spread to larger scales over time, as reported by Sobel and Camargo (2005). As for the magnitude of the SST reduction within the TC wake, Dare and McBride write that it can "range from less than 1°C (Cione *et al*., 2000), up to 3° (Shay

[18] http://www.co2science.org/articles/V15/N13/C3.php.

et al., 1991), 4° (Price *et al*., 2008), 5° (Price, 1981), 6° (Berg, 2002), 7° (Walker *et al*., 2005), and 9°C (Lin *et al*., 2003)."

Spurred on by these facts, and using the International Best Track Archive for Climate Stewardship (IBTrACS; Knapp *et al*., 2009) to provide the latitudes and longitudes at six-hour intervals for all TCs that occurred throughout the world over the period 1 September 1981-31 December 2008, together with a corresponding set of SST data that was provided by NOAA's National Climatic Data Center at every 0.25° of latitude and longitude (Reynolds *et al*., 2007), the two Australian researchers calculated the mean magnitude of the SST reductions and the average amount of time required for the reduced SSTs to return to pre-storm values. This effort revealed, first of all, that the time of maximum SST cooling occurred one day after cyclone passage, when the SST depression averaged 0.9°C. Thereafter, they report that 44% of the SST depressions returned to normal within 5 days, while 88% of them recovered within 30 days. And although there were differences among individual cyclone basins, they say the individual basin results were in broad agreement with the global mean results. Last of all, they indicate that "cyclones occurring in the first half of the cyclone season disrupt the seasonal warming trend, which is not resumed until 20-30 days after cyclone passage," while they note that "cyclone occurrences in the latter half of the season bring about a 0.5°C temperature drop from which the ocean does not recover due to the seasonal cooling cycle." And in light of these findings, it can be appreciated that each TC that occurs somewhere in the world leaves behind it a significantly altered SST environment that would be expected to have somewhat of a tempering effect on other TCs that might pass through the same location up to as many as 20 to 30 days later.

Studying the same phenomenon, Manucharyan *et al*. (2011)[19] analyzed the effects of *TCs on TCs* using several representative cases of time-dependent mixing that yielded the same annual mean values of vertical diffusivity, conforming with the studies of Jansen and Ferrari (2009) and Fedorov *et al*. (2010), wherein spatially uniform (but varying in time) mixing is imposed on zonal bands in the upper ocean. This work revealed "a weak surface cooling at the location of the mixing (~0.3°C), a strong warming of the equatorial cold tongue (~2°C), and a moderate warming in middle to high latitudes (0.5°C-1°C)," together with "a deepening of the tropical thermocline with subsurface temperature anomalies extending to 500 m [depth]." And they say that "additional mixing leads to an enhanced oceanic heat transport from the regions of increased mixing toward high latitudes and the equatorial region." But "ultimately," as they continue, "simulations with TC-resolving climate models will be necessary to fully understand the role of tropical cyclones in climate," for they note, in this regard, that "the current generation of GCMs [is] only slowly approaching this limit and [is] still unable to reproduce many characteristics of the observed hurricanes, especially of the strongest storms critical for the ocean mixing (e.g., Gualdi *et al*., 2008; Scoccimarro *et al*., 2011)."

Closing out this summary of what has been learned about the causes and consequences of tropical cyclones or hurricanes, Nott and Forsyth (2012)[20] write that "understanding the long-term natural variability of tropical cyclones (TCs) is important for forecasting their future

[19] http://www.co2science.org/articles/V15/N14/C1.php.
[20] http://www.co2science.org/articles/V16/N2/C1.php.

behavior and for the detection and attribution of changes in their activity as a consequence of anthropogenically induced climate change." And they state, in this regard, that "critical to these endeavors is determining whether, over the long-term, TCs occur randomly or display identifiable patterns influenced by one or several factors."

In an effort designed to shed some light on this important subject, the two researchers present what they describe as "new sedimentary data from the southwest (SW) Pacific and southeast (SE) Indian Ocean regions which allow us to make comparisons with existing sediment records from the Atlantic Ocean (Donnelly and Woodruff, 2007; Mann *et al*., 2009), northwest (NW) Pacific (Woodruff *et al*., 2009), Gulf of Mexico (Liu and Fearn, 1993, 2000; Lane *et al*., 2011) and the Gulf of Carpentaria, Australia (Rhodes *et al*., 1980)." And in doing so, they find that "long-term global TC activity is not random." Rather, as they demonstrate, there is "a substantial degree of synchroneity in global intense TC behavior over the past 3,000 to 5,000 years." And they indicate in this regard that "one of the most striking aspects of these records is they all display extended alternating periods (centuries to millennia) of relative quiescence and heightened intense TC activity irrespective of both the resolution and type of long-term TC record."

Truly, something yet unknown has orchestrated the ebbing and flowing of *global* TC activity over the last 5,000 years. What we *do* know, however, is that it has *not* been changes in the atmosphere's CO_2 concentration, which has remained quite stable over this entire period ... except for the past 100 years, when it has risen substantially, but without any demonstrable change in global TC activity. Hence, there is no compelling reason to believe that any further increase in the air's CO_2 content will have any significant impact on these destructive storms.

***Truly*, something yet unknown has orchestrated the ebbing and flowing of *global* TC activity over the last 5,000 years. What we *do* know, however, is that it has *not* been changes in the atmosphere's CO_2 concentration.**

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