Observed Climate Change and the Negligible Global Effect of Greenhouse-gas Emission Limits in the State of North Carolina

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Observed climate change in North Carolina

THERE IS no observational evidence of unusual long-term climate changes in North Carolina. No emissions reductions by North Carolina will have any detectable regional or global effect whatsoever on climate change.

Annual Temperature: Averaged across the state of North Carolina, there has been no long-term trend in the state's annual temperature history since 1895, the year when well-compiled temperature records first become available from the National Climatic Data Center (located in Asheville). Figure 1 shows that the coolest period of the past 113 years in North Carolina occurred during the 1960s. Since then, average temperatures across the state have returned to the levels that were common during the four decades prior to the 1960s. Temperatures during the past decade are by no means unusual when properly set against the long-term temperature history of the state.

North Carolina annual temperatures, 1895-2007

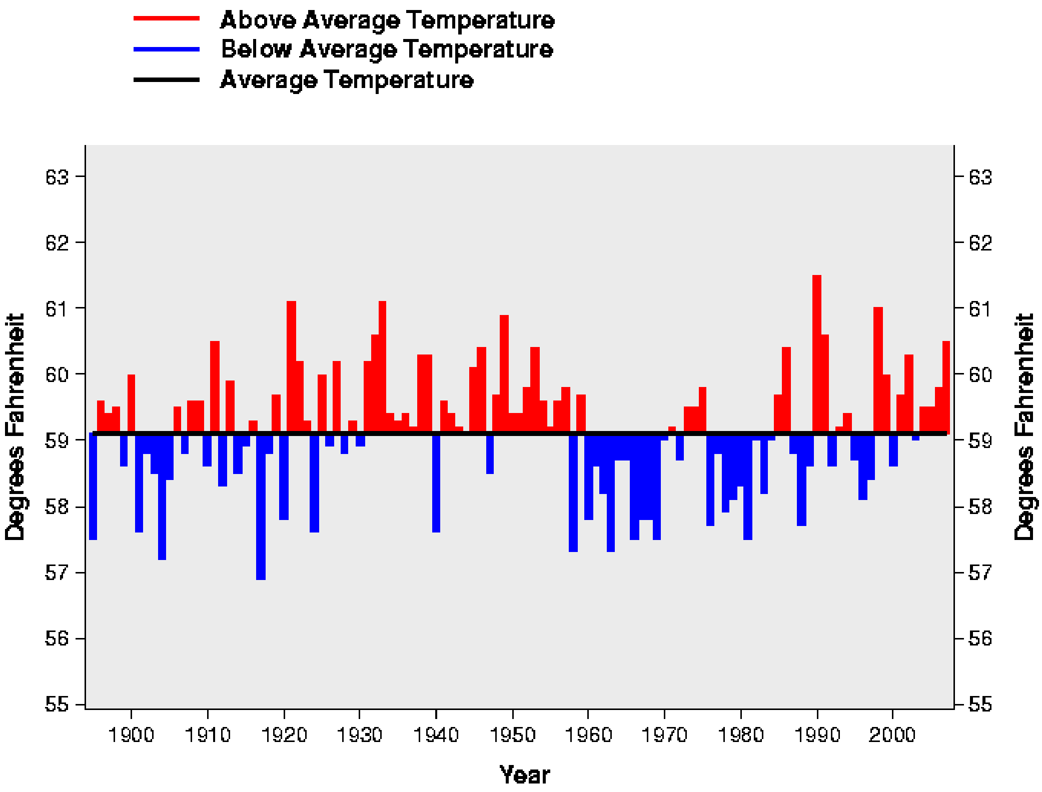

Figure 1. North Carolina's long-term statewide annual average temperature history, 1895-2007.
Source: US National Climate Data Center
(http://www.ncdc.noaa.gov/oa/climate/research/cag3/nc.html)

Seasonal Temperatures: Likewise, if you examine North Carolina's statewide temperature history within the four seasons, you again find no evidence of any unusual climate changes occurring throughout any portion of the year. Recent temperatures are unremarkable in every way and no long-term warming trends are present. There have been periods in the past during every season that have been warmer than any conditions currently experienced.

North Carolina's seasonal temperatures, 1895-2007

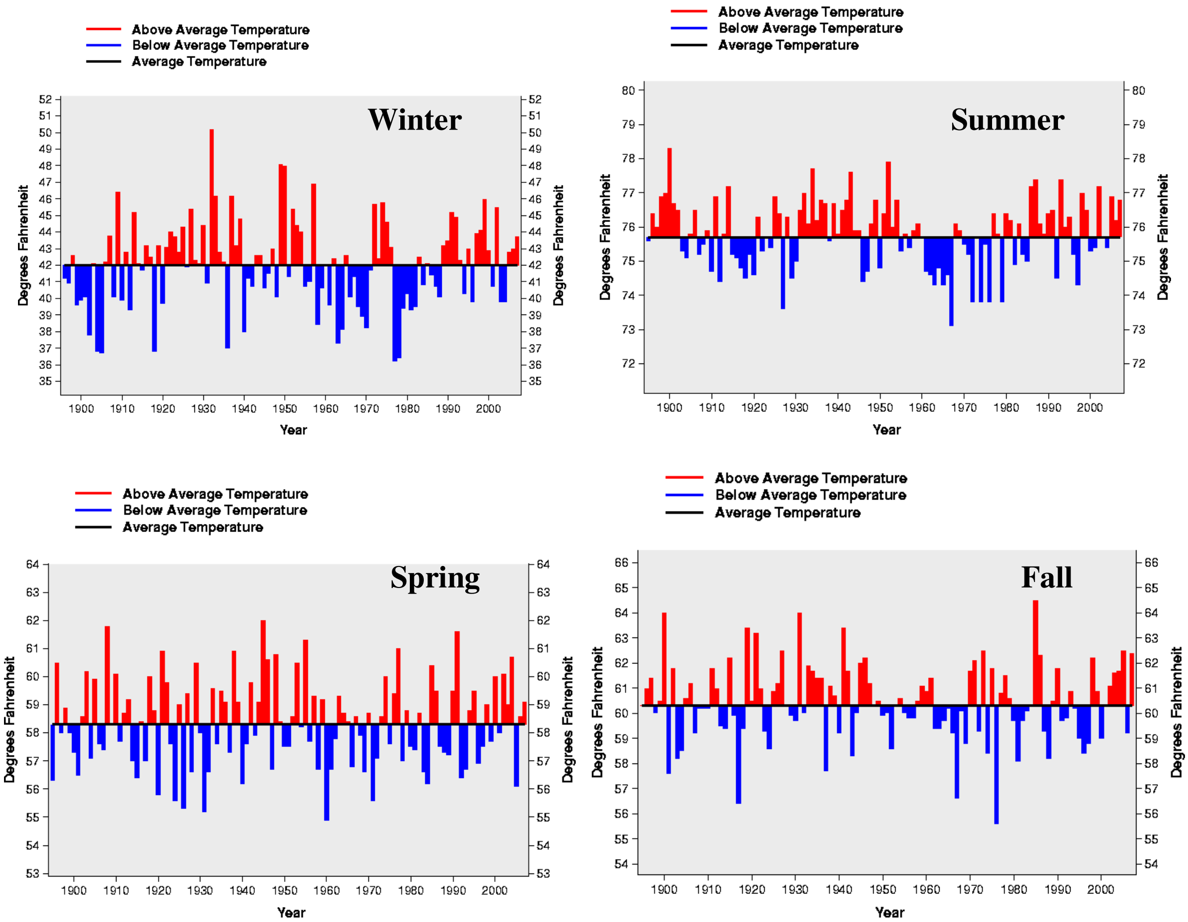

Figure 2. North Carolina's long-term statewide average temperature history, 1895-2007, by season. Source: US National Climate Data Center (http://www.ncdc.noaa.gov/oa/climate/research/cag3/nc.html).

Precipitation: Averaged across the state of North Carolina for each of the past 113 years, statewide annual total precipitation exhibits no long-term trend, averaging just less than 50 inches per year. North Carolina's annual precipitation is quite variable from year to year, and has varied from as much as 64.67 inches falling in 2003 to a little as 36.38

inches in 2007. North Carolina experienced its driest year on record in 2007; however, it came after a succession of 4 years with precipitation above normal, including 2003, which was the wettest year on record. Neither the dry year in 2007, nor the wet year in 2003, is part of a long-term tendency for either wet or dry conditions to predominate. Instead, they represent just part of the large year-to-year variability that is characteristic of the climate of North Carolina. Similar swings from very wet to very dry years occurred on several occasions in the 20th century, including the late 1920s and the late 1980s and do not represent abnormal behavior.

North Carolina annual precipitation history, 1885-2007

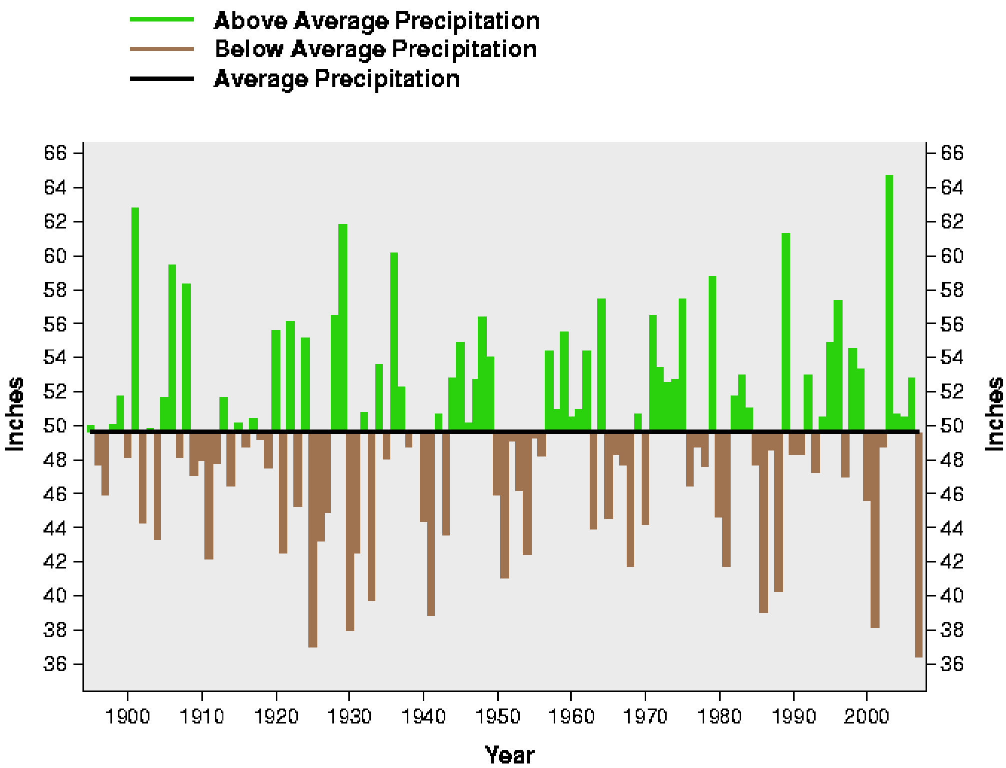

Figure 3. North Carolina's long-term statewide annual precipitation history. Source: US National Climate Data Center (http://www.ncdc.noaa.gov/oa/climate/research/cag3/nc.html)

Drought: As is evident from North Carolina's long-term observed precipitation history, there are oftentimes strings of dry years, as in the mid-1920s. Several dry years in a row can lead to widespread drought conditions. However, as is also evident from North Carolina's precipitation history, there is no long-term trend in the total precipitation across the state. Consequently, neither has there been any long-term trend in drought

conditions, as indicated by the history of the Palmer Drought Severity Index (PDSI).[1] Instead of a long-term trend, the PDSI is dominated by shorter term variations which largely reflect the state's precipitation variability. Droughts in the mid-1920s, mid-1950s and early 2000s mark the most significant events of the past 113 years.

