STORM TRENDS ACROSS NORTH AMERICA

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Among the highly publicized doom-and-gloom scenarios that climate alarmists allege to attend the ongoing rise in the air's CO_2 content are predicted increases in the frequency and severity of storms. As a result, and in an effort to determine if these predictions have any validity, many scientists are examining historical and proxy storm records in an attempt to determine how temperature changes of the past millennium have impacted this aspect of Earth's climate. This summary reviews what some of them have learned about various storm trends across North America.

CANADA

Recognizing that "media reports in recent years have left the public with the distinct impression that global warming has resulted, and continues to result, in changes in the frequencies and intensities of severe weather events," Hage (2003)[1] set out to test this hypothesis in the prairie provinces of Alberta and Saskatchewan in western Canada. This was accomplished by utilizing "previously unexploited written resources such as daily and weekly newspapers and community histories" to establish a data base adequate for determining long-term trends of all destructive windstorms (primarily thunderstorm-based tornadoes and downbursts) for the region over the period 1882 to 2001. Moreover, the author states that because "sampling of small-scale events such as destructive windstorms in the prairie provinces of Canada depends strongly on the human influences of time and space changes in rural settlement patterns, ... extensive use was made of Statistics Canada data on farm numbers by census years and census areas, and on farm sizes by census years in attempts to correct for sampling errors." The results of the study revealed that "all intense storms showed no discernible changes in frequency after 1940," while *prior* to that time they had exhibited minor *maxima*.

Focusing on blizzards, Lawson (2003)[2] examined their occurrences at a number of locations within the Prairie Ecozone of western Canada, analyzing trends in occurrence and severity over the period 1953-1997. In doing so, no significant trends were found in central and eastern locations. However, there was a significant *downward* trend in blizzard frequency in the more westerly part of the prairies; and the author notes that "this trend is consistent with results found by others that indicate a decrease in cyclone frequency over western Canada." He also notes that the blizzards that *do* occur "exhibit no trend in the severity of their individual weather elements." And these observed trends, in the words of the author, "serve to illustrate that the changes in extreme weather events anticipated under Climate Change may not always be for the worse."

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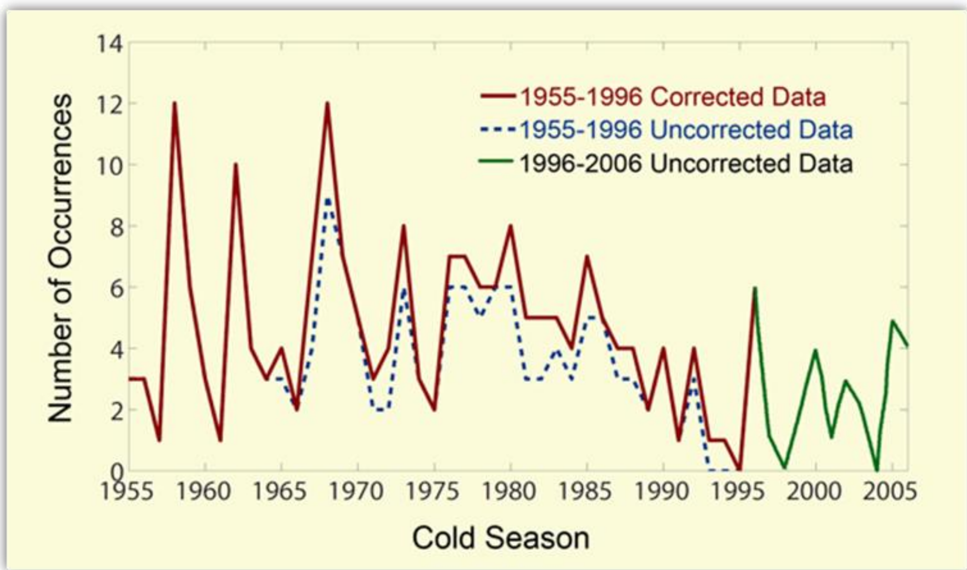
[1] http://www.co2science.org/articles/V6/N32/C2.php.

[2] http://www.co2science.org/articles/V6/N27/C1.php.

