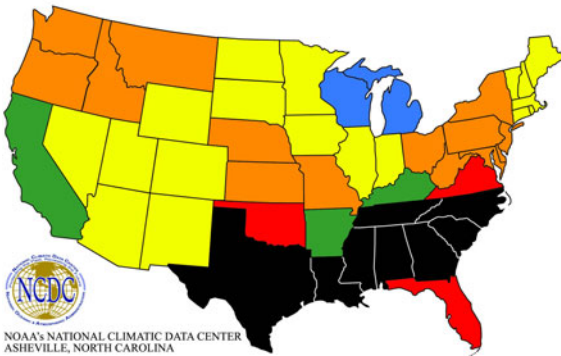


National Climatic Data Center



Billion Dollar Climate and Weather Disasters 1980 - 2003



NOAA's NATIONAL CLIMATIC DATA CENTER
ASHEVILLE, NORTH CAROLINA

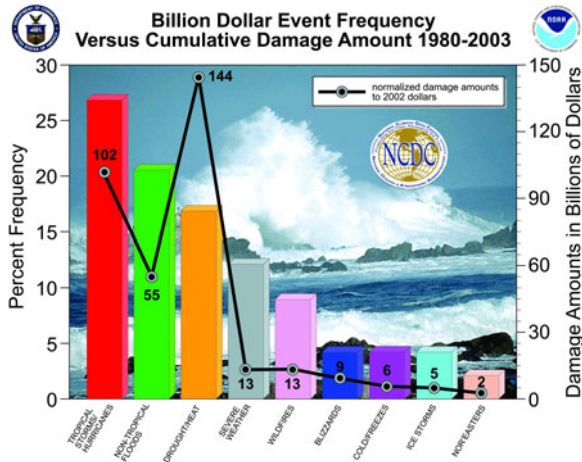
NUMBER OF EVENTS	DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	NORMALIZED DAMAGES (Billions of Dollars)	PERCENT DAMAGE
1 - 3	Tropical Storms/Hurricanes	16	28.0%	102	29.2%
4 - 6	Non-Tropical Floods	12	21.0%	55	15.8%
7 - 9	Heatwaves/Droughts	10	17.0%	144	41.2%
10 - 12	Severe Weather	7	12.0%	13	3.7%
13 - 15	Fires	6	10.0%	13	3.7%
16 - 20	Freezes	2	3.5%	6	1.7%
	Blizzards	2	3.5%	9	2.6%
	Ice Storms	2	3.5%	5	1.4%
	Noreaster	1	1.5%	2	0.7%
		58		349	

A Climatology of 1980-2003 Extreme Weather and Climate Events

Tom Ross, Neal Lott



US Department of Commerce
NOAA/ NESDIS
National Climatic Data Center
Asheville, NC 28801-5696
December 2003



=====
=====

National Climatic Data Center Technical Report No. 2003-01

A Climatology of 1980-2003 Extreme Weather and Climate Events

Tom Ross, Neal Lott

December 2003

U.S. Dept of Commerce
National Oceanic and Atmospheric Administration
National Environmental Satellite Data and Information Service
National Climatic Data Center
Asheville, NC 28801-5001

=====
=====

A CLIMATOLOGY OF 1980-2003 EXTREME WEATHER AND CLIMATE EVENTS

Thomas F. Ross and J. Neal Lott
National Climatic Data Center, Asheville, North Carolina

1. INTRODUCTION

The National Climatic Data Center (NCDC) is responsible for monitoring and assessing the Earth's climate. Each month NCDC provides comprehensive analyses of global and U.S. temperature and precipitation to place the current state of the climate into historical perspective. Identification and assessment of extreme weather events is part of this effort. An "Extreme Weather and Climate Events" suite of web pages (Figure 1) highlights these events and provides access to images, descriptions, statistics, and other detailed information for each event via the worldwide web (<http://www.ncdc.noaa.gov/extremes.html>).

One of our more popular reports in the "Extreme Weather and Climate Events" suite is the "Billion Dollar U.S. Weather Disaster" web page (<http://www.ncdc.noaa.gov/ol/reports/billionz.html>), which focuses on extreme events that caused more than \$1 billion in monetary losses in the United States, and provides links to detailed reports on many of these events. During the 1980-2003 period, there were 58 of these billion-dollar weather disasters in the United States with 46 of these events occurring since 1990. Total costs of the 58 events were nearly \$350 billion, using an inflation/wealth index to adjust damage amounts to 2002 dollars. This paper provides a climatology of these disasters and the damage and loss of life they caused.