North Carolina drought severity, 1885-2007

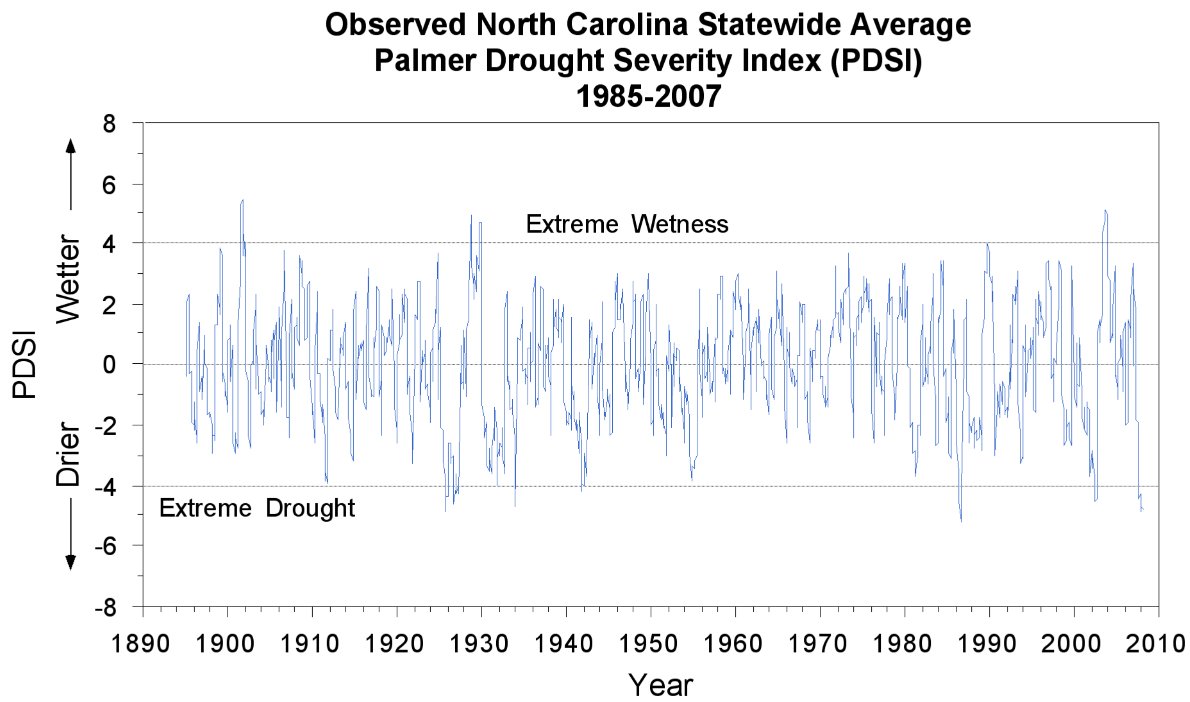

Figure 4. North Carolina's long-term statewide monthly Palmer Drought Severity Index values as compiled and maintained by the National Climate Data Center (http://cdo.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp)

A recent study conducted by researchers at the North Carolina State Climatology Office concluded that North Carolina's precipitation patterns are impacted by the cycles of El Niño and La Niña that take place in the central Pacific Ocean. El Nino conditions are associated with drier than normal summer and wetter than normal winter, while La Niña conditions are associated with the opposite pattern. Some of the dryness in late 2007 and early 2008 are thus likely caused by the development of the relatively strong La Niña conditions during the fall of 2007 and winter of 2007-08.

That conditions as far away as those in the southern Pacific Ocean can impact the precipitation and drought conditions of North Carolina is a testament to the complexities

[1] A standard measure of moisture conditions that takes into account both inputs from precipitation and losses from evaporation.

of the state's climate and its influences. These complexities serve to make drought events a normal part of North Carolina's climate and that of the Southeastern United States.

This fact can be further evidenced by examining an even longer-term record of moisture conditions in North Carolina. Using information contained in tree rings, Dr. Edward Cook and colleagues were able to reconstruct a summertime PDSI record for North Carolina that extends back in time more than 1500 years. That paleoclimate record of moisture indicates that alternating multi-decadal periods of wet and dry conditions have occurred with regularity during the past 1500 years. Additionally, the long-term record indicates droughts prior to the 20th century with much longer duration and greater severity than anything experienced in recent years. Droughts in the mid-1700s, early 1200s and around 700 AD dwarf any recent conditions. This is clear indication that droughts are a normal part of the region's climate system and thus cannot be used as an example of events that are caused by any type of human activity.

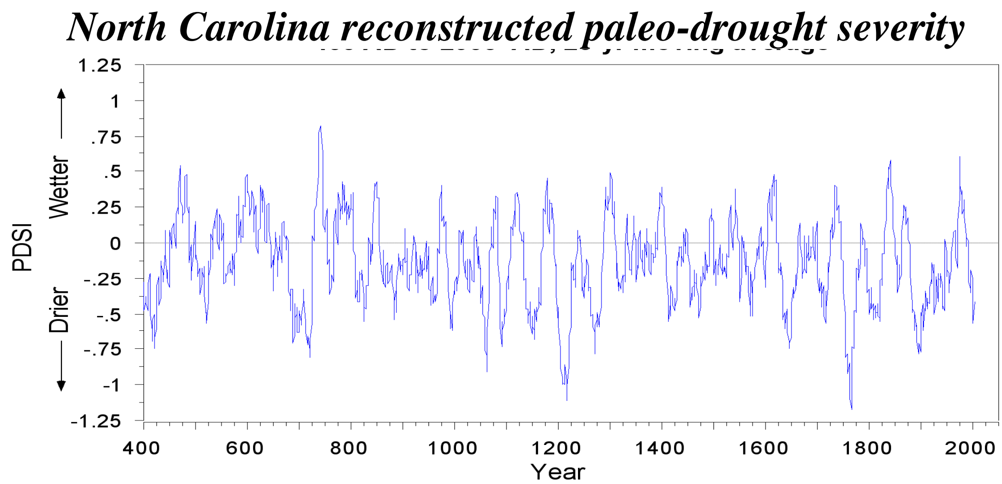

Figure 5. The reconstructed summer (June, July, August) Palmer Drought Severity Index (PDSI) for central North Carolina from 400 A.D. to 2003 A.D. depicted as a 20-yr running mean. (National Climate Data Center, http://www.ncdc.noaa.gov/paleo/pdsi.html)

Sea Level Rise: With over 300 miles of shoreline along the Atlantic Ocean and many times that amount of coastline along its bays and tributaries, the coastal regions of North Carolina are a major component of both the state's ecology and economy. As such North Carolina is particularly sensitive to climate changes that may have an effect on future sea level. It is thus worth noting, that over the course of the past 50 years or so, North Carolina's coastline has already experienced a relative sea-level rise of the same order of magnitude as the one that is forecast to occur during the next 50 years because of warming temperatures: around six inches (Zervas, 2001).

This relative sea level rise along the North Carolina coast results from a combination of the land slightly sinking (from complex geological processes) and the ocean slightly

rising (Aubrey and Emery, 1991; Wöpplemann et al., 2007). North Carolina's coastal residents have adapted to this change with obvious success, as the unprecedented population growth of its coastal counties attests. From 1970 to 2000, the population of North Carolina's 20 coastal counties grew by 62% increasing by 315,662 residents. Projections for 2000 to 2015 indicate the coastal population will increase by another 20%, adding an additional 162,000 people (North Carolina Division of Coastal Management). Primarily county populations which predominately border the ocean and which are popular to vacationers, such as Dare country and Currituck county along the state's northern Outer Banks, more than doubled (Currituck) or tripled (Dare) from 1970 to 2000. These counties are estimated to grow by another 30 to 35% from 2000 to 2015. Clearly, ongoing and potential future sea level rise is not enough of a concern to keep the growth rate in these locations in North Carolina from being among the fastest in the country.

North Carolina coastal county population growth, 1970-2000

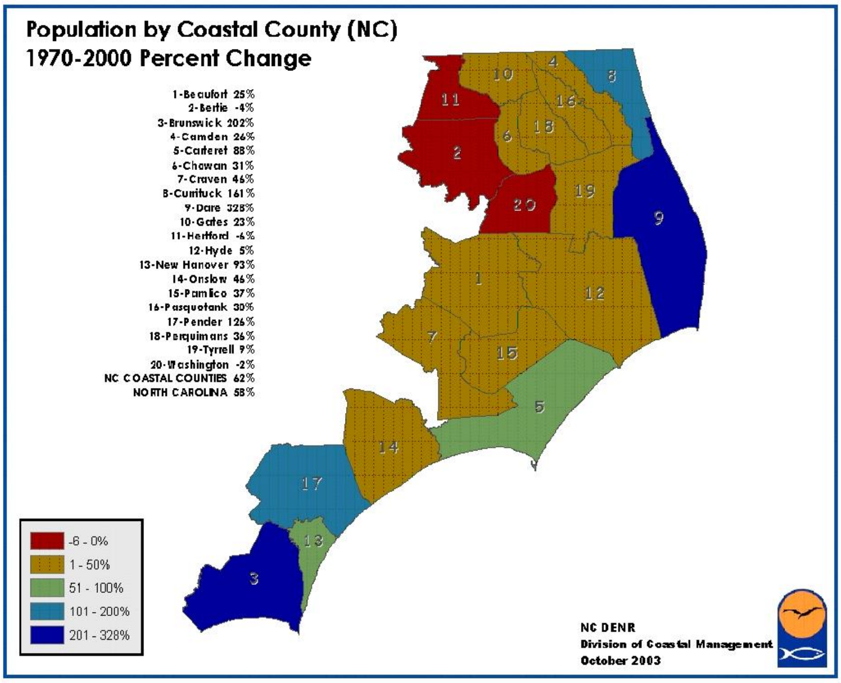

Figure 6. Population change (percentage) in North Carolina's coastal counties, 1970-2000 (from North Carolina Division of Coastal Management, http://dcm2.enr.state.nc.us/)

North Carolina projected coastal county population growth, 2000-2015

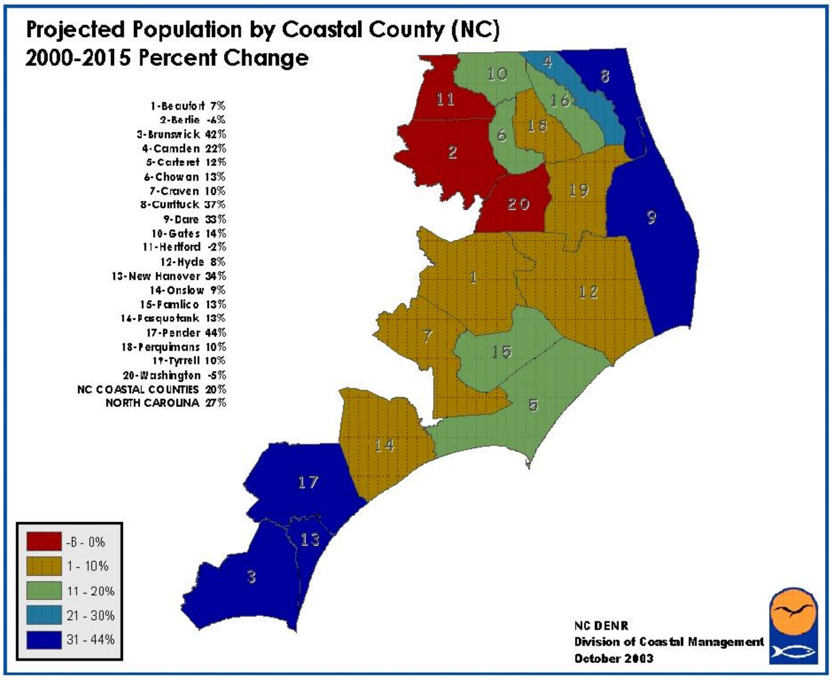

Figure 7. Projected population change (percentage) in North Carolina's coastal counties, 2000-2015 (from North Carolina Division of Coastal Management, http://dcm2.enr.state.nc.us/)