Moving further east and north, Gascon *et al*. (2010)[3] conducted a study that they describe as "the first to document the climatology of major cold-season precipitation events that affect southern Baffin Island." Specifically, they set out to examine the characteristics and climatology of the 1955-2006 major cold-season precipitation events that occurred at Iqaluit -- the capital of Nunavut, located on the southeastern part of Baffin Island in the northwestern end of Frobisher Bay -- based on analyses of hourly surface meteorological data obtained from the public archives of Environment Canada. The precipitation data from this period were corrected to account for gauge catchment errors due to wind effects, snow-water equivalence variations, and human error in the manually-retrieved precipitation data for the period 1955-1996, while the remaining data were used in their uncorrected state.

In describing their findings, the three researchers report that they detected a non-significant *decrease* in autumn and winter storm activity over the period of their study, which they say is in line with the results of Curtis *et al*. (1998), who observed a concomitant decrease in annual precipitation in the western Arctic. And this was the case in spite of the findings of Zhang *et al*. (2004), who the Canadian scientists say "reported an increase in cyclonic activity over the past fifty years, as well as McCabe *et al*. (2001), Wang *et al*. (2004) and Yin (2005)," who reported a northward shift in such activity, but which was apparently not great enough to "translate into major precipitation events, or at least not in Iqaluit," as revealed by the authors' results depicted in the figure below.



Cold-season occurrences of major precipitation events at Iqaluit, Nunavut, Canada. Adapted from Gascon et al. (2010).

ALASKA

Hudak and Young (2002)[4] examined the number of fall (June-November) storms in the southern Beaufort Sea region based on criteria of surface wind speed for the relatively short period of 1970-1995. Although there was considerable year-to-year variability in the number of storms, there was no discernible trend over the 26-year period in this region of the globe where climate models predict the effects of CO_2-induced global warming to be most evident.

[3] http://www.co2science.org/articles/V14/N1/C2.php.
[4] http://www.co2science.org/articles/V5/N37/C1.php.

Also working off the coast of Alaska, but covering a much longer time period, Mason and Jordan (2002)[5] studied numerous depositional environments along the tectonically stable, unglaciated eastern Chuckchi Sea coast that stretches across northwest Alaska, deriving a 6000-year record of sea level change, while simultaneously learning some interesting things about the correlation between storminess and climate in that part of the world. With respect to storminess, they learned that "in the Chukchi Sea, storm frequency is correlated with colder rather than warmer climatic conditions." Consequently, they say that their data "do not therefore support predictions of more frequent or intense coastal storms associated with atmospheric warming for this region."

EASTERN USA

Several studies have examined storm trends in the eastern United States. Zhang *et al*. (2000)[6], for example, used ten long-term records of storm surges derived from hourly tide gauge measurements to calculate annual values of the number, duration and integrated intensity of storms in this region. Their analysis did not reveal any trends in storm activity during the twentieth century, which they say is suggestive of "a lack of response of storminess to minor global warming along the U.S. Atlantic coast during the last 100 yr."

Similar results were reported by Boose *et al*. (2001)[7]. After scouring historical records to reconstruct hurricane damage regimes for an area composed of the six New England states plus adjoining New York City and Long Island for the period 1620-1997, they could discern "no clear century-scale trend in the number of major hurricanes." For the most recent and reliable *200-year* portion of the record, however, the cooler 19th century had five of the highest-damage F3 category storms, while the warmer 20th century had only one such storm. Thus, as the Earth experienced the warming associated with its recovery from the cold temperatures of the Little Ice Age, it would appear that this part of the planet (New England, USA) experienced, if anything, a *decline* in the intensity of severe hurricanes.