2. U.S. EVENTS, 1980-2003

The U.S. sustained 58 weather-related disasters during the 1980-2003 period in which overall losses reached or exceeded \$1 billion dollars at the time of the event. This analysis did not include any events that had unadjusted damages/losses less than \$1 billion dollars and then subsequently may have reached \$1 billion after applying the GNP inflation/wealth index. Forty-nine of these disasters occurred since 1988 with total unadjusted losses of nearly \$220 billion. Seven events occurred in 1998 alone, the most for any year in this summary period, though other years have recorded higher damage totals.

Below is a list of these disasters in chronological order, beginning with the most recent. Two damage figures are given for events prior to 2002. The first figure represents actual dollar costs at the time of the event and is not adjusted for inflation. The value in parenthesis (if given) is the dollar cost normalized to 2002 dollars using a Gross National Product (GNP) inflation/wealth index. The total normalized losses from the 58 events are nearly \$350 billion. Figures 2 through 6 provide graphical representations of these statistics.

A wide variety of sources were used to compile these statistics and represent the authors' effort to estimate the total costs for these events in both dollars and lives. These sources include NCDC's Storm Data publication, the National Weather Service, the Federal Emergency Management Agency, other U.S. government agencies, individual state emergency management agencies, regional and state climatologists, and insurance industry estimates. The process of gathering this information, verifying the data, and keeping it up-to-date is complex. In this report, damage estimates include both insured and uninsured losses. Fatality totals incorporate both direct and indirect deaths (i.e., deaths not directly caused by the event but closely tied to it). Economic costs are included, if available, for widespread, long-lasting droughts (e.g., losses to agriculture plus related industries). Estimates are periodically updated as additional information becomes available.

3. CHRONOLOGICAL LISTING OF BILLION DOLLAR EVENTS

2003 Southern California Wildfires - Late October to early November 2003. Dry weather, high winds, and resulting wildfires in Southern California. More than 743,000 acres of brush and timber burned, over 3700 homes destroyed; at least \$2.5 billion damage/costs; 22 deaths.

Hurricane Isabel - September 2003. Category 2 hurricane makes landfall in eastern NC, causing considerable storm surge damage along the coasts of NC, VA, and MD, with wind damage and some flooding due to 4-12 inch rains in NC, VA, MD, DE, WV, NJ, NY, and PA; estimate of over \$4 billion in damages/costs; at least 47 deaths.

Severe Storms and Tornadoes - Early May 2003. Numerous tornadoes over the midwest, MS River valley, OH/TN River valleys, and portions of the southeast, with a modern record one-week total of approximately 400 tornadoes reported; over \$3.1 billion in damages/costs; 41 deaths.

Storms and Hail - Early April 2003. Severe storms and large hail over the southern plains and lower MS River valley, with TX hardest hit, and much of the monetary losses due to hail; over \$1.6 billion in damages/costs; no deaths reported.

2002 Widespread Drought - Spring through Fall 2002. Moderate to extreme drought over large portions of 30 states, including the western states, the Great Plains, and much of the eastern U.S.; estimate of over \$10 billion in damage/costs; no deaths reported.

Western Fire Season - Spring through Fall 2002. Major fires over 11 western states from the Rockies to the west coast, due to drought and periodic high winds, with over 7.1 million acres burned; over \$2.0 billion in damage/costs; 21 deaths.

2001 Tropical Storm Allison - June 2001. The persistent remnants of Tropical Storm Allison produce rainfall amounts of 30-40 inches in portions of coastal TX and LA, causing severe flooding especially in the Houston area, then moves slowly northeastward; fatalities and significant damage reported in TX, LA, MS, FL, VA, and PA; estimate of approximately \$5.0 (5.1) billion in damage/costs; at least 43 deaths.

Midwest and Ohio Valley Hail and Tornadoes - April 2001. Storms, tornadoes, and hail in the states of TX, OK, KS, NE, IA, MO, IL, IN, WI, MI, OH, KY, WV, and PA, over a 6-day period; over \$1.9 (1.9) billion in damage/costs, with the most significant losses due to hail; at least 3 deaths.

2000 Drought/Heat Wave - Spring-Summer 2000. Severe drought and persistent heat over south-central and southeastern states causing significant losses to agriculture and related industries; estimate of over \$4.0 (4.2) billion in damage/costs; estimated 140 deaths nationwide.