A dispassionate examination of projected sea level rise for the coming century shows that the rate of future sea level rise is projected to be less than the rates which are commonly highlighted in the popular press. According to the 2007 *Fourth Assessment Report* (AR4) on climate change published by the U.N.'s Intergovernmental Panel on Climate Change (IPCC), the potential sea level rise over the course of the 21st century lies between 7 and 23 inches, depending of the total amount of global warming that occurs. The IPCC links a lower sea level rise with lower future warming. The established warming rate of the earth is 0.18ºC per decade, which is near the low end of the IPCC range of projected warming for the 21st century which is from 0.11 to 0.64ºC per decade. Therefore, since we observe that the warming rate is tracking near the low end of the IPCC projections, we should also expect that the rate of sea level rise should track near the low end of the range given by the IPCC—in this case, a future rise much closer to 7 inches than to 23 inches. Thus, the reasonably expected rate of sea level rise in the coming decades is not much different to the rate of sea level rise that North Carolina's coastlines have been experiencing for more than a century—and have successfully adapted to.

Projected Global Sea Level Rise 2000-2100

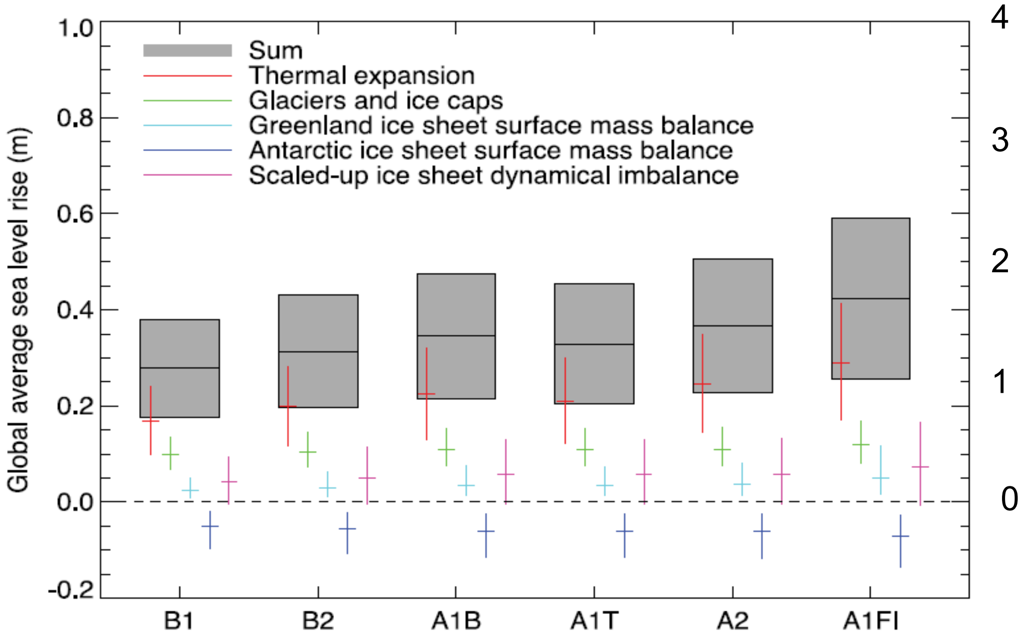

Figure 8. Range of sea level rise projections (and their individual components) for the year 2100 made by the IPCC AR4 for its six primary emissions scenarios.

There are a few individuals who argue that sea level rise will accelerate precipitously in the future and raise the level of the ocean to such a degree that it inundates low-lying areas along the North Carolina coast and other low-lying areas around the world and they clamor that the IPCC was far too conservative in its projections. However, these rather alarmist views are not based upon the most reliable scientific information, and in fact, ignore what our best understanding of how a warmer world will impact ice loss/gain on Greenland and Antarctica and correspondingly, global sea level. It is a fact, that all of the extant models of the future of Antarctica indicate that a warmer climate leads to more snowfall there (the majority of which remains for hundreds to thousands of years because it is so cold) which acts to slow the rate of global sea level rise (because the water remains trapped in ice and snow). And new data suggest that the increasing rate of ice loss from Greenland observed over the past few years has started to decline (Howat et al., 2007). Scenarios of disastrous rises in sea level are predicated on Antarctica and Greenland losing massive amounts of snow and ice in a very short period of time—an occurrence with virtual zero likelihood.

In fact, an author of the IPCC *AR4* chapter dealing with sea level rise projections, Dr. Richard Alley, recently testified before the House Committee on Science and Technology concerning the state of scientific knowledge of accelerating sea level rise and pressure to exaggerate what it known about it. Dr. Alley told the Committee:

> This document [the IPCC *AR4*] works very, very hard to be an assessment of what is known scientifically and what is well-founded in the refereed literature and when we come up to that cliff and look over and say we don't have a foundation right now, we have to tell you that, and **on this particular issue, the trend of acceleration of this flow with warming we don't have a good assessed scientific foundation right now**. [Emphasis added]

Thus the IPCC projections of future sea level rise, which average only about 15 inches for the next 100 years, stand as the best projections that can be made based upon our current level of scientific understanding. These projections are far less severe than the alarming projections of many feet of sea level rise that have been made by a few individuals whose views lie outside of the scientific consensus.

Hurricanes: North Carolina's Cape Hatteras has the dubious distinction of being among the most hurricane frequented locations in the United States. The shape of North Carolina's Outer Banks makes it uniquely vulnerable to tropical cyclones arriving from the Atlantic Ocean and re-curving northward along the southeastern coast of the U.S., as well as from tropical systems moving out of the Gulf of Mexico, crossing Florida or Georgia, and then regaining strength and striking North Carolina as they continue to progress northward. This unique geography makes the region from North Carolina's Sunset Beach to Cape Hatteras sport a lower return period and higher frequency of hurricane strikes than any portion of the U.S. outside of southern Florida.[2]

[2] State profiles for Kentucky, Kansas, Georgia, Texas, Tennessee and Florida available at: http://scienceandpublicpolicy.org/sppi_originals/

Return Period (in years) between Hurricane Strikes

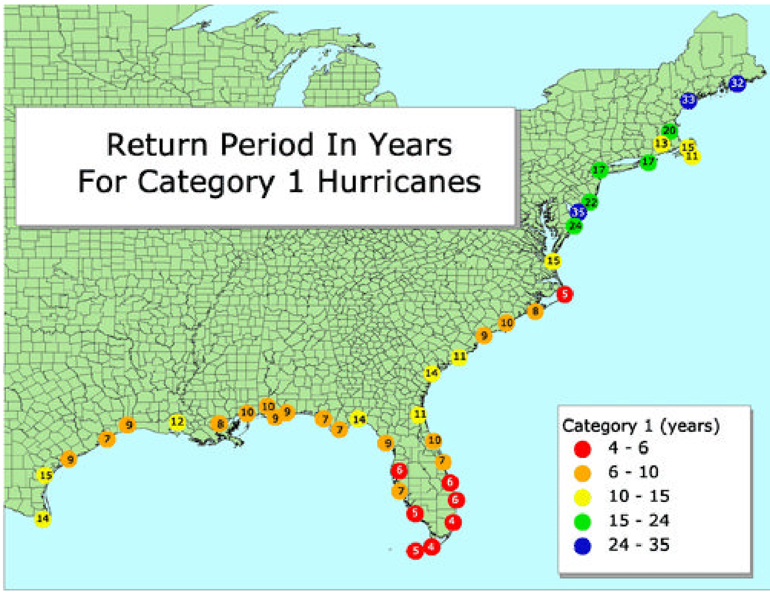

Figure 9. Average return frequency (in years) of hurricane landfalls along the U.S. coastline (source: National Hurricane Center)

Total Number of Hurricane Landfalls, 1926-2005

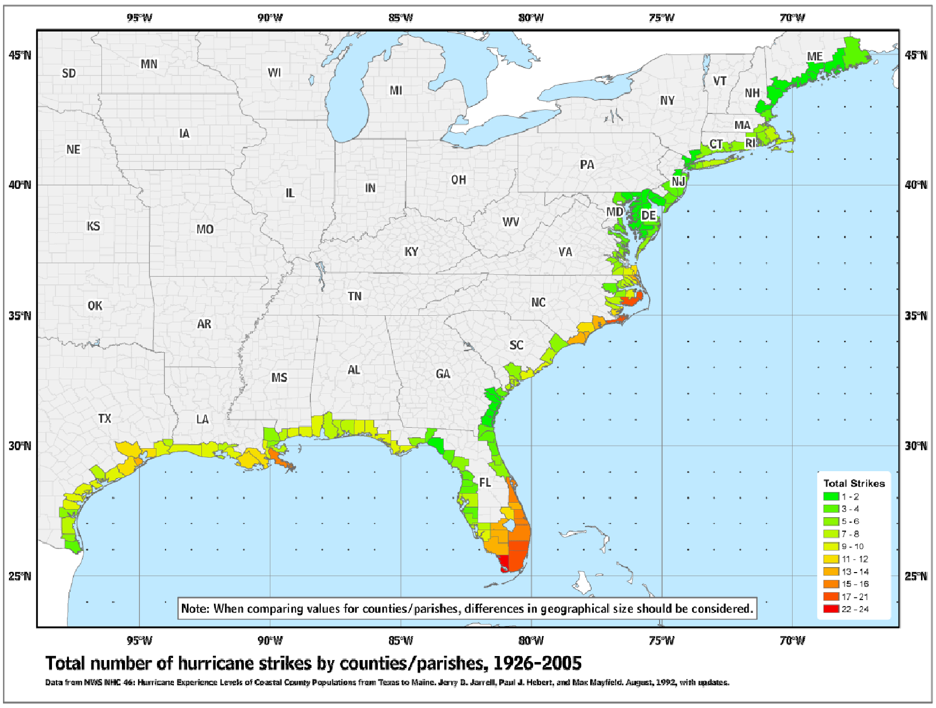

Figure 10. Total number of hurricane landfalls along the U.S. coast, 1926-2005 (source: National Hurricane Center)