Focusing solely on New York, Vermette (2007)[8] employed the Historical Hurricane Tracks tool of the National Oceanic and Atmospheric Administration's Coastal Service Center to document all Atlantic Basin tropical cyclones that reached the state between 1851 and 2005, in order to assess the degree of likelihood that 20th-century global warming might be influencing these storms. According to the author, "a total of 76 storms of tropical origin passed over New York State between 1851 and 2005," and of these storms, "14 were hurricanes, 27 were tropical storms, 7 were tropical depressions and 28 were extratropical storms." For Long Island, in particular, he further reports that "the average frequency of hurricanes and storms of tropical origin (all types) is one in every 11 years and one in every 2 years, respectively." But perhaps the most notable finding is that storm activity was greatest in *both* the late 19th century and the late 20th century, and the fact that "the frequency and intensity of storms in the late 20th century are similar to those of the late 19th century." Vermette thus concludes that "rather than a linear change, that may be associated with a global warming, the changes in recent time are following a multidecadal cycle and returning to conditions of the latter half of the 19th century."

Going back even further in time, Noren *et al*. (2002)[9] extracted sediment cores from thirteen small lakes distributed across a 20,000-km2 region of Vermont and eastern New York, finding that "the frequency of storm-related floods in the northeastern United States has varied in regular cycles during the past

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[5] http://www.co2science.org/articles/V5/N30/C3.php.
[6] http://www.co2science.org/articles/V3/N12/C4.php.
[7] http://www.co2science.org/articles/V4/N38/C2.php.
[8] http://www.co2science.org/articles/V10/N47/C1.php.
[9] http://www.co2science.org/articles/V5/N47/C1.php.

13,000 years (13 kyr), with a characteristic period of about 3 kyr." In addition, the most recent upswing in storminess did not begin with what climate alarmists call the *unprecedented warming* of the 20th century, but "at about 600 yr BP [Before Present], coincident with the beginning of the Little Ice Age." In reality, according to the authors, the increase in storminess was likely a product of natural changes in the Arctic Oscillation.

Mallinson *et al.* (2011)[10] employed *optically stimulated luminescence* (OSL) dating of inlet-fill and flood tide delta deposits from locations in the Outer Banks barrier islands of North Carolina, to provide a "basis for understanding the chronology of storm impacts and comparison to other paleoclimate proxy data" in the region over the past 2200 years. Analyses of the cores revealed that "the Medieval Warm Period (MWP) and Little Ice Age (LIA) were both characterized by elevated storm conditions as indicated by much greater inlet activity relative to today," and they say that "given present understanding of atmospheric circulation patterns and sea-surface temperatures during the MWP and LIA, we suggest that increased inlet activity during the MWP responded to intensified hurricane impacts, while elevated inlet activity during the LIA was in response to increased nor'easter activity." In addition, the group of five researchers state that their data indicate that, relative to climatic conditions of both the Medieval Warm Period and Little Ice Age, there has more recently been "a general decrease in storminess at mid-latitudes in the North Atlantic," reflecting "more stable climate conditions, fewer storm impacts (both hurricane and nor'easter), and a decrease in the average wind intensity and wave energy field in the mid-latitudes of the North Atlantic," which suggests that model projections of increasing storms in this region as a result of CO_2-induced global warming are significantly off target.

> *If one of these severe storms (which is now about a century overdue) were to hit the Alabama coast again, climate alarmists would be citing its occurrence as vindication of their doomsday predictions. In reality, however, it would be nothing more than an illustration of the age-old adage that history repeats itself.*

CENTRAL AND SOUTHERN USA

Moving further south still, land-falling hurricanes whose eyes crossed the coast between Cape Sable, Florida and Brownsville, Texas between 1896 and 1995 were the subject of investigation by Bove *et al.* (1998)[11]. With respect to those storms, the authors note that the first half of the 20th Century saw considerably more hurricanes than the last half: 11.8 per decade vs. 9.4 per decade. Ditto for intense hurricanes of category 3 on the Saffir-Simpson storm scale: 4.8 vs. 3.6. In fact, the numbers of *all* hurricanes and the numbers of *intense* hurricanes have *both* been trending downward since 1966, with the decade starting in 1986 exhibiting the fewest intense hurricanes of the entire century.