Western Fire Season - Spring-Summer 2000. Severe fire season in western states due to drought and frequent winds, with nearly 7 million acres burned; estimate of over \$2.0 (2.1) billion in damage/costs (includes fire suppression); no deaths reported.

1999 Hurricane Floyd - September 1999. Large, category 2 hurricane makes landfall in eastern NC, causing 10-20 inch rains in 2 days, with severe flooding in NC and some flooding in SC, VA, MD, PA, NY, NJ, DE, RI, CT, MA, NH, and VT; estimate of at least \$6.0 (6.5) billion damage/costs; 77 deaths.

Eastern Drought/Heat Wave - Summer 1999. Very dry summer and high temperatures, mainly in eastern U.S., with extensive agricultural losses; over \$1.0 (1.1) billion damage/costs; estimated 502 deaths.

Oklahoma-Kansas Tornadoes - May 1999. Outbreak of F4-F5 tornadoes hit the states of OK and KS, along with TX and TN, Oklahoma City area hardest hit; over \$1.6 (1.7) billion damage/costs; 55 deaths.

Arkansas-Tennessee Tornadoes - January 1999. Two outbreaks of tornadoes in 6-day period strike AR and TN; approximately \$1.3 (1.4) billion damage/costs; 17 deaths.

1998 Texas Flooding - October-November 1998. Severe flooding in southeast TX from 2 heavy rain events, with 10-20 inch rainfall totals; approximately \$1.0 (1.1) billion damage/costs; 31 deaths.

Hurricane Georges - September 1998. Category 2 hurricane strikes PR, FL Keys, and Gulf coasts of LA, MS, AL, and FL panhandle, 15-30 inch 2-day rain totals in parts of AL/FL; estimated \$5.9 (6.5) billion damage/costs; 16 deaths.

Hurricane Bonnie - August 1998. Category 3 hurricane strikes eastern NC and VA, extensive agricultural damage due to winds and flooding, with 10-inch rains in 2 days in some locations; approximately \$1.0 (1.1) billion damage/costs; 3 deaths.

Southern Drought/Heat Wave - Summer 1998. Severe drought and heat wave from TX/OK eastward to the Carolinas; \$6.0-\$9.0 (6.6-9.9) billion damage/costs to agriculture and ranching; at least 200 deaths.

Minnesota Severe Storms/Hail - May 1998. Very damaging severe thunderstorms with large hail over wide areas of MN; over \$1.5 (1.7) billion damage/costs; 1 death.

Southeast Severe Weather - Winter-Spring 1998. Tornadoes and flooding related to El Nino in southeastern states; over \$1.0 (1.1) billion damage/costs; at least 132 deaths.

Northeast Ice Storm - January 1998. Intense ice storm hits ME, NH, VT, and NY, with extensive forestry losses; over \$1.4 (1.5) billion damage/costs; 16 deaths.

1997 Northern Plains Flooding - April-May 1997. Severe flooding in Dakotas and MN due to heavy spring snowmelt; approximately \$3.7 (4.1) billion damage/costs; 11 deaths.

MS and OH River Valleys Flooding & Tornadoes - March 1997. Tornadoes and severe flooding hit the states of AR, MO, MS, TN, IL, IN, KY, OH, and WV, with over 10 inches of rain in 24 hours in Louisville; estimated \$1.0 (1.1) billion damage/costs; 67 deaths.

West Coast Flooding - December 1996-January 1997. Torrential rains (10-40 inches in 2 weeks) and snowmelt produce severe flooding over portions of CA, WA, OR, ID, NV, and MT; approximately \$3.0 (3.4) billion damage/costs; 36 deaths.

1996 Hurricane Fran - September 1996. Category 3 hurricane strikes NC and VA, over 10-inch 24-hour rains in some locations and extensive agricultural and other losses; over \$5.0 (5.8) billion damage/costs; 37 deaths.

Southern Plains Severe Drought - Fall 1995 through Summer 1996. Severe drought in agricultural regions of southern plains--TX and OK most severely affected; approximately \$5.0 (6.0) billion damage/costs; no deaths.

Pacific Northwest Severe Flooding - February 1996. Very heavy, persistent rains (10-30 inches) and melting snow over OR, WA, ID, and western MT; approximately \$1.0 (1.2) billion damage/costs; 9 deaths.

Blizzard of '96 Followed by Flooding - January 1996. Very heavy snowstorm (1-4 feet) over Appalachians, Mid-Atlantic, and Northeast; followed by severe flooding in parts of same area due to rain & snowmelt; approximately \$3.0 (3.5) billion damage/costs; 187 deaths.