Total Number of Hurricane Landfalls, 1926-2005

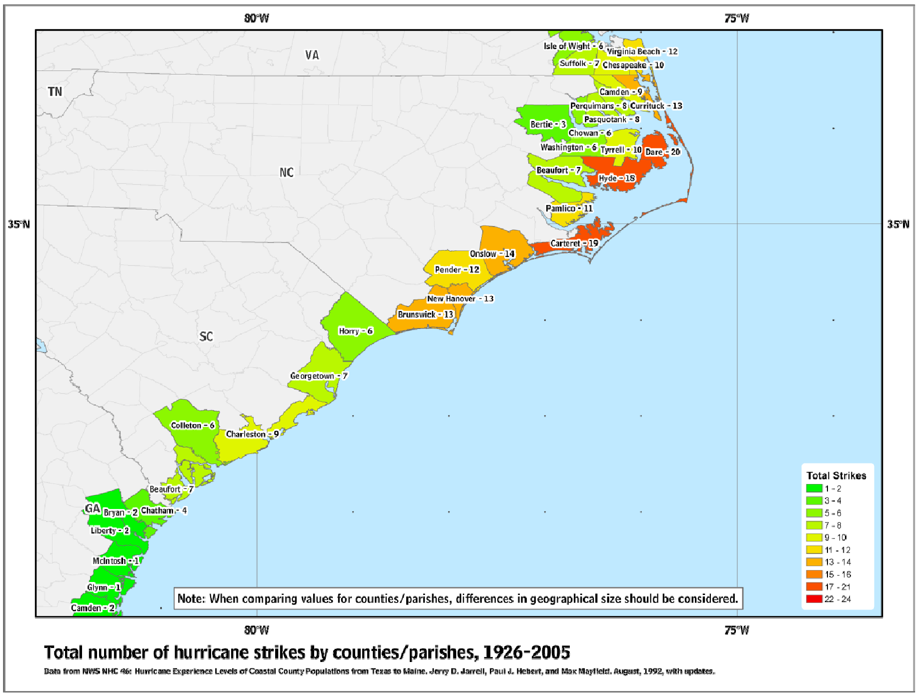

Figure 11. Total number of hurricane landfalls along the North Carolina coast, 1926-2005 (source: National Hurricane Center)

So clearly, North Carolina's residents have a lot at stake when hurricane season approaches each year. And the question of whether or not human-induced changes in the earth's greenhouse effect may impact current or future hurricane patterns is as important in North Carolina as virtually any place else.

Observed Trends: The best available scientific evidence suggests that natural variations, on time scales ranging from years to decades, dominate any small impacts that a warming climate may have on the frequency and intensity of Atlantic tropical cyclones. Far and away the most important determinant in future vulnerability is not changes to the hurricanes themselves, but changes to the population and wealth structure of North Carolina's coastal communities, many, as we have explored previously, rank among the fastest growing localities in America.

Since 1995 there has been an increase in both the frequency and intensity of tropical storms and hurricanes in the Atlantic basin. While some scientists have attempted to link this increase to anthropogenic global warming, others have pointed out that Atlantic hurricanes exhibit long-term cycles, and that this latest upswing is simply a return to conditions that characterized earlier decades in the 20th century. Along the North Carolina coast, according to records from the National Hurricane Center (http://www.aoml.noaa.gov/hrd/tcfaq/E23.html), the number of total hurricanes strikes exhibits decadal variations, but no real long-term trends. The number of hurricanes

impacting North Carolina during the last 10-year period, 1998-2007, was similar to periods in the first half of the 20th century. However, since it follows a 4 decade-long period of relative quiet, the recent period has seemed exceptionally active. In fact, it has *not* been in the greater historical perspective.

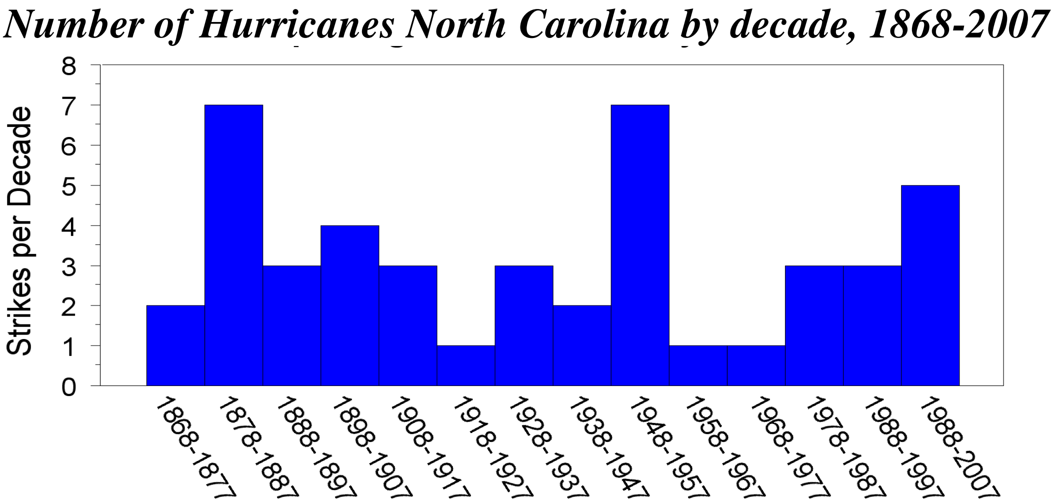

Figure 12. Number of hurricanes impacting North Carolina, by decade, 1868-2007. Source: US National Hurricane Center, http://www.aoml.noaa.gov/hrd/tcfaq/E23.html.

There is no long-term trend of greater dollar-valued damages from hurricanes when inflation and population demographics are factored.

A team of researchers led by Dr. Roger Pielke Jr. (2007) examined historical damage from tropical cyclones in the United States from 1900 to 2005. When they adjusted the reported damage estimates for inflation only, they discovered a trend towards increasing amounts of loss, peaking in the years 2004 and 2005. The period included hurricanes Wilma and Katrina causing 81 billion dollars in damage.

Total Losses from Atlantic Tropical Cyclones, 1900-2005

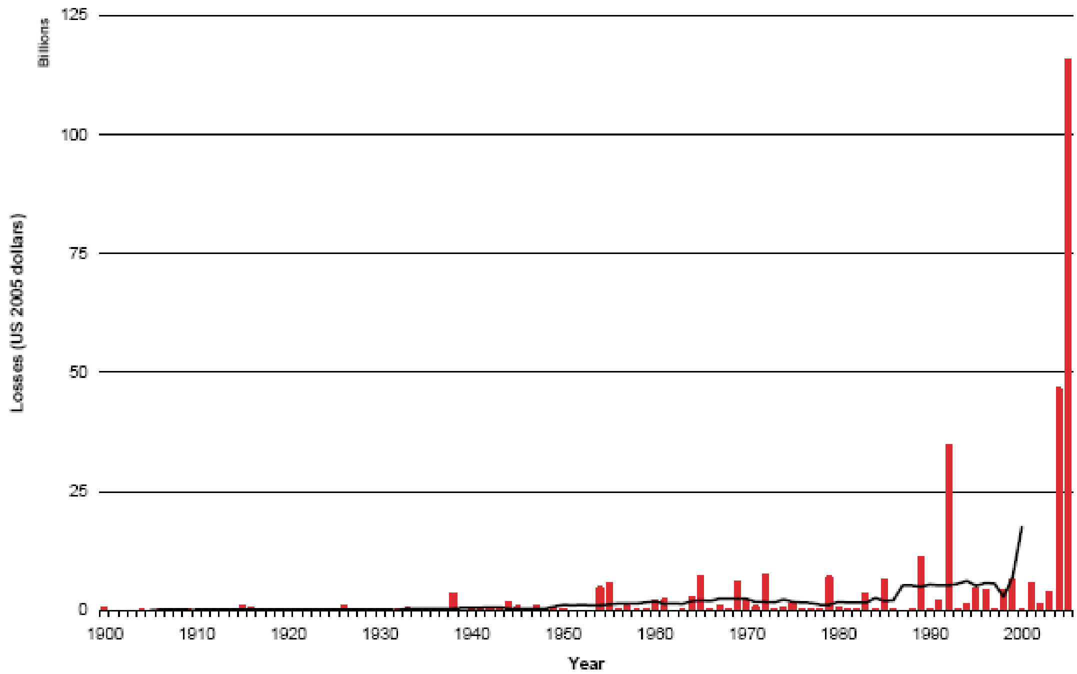

Figure 13. U.S. tropical cyclone damage (in 2005 dollars) when adjusted for inflation, 1900-2005 (from Pielke Jr., et al., 2007)

However, many changes have occurred in hurricane prone areas since 1900 besides inflation. These changes include a coastal population that is growing in size as well as wealth (as we have seen has been occurring in North Carolina). When the Pielke Jr. team made adjustments considering all three factors, they found no long-term change in damage amounts. And, in fact, the loss estimates in 2004 and 2005, while high, were not historically high. The new record holder, for what would have been the most damaging storm in history had it hit in 2005, was the Great Miami hurricane of 1926[3], which they estimated would have caused 157 billion dollars worth of damage. After the Great Miami hurricane and Katrina (which fell to second place), the remaining top-ten storms (in descending order) occurred in 1900 (Galveston 1), 1915 (Galveston 2), 1992 (Andrew), 1983 (New England), 1944 (unnamed), 1928 (Lake Okeechobee 4), 1960 (Donna/Florida), and 1969 (Camille/Mississippi). There is no obvious bias towards recent years. In fact, the combination of the 1926 and 1928 hurricanes places the damages in 1926-35 nearly 15% higher than 1996-2005, the last decade Pielke Jr. and colleagues studied.

[3] http://scienceandpublicpolicy.org/originals/hurricanethreat.html

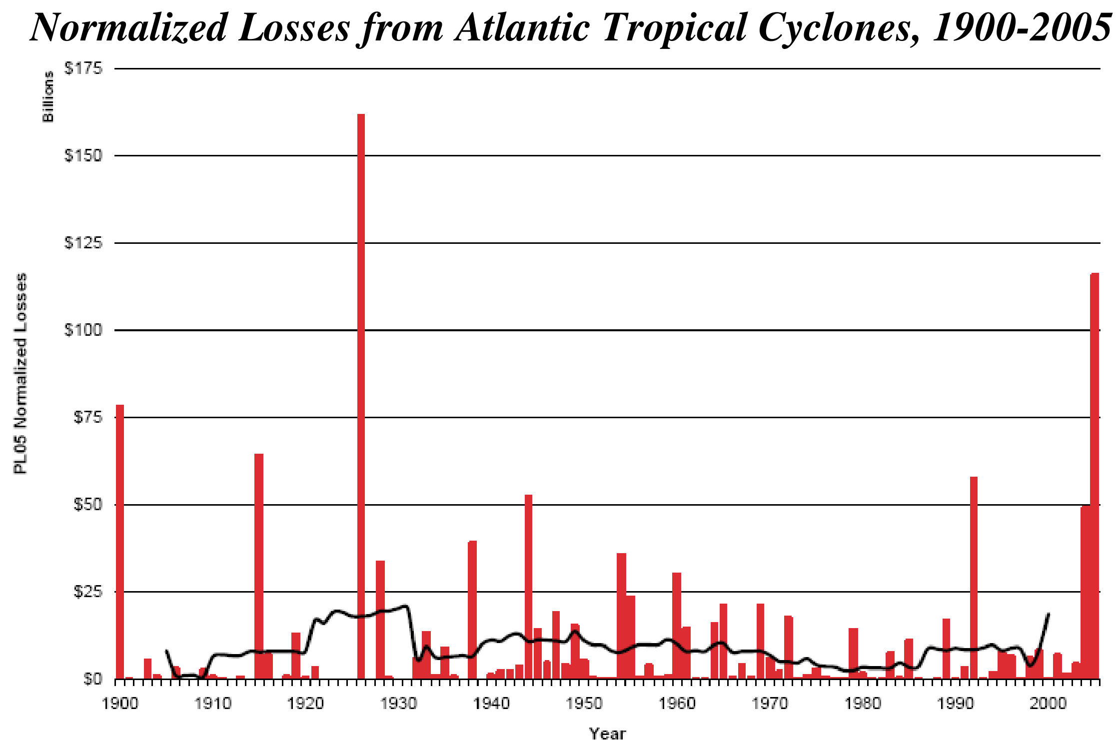

Figure 14. U.S. tropical cyclone damage (in 2005 dollars) when adjusted for inflation, population growth and wealth, 1900-2005 (from Pielke Jr., et al., 2007)

This new result by the Pielke Jr. team, that there has not been any long-term increase in tropical cyclone damage in the United States, is consistent with other science concerning the history of Atlantic hurricanes. One of Pielke Jr.'s co-authors, Dr. Chris Landsea, from the National Hurricane Center, has also found no trends in hurricane frequency or intensity when they strike the U.S. While there has been an increase in the number of strong storms in the past decade, there were also a similar number of major hurricanes in the 1940s and 1950s, long before such activity could be attributed to global warming.