Liu and Fearn (1993)[12] also studied major storms along the U.S. Gulf Coast, but over a much longer time period: the past 3500 years. Using sediment cores taken from the center of Lake Shelby in Alabama they

10 http://www.co2science.org/articles/V14/N34/C2.php.
11 http://www.co2science.org/articles/V5/N17/C1.php.
12 http://www.co2science.org/articles/V4/N39/C1.php.

determined that "major hurricanes of category 4 or 5 intensity directly struck the Alabama coast ... with an average recurrence interval of ~600 years," the last of which super-storms occurred around 700 years ago. They further note that "climate modeling results based on scenarios of greenhouse warming predict a 40% - 50% increase in hurricane intensities in response to warmer tropical oceans," suggestive of the likelihood that if one of these severe storms (which is now about a century overdue) were to hit the Alabama coast again, climate alarmists would be citing its occurrence as vindication of their doomsday predictions. In reality, however, it would be nothing more than an illustration of the age-old adage that history repeats itself.

In another severe storm study, Muller and Stone (2001)[13] examined historical data relating to tropical storm and hurricane strikes along the southeast U.S. coast from South Padre Island, Texas to Cape Hatteras, North Carolina for the 100-year period 1901-2000. The results of their analysis revealed that the temporal variability of tropical storm and hurricane strikes was "great and significant," with most coastal sites experiencing "pronounced clusters of strikes separated by tens of years with very few strikes." With respect to the climate-alarmist claim of a tendency for increased storminess during warmer El Niño years, the data did not support it; for tropical storms and hurricanes together, the authors found an average of 1.7 storms per El Niño season, 2.6 per neutral season, and 3.3 per La Niña season, while for hurricanes only, the average rate of occurrence ranged from 0.5 per El Niño season to 1.7 per La Niña season.

Focusing on tornadoes, Daoust (2003)[14] suggested that using tornado *days* instead of tornado *frequencies* "provides a more stable data set which should allow a more accurate analysis of the phenomenon," which analysis he proceeded to conduct. Specifically, Daoust catalogued daily tornado frequencies for each county of Missouri, USA, for the period 1950-2002, after which he transformed the results into monthly time series of tornado days for each of the state's 115 counties, its six climatic divisions, and the entire state. Results indicated the presence of positive trends in the tornado-day time series for five of the six climatic divisions of Missouri; however, *none* of these trends was statistically significant. For the sixth climatic division, on the other hand, the trend *was* significant; but it was *negative*. But perhaps most importantly, at the level of the *entire* state, Daoust reports that "for the last 53 years, no long-term trend in tornado days can be found."

In one final study from the Central United States, Changnon (2001)[15] compared thunderstorm activity at both an urban and rural location in Chicago in an attempt to determine if there might be an urban influence on thunderstorm activity. Over the 40-year period investigated (1959-1998), he found the urban station experienced an average of 4.5 (12%) more thunderstorm days per year than the more rural station; and statistical tests revealed this difference to be significant at the 99% level in all four seasons of the year. The implications of this finding should elicit caution in the interpretation of storm trend studies, many of which are based on data obtained from urban locations, which in the case of thunderstorms in Chicago, skewed the observational data upwards.

Conterminous USA

Several researchers have examined storm trends for the United States as a whole, or for large portions of it. Hayden (1999)[16], for example, investigated storm frequencies between 25° and 55°N latitude and 60° and 125°W longitude from 1885 to 1996. Over this 112-year period, he reported that large regional

13 http://www.co2science.org/articles/V5/N6/C1.php.
14 http://www.co2science.org/articles/V8/N1/C1.php.
15 http://www.co2science.org/articles/V4/N26/C2.php.
16 http://www.co2science.org/articles/V3/N6/C1.php.

changes in storm occurrences were observed; but when integrated over the entire geographic area, no net change in storminess was evident.

Similar results were noted by Changnon and Changnon (2000)[17], who examined hail-day and thunder-day occurrences over the 100-year period 1896-1995 in terms of 20-year averages obtained from records of 66 first-order weather stations distributed across the country. In doing so, they found that the frequency of thunder-days peaked in the second of the five 20-year intervals, while hail-day frequency peaked in the third or middle interval. Thereafter, both parameters declined to their lowest values of the century in the final 20-year period. Hail-day occurrence, in fact, decreased to only 65% of what it was at mid-century, accompanied by a drop in national hail insurance losses over the same period.

Several years later, the duo of authors reunited to conduct an analysis on snowstorms. Writing as background for their study, Changnon and Changnon (2006)[18] state that (1) "global climate models predict that more weather extremes will be a part of a changed climate due to greenhouse gases," that (2) such a climate change "is anticipated to result in alterations of cyclone activity over the Northern Hemisphere (Lawson, 2003)," and that (3) "a change in the frequency, locations, and/or intensity of extratropical cyclones in the mid-latitudes would alter the *incidence of snowstorms* [italics added]," citing the work of Trenberth and Owen (1999). Thus, they decided to see if real-world data could shed any light on the veracity of these predictions. Specifically, the authors conducted "a climatological analysis of the spatial and temporal distributions of...damaging snowstorms and their economic losses ... using property-casualty insurance data that consist of highly damaging storm events, classed as catastrophes by the insurance industry, during the 1949-2000 period." In support of this approach to the subject, they report that the National Academy of Sciences has identified insurance catastrophe data as "the nation's best available loss data (National Research Council, 1999)."

In describing their findings, the father-and-son research team reports that "the incidence of storms peaked in the 1976-1985 period," but that snowstorm incidence "exhibited no up or down trend during 1949-2000," although national monetary losses did have a significant upward time trend that was indicative of "a growing societal vulnerability to snowstorms." The two researchers conclude their paper by stating that "the temporal frequency of damaging snowstorms during 1949-2000 in the United States does not display any increase over time, indicating that either no climate change effect on cyclonic activity has begun, or if it has begun, altered conditions have not influenced the incidence of snowstorms."

Working with blizzards, Schwartz and Schmidlin (2002)[19] compiled a database for the years 1959-2000 for the conterminous United States. According to the pair of researchers, a total of 438 blizzards were identified in the 41-year record, yielding an average of 10.7 blizzards per year. Year-to-year variability was significant, with the number of annual blizzards ranging from a low of 1 in the winter of 1980/81 to a high of 27 during the winter of 1996/97. Linear regression analysis revealed a statistically significant increase in the annual number of blizzards during the 41-year period; but the total area affected by blizzards each winter remained relatively constant and showed no trend. If these observations are both correct, then average blizzard size is much smaller now than it was four decades ago. As the authors note, however, "it may also be that the NWS is recording smaller, weaker blizzards in recent years that went unrecorded earlier in the period, as occurred also in the official record of tornadoes in the United States."

17 http://www.co2science.org/articles/V3/N5/C3.php.
18 http://www.co2science.org/articles/V9/N28/C3.php.
19 http://www.co2science.org/articles/V5/N38/C2.php.

The results of this study thus suggest that -- with respect to U.S. blizzards -- frequency may possibly have increased, but if it did, intensity likely did the opposite. On the other hand, the study's authors suggest that the reported increase in blizzard frequency may well be due to an observational bias that developed over the years, for which there is a known analogue in the historical observation of tornados. That this possibility is likely a probability is suggested by the study of Gulev *et al*. (2001), who analyzed trends in Northern Hemispheric winter cyclones over essentially the same time period (1958-1999) and found a statistically significant decline of 1.2 cyclones per year using NCEP/NCAR reanalysis pressure data.

One year later, Balling and Cerveny (2003)[20] reviewed the scientific literature to determine what has been learned from United States weather records about severe storms during the modern era of greenhouse gas buildup in the atmosphere, paying particular attention to thunderstorms, hail events, intense precipitation, tornadoes, hurricanes and winter storm activity. Based on their review, Balling and Cerveny report that several scientists have identified an increase in heavy precipitation, but that "in other severe storm categories, the trends are downward." However, in a contemporaneous study by Kunkel (2003)[21], it is seen that although there was a sizable increase in the frequency of extreme precipitation events in the United States since the 1920s and 1930s, the frequencies of the late 1800s and early 1900s were about as high as those of the 1980s and 1990s, which finding suggests that there may well have been *no* century-long increase in this extreme type of weather either.

Shifting to a discussion on thunderstorms, Changnon (2003a)[22] utilized a newly available extensive data set on thunderstorm days covering the period 1896-1995 to assess long-term temporal variations in thunderstorm activity at 110 first-order weather reporting stations scattered across the United States. By dividing the data into five 20-year segments, Changnon found that "the 1936-1955 period was the nation's peak of storm activity during the 100-year period ending in 1995." During this central 20-year period, 40% of the 110 first-order weather stations experienced their greatest level of storm activity, whereas during the final 20-year period from 1976-1995, only 15% of the stations experienced their greatest level of storm activity.