As Pielke writes, "The lack of trend in twentieth century hurricane losses is consistent with what one would expect to find given the lack of trends in hurricane frequency or intensity at landfall."

Natural cycles dominate the observed record of Atlantic tropical cyclones, which dates back into the 18th and 19th centuries. The Figure below depicts the total number of hurricanes, and major hurricanes (category 3 or greater storms) observed in the Atlantic basin since 1930. Multidecadal oscillations are obvious in this record—hurricane activity was quiet in the 1910s and 1920s, elevated in the 1950 and 1960s, quiet in the 1970s and 1980s, and has picked up again since 1995.

Atlantic Hurricanes, 1886-2004

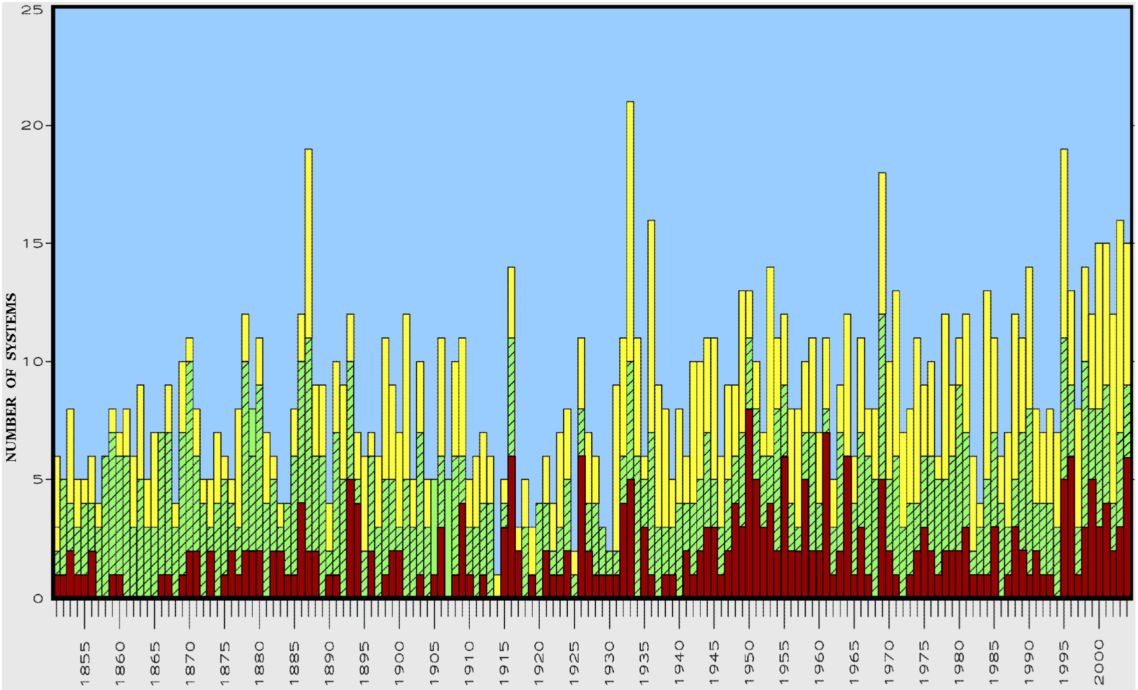

Figure 15. Annual number of hurricane and major hurricanes observed in the Atlantic basin, 1886-2004. Bars depict number of named systems (open/yellow), hurricanes (hatched/green), and category 3 or greater (solid/red) (source: National Hurricane Center).

The timing of these oscillations match well with the oscillations of a phenomenon known as the Atlantic Multidecadal Oscillation (AMO) which reflects changes in large-scale patterns of sea surface temperatures in the Atlantic Ocean. Much research has shown a connection between the AMO and Atlantic hurricane activity (Knight et al., 2006, Zhang and Delworth, 2006; Gray, 2007) despite some claims to the contrary (Mann and Emanuel, 2006). And from patterns in paleoclimate datasets coupled with model simulations, the AMO can be simulated back for more than 1,400 years (Knight et al., 2005).

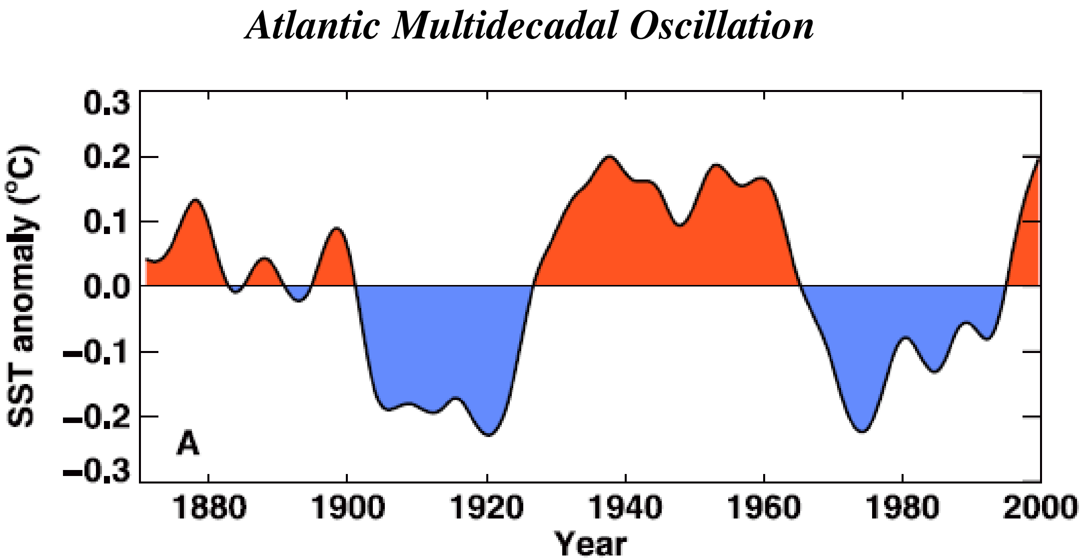

Figure 16. The observed historical time series of the Atlantic Multidecadal Oscillation (AMO) (from Knight et al., 2005).

Further, not only is there evidence that the AMO has been operating for at least many centuries (prior to any possible human influence on the climate), but there is also growing evidence that there have been active and inactive periods in the Atlantic hurricane frequency and strength extending many centuries into the past (as far as backward the various paleodatasets will allow). For instance, research by Miller et al. (2006) using oxygen isotope information stored in tree-rings in the southeastern United States, finds distinct periods of activity/inactivity in a record dating back 220 years. And in research that examined sediment records deposited from beach overwash in a lagoon in Puerto Rico, scientists Donnelly and Woodruff (2007) have identified patterns of Atlantic tropical cyclone activity extending back 5,000 years.

So clearly, there is strong evidence for natural oscillations in the frequency and intensity of tropical cyclone activity in the Atlantic basin. Hurricane researchers have known this fact for many years and they expected the coming of the period of enhanced activity that began in 1995. Further, they recognize that the heighten activity levels are likely here to stay awhile, as the oscillations usually last several decades.

Future Trends: The question of whether human-induced climate changes will impact future patterns of tropical cyclone frequency and/or intensity in the Atlantic basin is currently one of the most active research topics in climate science. And simply put, there is no general consensus on the matter.

As we head into the future, it is expected that human activity will lead to an overall climate warming. A warming climate is reasonably expected to lead to higher sea surface temperatures in the tropical Atlantic spawning grounds of hurricanes. And sea surface temperatures play an important role in the processes of formation and intensification of

tropical cyclones. Therefore, some researchers (e.g., Knutson and Tuleya, 2004; Emanuel, 2005; Webster et al. 2005) suggest that hurricanes will become stronger in a warmer world. However, at the same time, some of the climate changes that are projected to occur as the levels of atmospheric carbon dioxide continue to grow into the future, are ones that act to hinder tropical cyclone formation and development. This includes projections of increased vertical wind shear (Vecchi and Soden, 2007) and increasing atmospheric stability (Knutson and Tuleya, 2004). Thus, when *all* of the projected changes are incorporated into climate models, the models generally predict only small increases in intensity (maximum winds increase by just 6%) over the course of the next coming century (Knutson and Tuleya, 2004), and *decreases* in frequency of storms (Bengtsson et al., 2006). And the small intensity increases are produced by a climate model which was driven by scenarios of future carbon dioxide increases that are much greater than current trends suggest that they will be (Michaels et al., 2006). Thus, even the small projected intensity increases may be overestimates.

Some claims are being made that the current period of elevated hurricane activity is the result of human-induced climate changes which have led to a long-term increase in the number and intensity of hurricanes during recent decades (e.g., Hoyos et al., 2006; Webster et al., 2005; Emanuel, 2005) as well as over the longer term (Holland and Webster, 2007). However, analytical errors (Landsea, 2005), the lack of strike (Landsea, 2005) and damage (Pielke Jr., 2005; Pielke Jr. et al., 2007) trends in the United States, changes in observational technology (Landsea et al., 2006; Landsea, 2007), among other issues (Klotzbach, 2006; Landsea, 2007), coupled with climate models simulations that project only minor intensity increases and frequency decreases not anticipated to be detectable towards the end of the 21st century, combine to argue against those who have claimed to have detected anthropogenic-induced trends.

Certainly, there is neither strong current evidence, nor any strong future projections, that support the idea that the frequency and/or intensity of Atlantic basin tropical cyclones—which included all the storms that potentially impact North Carolina—have increased or will increase in any detectable manner as a result of the human enhancement of the earth's natural greenhouse effect.

Despite the lack of any trends in hurricane landfalls along the U.S. and North Carolina coast, or damage to U.S. coastlines when population demographics are taken into account, the impact from a single storm can be enormous as residents of North Carolina know all too well. The massive build-up of the coastline has vastly raised the potential damage that a storm can inflict. Recently, a collection of some of the world's leading hurricane researchers issued the following statement that reflects the current scientific thinking on hurricanes and their potential impact (http://wind.mit.edu/~emanuel/Hurricane_threat.htm) in coming years:

> As the Atlantic hurricane season gets underway, the possible influence of climate change on hurricane activity is receiving renewed attention. While the debate on this issue is of considerable scientific and societal interest and concern, it should in no event detract from the main hurricane problem facing the United States: the ever-growing concentration of population and wealth in vulnerable coastal regions. These demographic trends are setting us up for rapidly increasing human and economic losses from hurricane disasters, especially in this era of heightened activity. Scores of scientists and engineers had warned of the threat to New Orleans long before climate change was seriously considered, and a Katrina-like storm or worse was (and is) inevitable even in a stable climate.
>
> Rapidly escalating hurricane damage in recent decades owes much to government policies that serve to subsidize risk. State regulation of insurance is captive to political pressures that hold down premiums in risky coastal areas at the expense of higher premiums in less risky places. Federal flood insurance programs likewise undercharge property owners in vulnerable areas. Federal disaster policies, while providing obvious humanitarian benefits, also serve to promote risky behavior in the long run.
>
> We are optimistic that continued research will eventually resolve much of the current controversy over the effect of climate change on hurricanes. But the more urgent problem of our lemming-like march to the sea requires immediate and sustained attention. We call upon leaders of government and industry to undertake a comprehensive evaluation of building practices, and insurance, land use, and disaster relief policies that currently serve to promote an ever-increasing vulnerability to hurricanes.

However, all impacts from tropical cyclones in North Carolina are not negative. In fact, precipitation that originates from tropical systems and that eventually falls over the state of North Carolina proves often to be quite beneficial to the state's 8 billion dollar/year agriculture industry. The late summer is the time when, climatologically, the precipitation deficit is the greatest and crops and other plants are the moisture stressed. A passing tropical cyclone often brings much needed precipitation over large portions of the state. In fact, recent research shows that North Carolina, on average, receives more than one-quarter of its normal September precipitation, and about 11 to 17 percent of its total June through November precipitation from passing tropical systems. And since about 95 percent of North Carolina's cropland is not irrigated, widespread rainfall from a tropical cyclone becomes almost an expected and relied upon late summer moisture source.

June - November Precipitation Originating from Tropical Systems

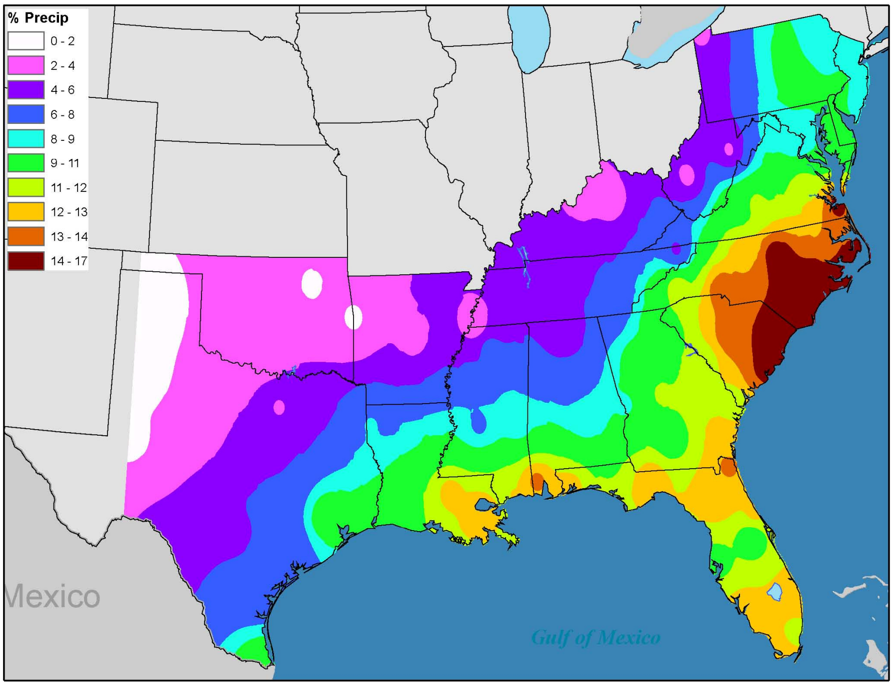

Figure 17. Percentage of June through November precipitation that comes from tropical systems (Knight and Davis, 2007).

Heat waves: A number of studies have shown that during the several decades, the population in major U.S. cities has grown better adapted, and thus less sensitive, to the effects of excessive heat events (Davis et al., 2003ab). This desensitization is attributed to better medical practices, increased access to air-conditioning, and improved community response programs. In some cities, by the 1990s, heat-related mortality was virtually non-existent. In general, the locations across the country where high summertime temperatures are commonplace were found to be well-adapted to high heat events and typically displayed little if any mortality response to heat waves. This is true of the Charlotte, the North Carolina city that was included in the study, as well as the nearby coastal city of Norfolk, Virginia. Both in Charlotte and in Norfolk, no significant relationship was found between daily mortality and daily temperatures during the summertime during the 1990s—the most recent decade studied. Interestingly, the studies did find evidence of a significant relationship between summertime heat and increased mortality in these cities during the 1960s and 1970s. That the population was once more sensitive to heat waves than it is now is clear and strong evidence that North Carolinians have adapted their way of life to best cope with high summer temperatures.

The declining sensitivity to high summer temperatures that has taken place in North Carolina and in cities across the country is well illustrated in the Figure below (taken

from Davis et al., 2003b). Each of the bars of the illustration below represents the annual number of heat-related deaths in 28 major cities across the United States. There should be three bars for each city, representing, from left to right, the decades of the 1970s, 1980s and 1990. For nearly all cities, the number of heat-related deaths is declining (the bars are get smaller), and in many cities in the southeastern United States, there is no bar at all in the 1990s, indicating that there were no statistically distinguishable heat-related deaths during that decade (the most recent one studied). In other words, the population of those cities has become nearly completely adapted to heat waves. This adaptation is most likely a result of improvements in medical technology, access to air-conditioned homes, cars, and offices, increased public awareness of potentially dangerous weather situations, and proactive responses of municipalities during extreme weather events.

Heat-related mortality trends across the U.S.

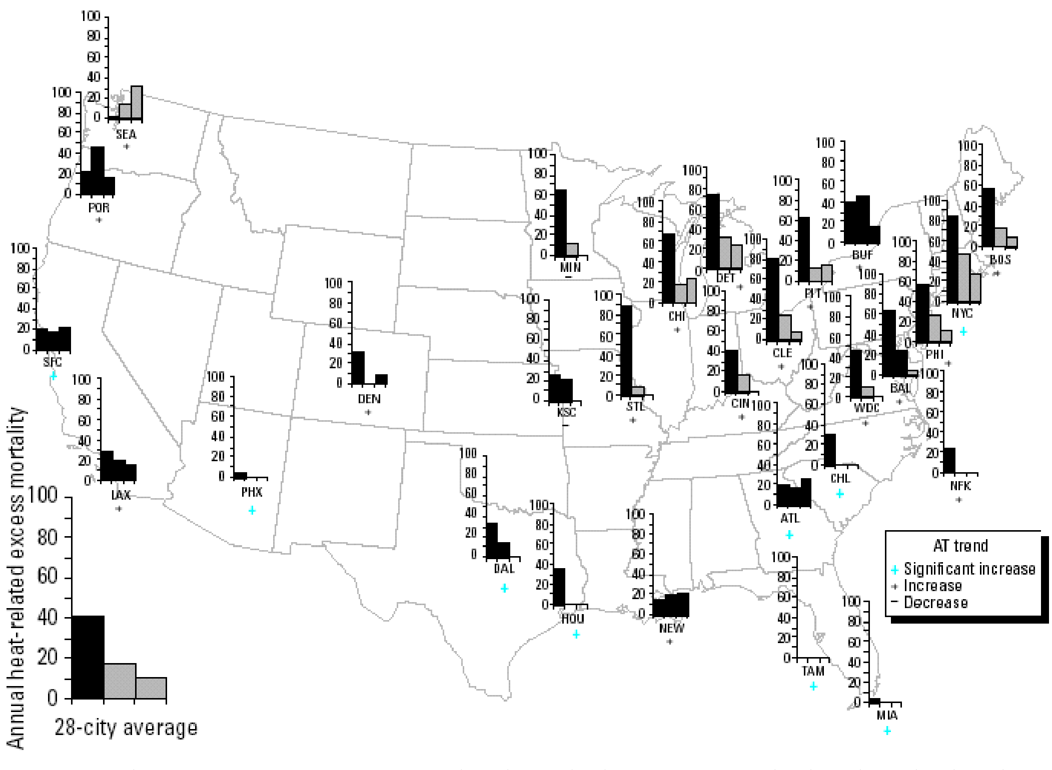

Figure 18. Annual average excess summer mortality due to high temperatures, broken down by decade, for 28 major cities across the United States. For each city each of the three bars represents the average mortality during successive decades (left bar 1964-66 + 1973-1979; middle bar 1980-1989, right bar 1990-1998). Bars of different color indicate a statistically significant difference. No bar at all means that no temperature/mortality relationship could be found during that decade/city combination (taken from Davis et al., 2003b).

In a subsequent study, Davis et al. (2004) focused not just on summertime heat/mortality relationships, but looked across all months of the year. Unlike the lack of strong response

to summer high temperatures in Charlotte, Davis et al. (2004) found that, during the cooler times of the year, colder temperatures can lead to elevated mortality totals.

Relationship between monthly average temperature and monthly average mortality for Charlotte, North Carolina

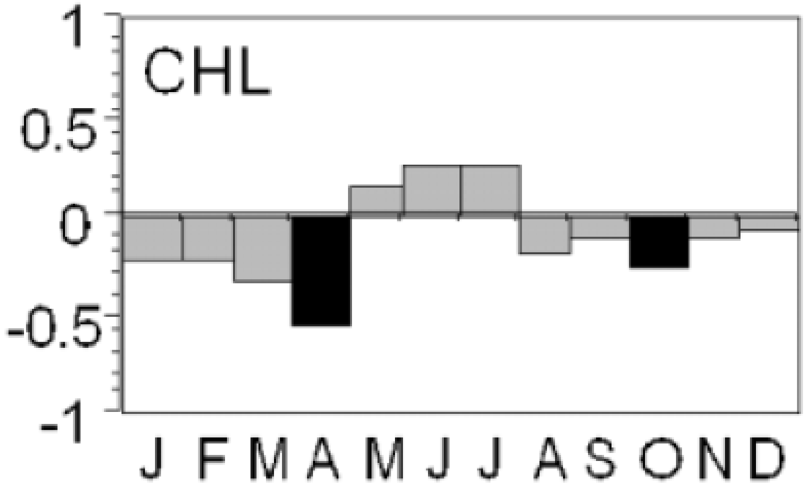

Figure 19. Relationship between average monthly temperature and total monthly mortality in Charlotte. Positive bars mean high temperatures lead to higher mortality, while negative bars mean lower temperatures lead to higher mortality. Only the bars shaded in black represent statistically significant relationships (from Davis et al., 2004).

The figure above (taken from Davis et al., 2004) illustrates this pattern of temperature/mortality relationships for Charlotte. Negative bars indicate a negative relationship between temperature and mortality. The colder it is, the more people die and vice versa for warmer than average conditions (i.e., the warmer it is, the fewer people die). Solid bars mean the relationship is statistically significant. Positive bars indicate positive relationships between temperature and mortality, that is more people die when it is hotter than normal, and few die when it is below normal. For the most part, Charlotte exhibits more negative bars than positive ones, with the cold season months showing negative relationships and a couple months in summer showing weak positive relationships. Taken together, this indicates that if the future was marked by a warming climate, especially one in which winters warmed a greater degree than summers (in character, matching the pattern of warming that has been observed in the Northern Hemisphere for the past 50 years or so), that this would result in fewer temperature-related deaths in Charlotte and probably throughout North Carolina.

All told, however, the total annual number of direct weather-related deaths, whether as a result of cold or warm conditions, is quite small compared to the annual overall mortality. For instance, in general, in the United States, the annual mortality rate is a bit less than 1% per year, meaning that about 8,000 to 9,000 people die each year out of every million persons. In Charlotte, the net effect of the *weather* in a typical year is about 1,000 times

less, or fewer than ±10 deaths per million people. So, despite proclamations to the contrary, the weather and climate have only an exceedingly small impact on overall mortality when the population at large is considered. This is true now and should remain true into the future, no matter how the climate evolves.