When properly adjusted for societal and economic trends over the past half-century, monetary loss values associated with damages inflicted by extreme weather events do not exhibit an upward trend.

In a separate paper published by Changnon in 2003 (Changnon, 2003b[23]), the author investigated trends in both severe weather events and changes in societal and economic factors over the last half of the 20th century in the United States, finding mixed results. For example, he reports that "one trend is upwards (heavy rains-floods), others are downward (hail, hurricanes, tornadoes, and severe thunderstorms), and others are unchanging flat trends (winter storms and wind storms)." As mentioned earlier, however, had the analysis of heavy rains-floods been extended back to the *beginning* of the 20th century, the *longer*-term behavior of this phenomenon would likely have been found to be indicative of *no net change* over the past hundred years, as recently demonstrated by Kunkel (2003).

[20] http://www.co2science.org/articles/V6/N26/C3.php.
[21] http://www.co2science.org/articles/V6/N26/C1.php.
[22] http://www.co2science.org/articles/V8/N10/C1.php.
[23] http://www.co2science.org/articles/V6/N32/C3.php.

Insurance losses, on the other hand, rose rapidly over the past several decades, the primary reason of which was "a series of societal shifts (demographic movements, increasing wealth, poor construction practices, population growth, etc.) that collectively had increased society's vulnerability." Yet when properly adjusted for societal and economic trends over the past half-century, monetary loss values associated with damages inflicted by extreme weather events "do not exhibit an upward trend." Thus, as Changnon emphasizes, "the adjusted loss values for these extremes [do] not indicate a shift due to global warming." And to make his point perfectly clear, he reiterates that these real-world observations "do not fit the predictions, based on GCM simulations under a warmer world resulting from increased CO_2 levels, that call for weather extremes and storms to increase in frequency and intensity."

Similar findings with respect to monetary loss trends due to extreme storm events were reported again by Changnon three years later in two separate papers.

In the first of these papers, working with data from the insurance industry, the researcher from the Illinois State Water Survey analyzed "catastrophes caused solely by high winds" that had had their losses adjusted so as to make them "comparable to current year [2006] values" (Changnon (2009a)[24]). Although the *average monetary loss* of each year's catastrophes "had an upward linear trend over time, statistically significant at the 2% level," when the *number* of each year's catastrophes was considered, it was found that "low values occurred in the early years (1952-1966) and in later years (1977-2006)," while "the peak of incidences came during 1977-1991." Thus, it was not surprising, as Changnon describes it, that "the fit of a linear trend to the annual [catastrophe number] data showed no upward or downward trend."

In his second paper from 2009, Changnon (2009b)[25] utilized "records of *extremely damaging storms* [italics added] in the United States during the years 1949-2006 ... to define their temporal distribution," where such storms were defined as those producing losses greater than $100 million, with a special subset defined as those producing losses greater than $1 billion. At this extreme level of classification it was clearly evident from the pertinent data that "the number of storms at both loss levels has increased dramatically since 1990." The intriguing question, however, is *why*, to which the author presents four possible explanations. First, he notes that "storm measurement and data collection have improved over time." Second and third, he says "the increases may also reflect natural variations in climate or a shift in climate due to global warming." And he says that "a fourth reason is that society has become more vulnerable to storm damages."

In conclusion, as the Earth has warmed over the past hundred and fifty years, during its recovery from the global chill of the Little Ice Age, there has been little to no significant increase in either the frequency or intensity of stormy weather in North America. In fact, most studies suggest just the *opposite* has likely occurred. This observation -- coupled with the fact that storminess in many other parts of the planet has also decreased or held steady as the world has warmed -- thus suggests there is no data-based reason to believe that storms *anywhere* will become either more frequent or more intense if the world warms a bit more in the future.

[24] http://www.co2science.org/articles/V12/N28/C1.php.
[25] http://www.co2science.org/articles/V12/N36/C1.php.

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