Vector-borne Diseases: "Tropical" diseases such as malaria and dengue fever have been erroneously predicted to spread due to global warming. In fact, they are related less to climate than to living conditions. These diseases are best controlled by direct application of sound, known public health policies.

Malaria Distribution in the United States

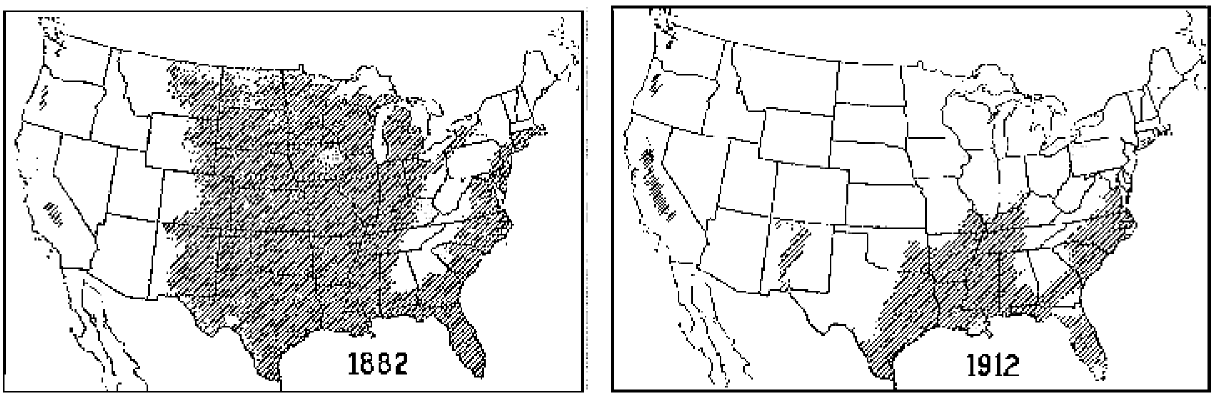

Figure 20. Shaded regions indicate locations where malaria was endemic in the United States (from Zucker et al., 1996).

The two tropical diseases most commonly cited as spreading as a result of global warming, malaria and dengue fever, are not in fact "tropical" at all and thus are not as closely linked to climate as many people suggest. For example, malaria epidemics occurred as far north as Archangel, Russia, in the 1920s, and in the Netherlands. Malaria was common in most of the United States prior to the 1950s (Reiter, 1996). In fact, in the late 1800s, a period when it was demonstrably colder in the United States than it is today, malaria was endemic in most of the United States east of the Rocky Mountains—a region eastern 2/3rds (non-mountainous portions) of North Carolina. In 1878, about 100,000 Americans were infected with malaria; about one-quarter of them died. By 1912, malaria was already being brought under control, yet persisted in the southeastern United States well into the 1940s. In fact, in 1946 the Congress created the Communicable Disease Center (the forerunner to the current U.S. Centers for Disease Control and Prevention) for the purpose of eradicating malaria from the regions of the U.S. where it continued to persist. By the mid-to-late 1950s, the Center had achieved its goal and malaria was effectively eradicated from the United States. This occurred not because of climate change, but because of technological and medical advances. Better anti-malaria drugs, air-conditioning, the use of screen doors and windows, and the elimination of urban

overpopulation brought about by the development of suburbs and automobile commuting were largely responsible for the decline in malaria (Reiter, 1996; Reiter, 2001). Today, the mosquitoes that spread malaria are still widely present in the Unites States, but the transmission cycle has been disrupted and the pathogen leading to the disease is absent. Climate change is not involved.

U.S. Mortality Rates From Malaria, 1900-1949

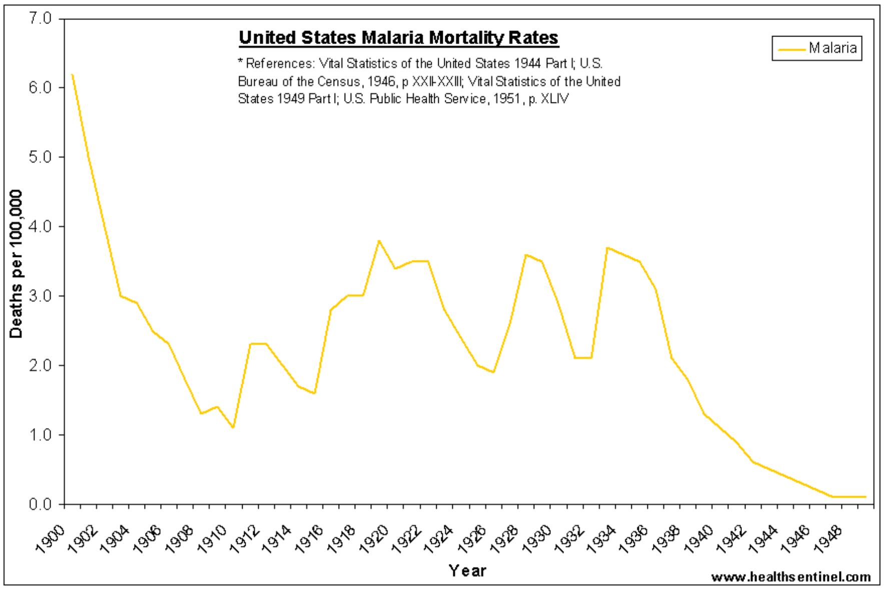

Figure 21. Mortality rate in the United States from malaria (deaths per 100,000) from 1900 to 1949, when it was effectively eradicated from the country. (Figure from http://www.healthsentinel.com/graphs.php?id=4&event=graphcats_print_list_item)

The effect of technology is also clear from statistics on dengue fever outbreaks, another mosquito-borne disease. In 1995, a dengue pandemic hit the Caribbean and Mexico. More than 2,000 cases were reported in the Mexican border town of Reynosa. But in the town of Hidalgo, Texas, located just across the river, there were only seven reported cases of the disease (Reiter, 1996). This is just not an isolated example, for data collected over the past several decades has shown a similarly large disparity between the high number of cases of the disease in northern Mexico and the rare occurrences in the southwestern United States (Reiter, 2001). There is virtually no difference in climate between these two locations, but a world of difference in infrastructure, wealth, and technology—city layout, population density, building structure, window screens, air-conditioning and personal behavior are all factors that play a large role in the transmission rates (Reiter, 2001).

DengueFever at the Texas/Mexico border from 1980 to 1999

Figure 22. Number of cases of Dengue Fever at the Texas/Mexico border from 1980 to 1999. During these 20 years, there were 64 cases reported in all of Texas, while there was nearly 1,000 times that amount in the bordering states of Mexico. (figure from Reiter, 2001).

Another "tropical" disease that is often (falsely) linked to climate change is the West Nile Virus. The claim is often made that a warming climate is allowing the mosquitoes that carry West Nile Virus to spread into North Carolina. However, nothing could be further from the truth.

West Nile Virus was introduced to the United States through the port of New York City in the summer of 1999. Since its introduction, it has spread rapidly across the country, reaching the West Coast by 2002 and has now been documented in every state as well as most provinces of Canada. This is not a sign that the U.S. and Canada are progressively warming. Rather, it is a sign that the existing environment is naturally primed for the virus.

Spread of the West Nile Virus across the United States after its Introduction in New York City in 1999

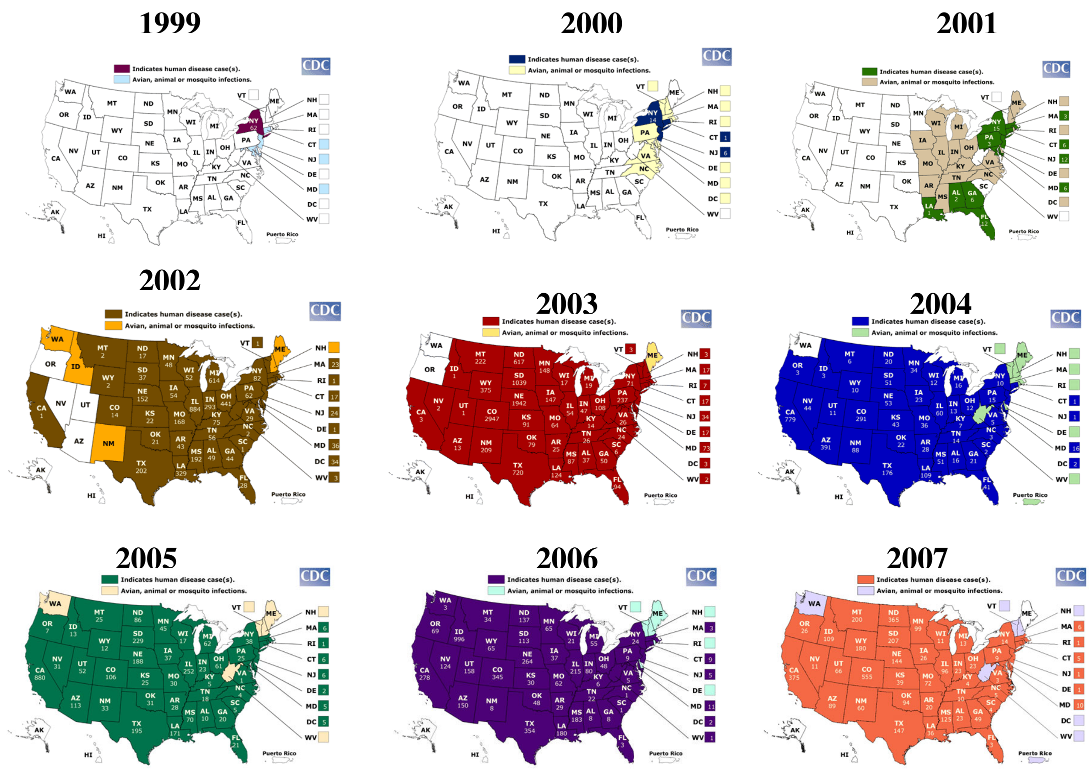

Figure 23. Spread of the occurrence of the West Nile Virus from its introduction to the United States in 1999 through 2007. By 2003, virtually every state in the country had reported the presence of virus. (source: http://www.cdc.gov/ncidod/dvbid/westnile/Mapsactivity/surv&control07Maps.htm).

The vector for West Nile is mosquitoes; wherever there is a suitable host mosquito population, an outpost for West Nile virus can be established. And it is not just *one* mosquito species that is involved. Instead, the disease has been isolated in over *40 mosquito species* found throughout the United States. So the simplistic argument that climate change is allowing a West Nile carrying mosquito species to move into North Carolina is simply wrong. The already-resident mosquito populations of North Carolina are appropriate hosts for the West Nile virus—as they are in every other state.

Clearly, as is evident from the establishment of West Nile virus in every state in the contiguous U.S., climate has little, or nothing, to do with its spread. The annual average temperature from the southern part of the United States to the northern part spans a range of more than 40ºF, so clearly the virus exists in vastly different climates. In fact, West

Nile virus was introduced in New York City—hardly the warmest portion of the country—and has spread westward and southward into both warmer and colder and wetter and drier climates. This didn't happen because climate changes allowed its spread, but because the virus was introduced to a place that was ripe for its existence—basically any location with a resident mosquito population (which describes basically anywhere in the U.S).

West Nile virus now exists in North Carolina because the extant climate/ecology of North Carolina is one in which the virus can thrive. The reason that it was not found in North Carolina in the past was simply because it had not been introduced. Climate change in North Carolina, which is demonstrably small compared to the natural variability of the state's climate history, has absolutely nothing to do with it. By following the virus' progression from 1999 through 2007, one clearly sees that the virus spread from NYC southward and westward, it did not invade slowly from the (warmer) south, as one would have expected if warmer temperatures was the driver.

Since the disease spreads in a wide range of both temperature and climatic regimes, one could raise or lower the average annual temperature in North Carolina by many degrees or vastly change the precipitation regime and not make a bit of difference in the aggression of the West Nile Virus. Science-challenged claims to the contrary are not only ignorant but also dangerous, serving to distract from real epidemiological diagnosis which allows health officials critical information for protecting the citizens of North Carolina.

Impacts of climate-mitigation measures in North Carolina

GLobally, in 2003, humankind emitted 25,780 million metric tons of carbon dioxide (mmtCO_2: EIA, 2007a), of which North Carolina accounted for 146.2 mmtCO_2, or only 0.57% (EIA, 2007b). The proportion of manmade CO_2 emissions from North Carolina will decrease over the 21st century as the rapid demand for power in developing countries such as China and India outpaces the growth of North Carolina's CO_2 emissions (EIA, 2007b).

During the past 5 years, global emissions of CO_2 from human activity have increased at an average rate of 3.5%/yr (EIA, 2007a), meaning that the annual *increase* of anthropogenic global CO_2 emissions is more than 6 times greater than North Carolina's *total* emissions. This means that even a complete cessation of *all* CO2 emissions in North Carolina will be undetectable globally, and would be *entirely subsumed by rising global emissions in less than two month's time. A fortiori,* regulations prescribing a *partial reduction*, rather than a complete cessation, of North Carolina's CO2 emissions will have no effect on global climate.

Wigley (1998) examined the climate impact of adherence to the emissions controls agreed under the Kyoto Protocol by participating nations, and found that, if all developed countries meet their commitments in 2010 and maintain them through 2100, with a mid-range sensitivity of surface temperature to changes in CO_2, the amount of warming "saved" by the Kyoto Protocol would be 0.07°C by 2050 and 0.15°C by 2100. The global sea level rise "saved" would be 2.6 cm, or one inch. A complete cessation of CO_2 emissions in North Carolina is only a tiny fraction of the worldwide reductions assumed in Dr. Wigley's global analysis, so its impact on future trends in global temperature and sea level will be only a minuscule fraction of the negligible effects calculated by Dr. Wigley.

We now apply Dr. Wigley's results to CO_2 emissions in North Carolina, assuming that the ratio of U.S. CO_2 emissions to those of the developed countries which have agreed to limits under the Kyoto Protocol remains constant at 39% (25% of global emissions) throughout the 21st century. We also assume that developing countries such as China and India continue to emit at an increasing rate. Consequently, the annual proportion of global CO_2 emissions contributed by human activity in the United States will decline. Finally, we assume that the *proportion* of total U.S. CO_2 emissions in North Carolina – now 2.5% – remains constant throughout the 21st century. With these assumptions, we generate the following table derived from Wigley's (1998) mid-range emissions scenario (which itself is based upon the IPCC's scenario "IS92a"):

Table 1
Projected annual CO_2 emissions (mmtCO_2)

Year	**Global emissions:** ***Wigley, 1998***	**Developed countries:** ***Wigley, 1998***	**U.S. (39% of developed countries)**	**North Carolina (2.5% of U.S.)**
2000	26,609	14,934	5,795	145
2025	41,276	18,308	7,103	178
2050	50,809	18,308	7,103	178
2100	75,376	21,534	8,355	209

Note: *Developed countries' emissions, according to Wigley's assumptions, do not change between 2025 and 2050: neither does total U.S or North Carolina emissions.*

In Table 2, we compare the total CO_2 emissions saving that would result if North Carolina's CO_2 emissions were completely halted by 2025 with the emissions savings assumed by Wigley (1998) if all nations met their Kyoto commitments by 2010, and then held their emissions constant throughout the rest of the century. This scenario is "Kyoto Const."

Table 2
Projected annual CO_2 emissions savings (mmtCO_2)

Year	North Carolina	Kyoto Const.
2000	0	0
2025	178	4,697
2050	178	4,697
2100	209	7,924

Table 3 shows the proportion of the total emissions reductions in Wigley's (1998) case that would be contributed by a complete halt of all North Carolina's CO_2 emissions (calculated as column 2 in Table 2 divided by column 3 in Table 2).

Table 3
North Carolina's percentage of emissions savings

Year	North Carolina
2000	0.0%
2025	3.8%
2050	3.8%
2100	2.6%

Using the percentages in Table 3, and assuming that temperature change scales in proportion to CO_2 emissions, we calculate the global temperature savings that will result from the complete cessation of anthropogenic CO_2 emissions in North Carolina:

Table 4
Projected global temperature savings (ºC)

Year	Kyoto Const	North Carolina
2000	0	0
2025	0.03	0.001
2050	0.07	0.003
2100	0.15	0.004

Accordingly, a cessation of all of North Carolina's CO_2 emissions would result in a climatically-irrelevant global temperature reduction by the year 2100 of no more than four *thousandths* of a degree Celsius (ignoring growing Asian emissions). Results for sea-level rise are also negligible:

Table 5
Projected global sea-level rise savings (cm)

Year	Kyoto Const	North Carolina
2000	0	0
2025	0.2	0.008
2050	0.9	0.03
2100	2.6	0.07

A complete cessation of all anthropogenic emissions from North Carolina will result in a global sea-level rise savings by the year 2100 of an estimated 0.07 cm, or three *hundredths* of an inch. Again, this value is climatically irrelevant.

Even if the entire United States were to close down its economy completely and revert to the Stone Age, without even the ability to light fires, the *growth* in emissions from China and India would replace our *entire* emissions in little more than a decade. In this context, any cuts in emissions from North Carolina would be extravagantly pointless.

Costs of Federal Legislation

And what would be the potential costs to North Carolina of legislative actions designed to cap greenhouse gas emissions? An analysis was recently completed by the Science Applications International Corporation (SAIC), under contract from the American Council for Capital Formation and the National Association of Manufacturers (ACCF and NAM), using the National Energy Modeling System (NEMS); the same model employed by the US Energy Information Agency to examine the economic impacts.

For a complete description of their findings please visit:
http://www.instituteforenergyresearch.org/cost-of-climate-change-policies/

To summarize, SAIC found that by the year 2020, average annual household income in North Carolina would decline by $836 to $2712 and by the year 2030 the decline would increase to between $3525 and $6428. The state would stand to lose between 39,000 and 59,000 jobs by 2020 and between 110,000 and 147,000 jobs by 2030. At the same time gas prices could increase by more than $5 a gallon by the year 2030 and the states' Gross Domestic Product could decline by then by as much as $18.9 billion/yr.

And all this economic hardship would come with absolutely no detectable impact on the course of future climate. This is the epitome of a scenario of all pain and no gain.

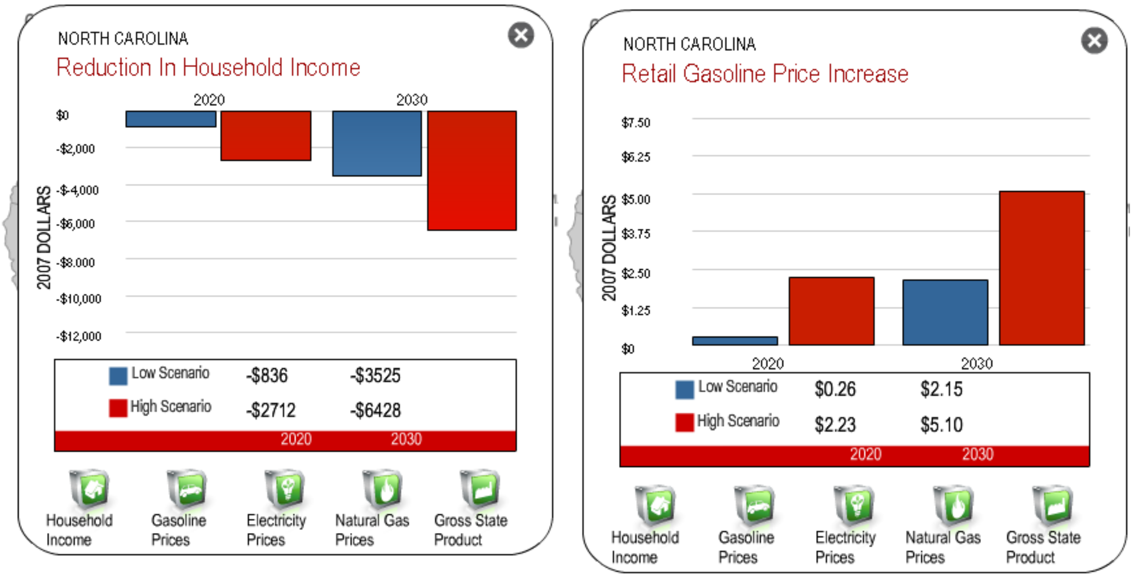

Figure 24. *The economic impacts in North Carolina of federal legislation to limit greenhouse gas emissions green. (Source: Science Applications International Corporation, 2008,* http://www.accf.org/pdf/NAM/fullstudy031208.pdf*)*

North Carolina Scientists Reject UN's Global Warming Hypothesis

At least 610 North Carolina scientists have petitioned the US government that the UN's human caused global warming hypothesis is "without scientific validity and that government action on the basis of this hypothesis would unnecessarily and counterproductively damage both human prosperity and the natural environment of the Earth."

They are joined by over **31,072** Americans with university degrees in science – including **9,021** PhDs.

The petition and entire list of US signers can be found here:
http://www.petitionproject.org/index.html

Names of the North Carolina scientists who signed the petition:

Eugene Adams, Walter F. Adams, Rolland W. Ahrens, PhD, Allan J. Albrecht, William D. Albright, Moorad Alexanian, PhD, Charles M. Allen, PhD, Reevis Stancil Alphin, PhD, John Pruyn Van Alstyne, Robert H. Appleby, Webster J. Arceneaux Jr., Robert L. Austin, Max Azevedo, Rodger W. Baier, PhD, Lloyd W. Bailey, Jim Bailey, Richard J. Baird, John L. Bakane, Charles R. Baker, PhD, D. K. Baker, PhD, R. Baker, Walter E. Ballinger, PhD, Steven Bardwell, PhD, Stanley O. Barefoot, James A. Bass, Norman J.

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Summary

The observations we have detailed in this review illustrate that year-to-year and decade-to-decade variability plays a greater role in North Carolina's climate than any long-term trends. Such short-term variability will continue dominate North Carolina's climate into the future. At the century timescale, North Carolina's climate shows no statically significant trend in statewide average annual temperature, statewide total annual precipitation, or in the frequency and/or severity of droughts—an indication that "global warming" is anything but "global" and also strong evidence that local and regional processes are more important than global ones in determining local climate and local climate variations and changes. The same is true for tropical cyclones impacting North Carolina and the United States—there is a great degree of annual and decadal variability that can be traced long into the past, but no 20th century trends in frequency, intensity, or damage. Global sea levels are indeed rising, but they are rising, and should continue to rise, at a pace that is not dissimilar to the pace of rise experienced and adapted to during the 20th century. And climate change is shown to have little, if any, detectable impacts on the overall health of North Carolina's population. Instead, application of direct measures aimed at combating the negative impacts of heat waves and vector-borne diseases prove far and away to be the most efficient and effective methods at improving the public health.

Further, no emissions reductions by North Carolina will have any detectable regional or global effect whatsoever on climate change.

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