1995 Hurricane Opal - October 1995. Category 3 hurricane strikes FL panhandle, AL, western GA, eastern TN, and the western Carolinas, causing storm surge, wind, and flooding damage; over \$3.0 (3.6) billion damage/costs; 27 deaths.

Hurricane Marilyn - September 1995. Category 2 hurricane devastates U.S. Virgin Islands; estimated \$2.1 (2.5) billion damage/costs; 13 deaths

Texas/Oklahoma/Louisiana/Mississippi Severe Weather and Flooding - May 1995. Torrential rains, hail, and tornadoes across TX - OK and southeast LA - southern MS, with Dallas and New Orleans areas (10-25 inch rains in 5 days) hardest hit; \$5.0-\$6.0 (6.5-7.1) billion damage/costs; 32 deaths.

California Flooding - January-March 1995. Frequent winter storms cause 20-70 inch rainfall and periodic flooding across much of CA; over \$3.0 (3.6) billion damage/costs; 27 deaths.

1994 Western Fire Season - Summer-Fall 1994. Severe fire season in western states due to dry weather; approximately \$1.0 (1.2) billion damage/costs; death toll undetermined.

Texas Flooding - October 1994. Torrential rain (10-25 inches in 5 days) and thunderstorms cause flooding across much of southeast TX; approximately \$1.0 (1.2) billion damage/costs; 19 deaths.

Tropical Storm Alberto - July 1994. Remnants of slow-moving Alberto bring torrential 10-25 inch rains in 3 days, widespread flooding and agricultural damage in parts of GA, AL, and panhandle of FL; approximately \$1.0 (1.2) billion damage/costs; 32 deaths.

Southeast Ice Storm - February 1994. Intense ice storm with extensive damage in portions of TX, OK, AR, LA, MS, AL, TN, GA, SC, NC, and VA; approximately \$3.0 (3.7) billion damage/costs; 9 deaths.

1993 California Wildfires - Fall 1993. Dry weather, high winds and wildfires in Southern CA; approximately \$1.0 (1.3) billion damage/costs; 4 deaths.

Midwest Flooding - Summer 1993. Severe, widespread flooding in central U.S. due to persistent heavy rains and thunderstorms; approximately \$21.0 (26.7) billion damage/costs; 48 deaths.

Drought/Heat Wave - Summer 1993. Southeastern U.S.; about \$1.0 (1.3) billion damage/costs to agriculture; at least 16 deaths.

Storm/Blizzard - March 1993. "Storm of the Century" hits entire eastern seaboard with tornadoes (FL), high winds, and heavy snows (2-4 feet); \$3.0-\$6.0 (3.8-7.6) billion damage/costs; approximately 270 deaths.

1992 Nor'easter of 1992 - December 1992. Slow-moving storm batters northeast U.S. coast, New England hardest hit; \$1.0-\$2.0 (1.3-2.6) billion damage/costs; 19 deaths.

Hurricane Iniki - September 1992. Category 4 hurricane hits HI island of Kauai; about \$1.8 (2.4) billion damage/costs; 7 deaths.

Hurricane Andrew - August 1992. Category 5 hurricane hits FL and LA, high winds damage or destroy over 125,000 homes; approximately \$27.0 (35.6) billion damage/costs; 61 deaths.

1991 Oakland Firestorm - October 1991. Oakland, CA, firestorm due to low humidities and high winds; approximately \$2.5 (3.5) billion damage/costs; 25 deaths.

Hurricane Bob - August 1991. Category 2 hurricane--Mainly coastal NC, Long Island, and New England; \$1.5 (2.1) billion damage/costs; 18 deaths.

1990 Texas/Oklahoma/Louisiana/Arkansas Flooding - May 1990. Torrential rains cause flooding along the Trinity, Red, and Arkansas Rivers in TX, OK, LA, and AR; over \$1.0 (1.4) billion damage/costs; 13 deaths.

1989 Hurricane Hugo - September 1989. Category 4 hurricane devastates SC and NC with ~ 20 foot storm surge and severe wind damage after hitting PR and the U.S. Virgin Islands; over \$9.0 (13.9) billion

damage/costs (about \$7.1 (10.9) billion in Carolinas); 86 deaths (57--U.S. mainland, 29--U.S. Islands).

Northern Plains Drought - summer 1989. Severe summer drought over much of the northern plains with significant losses to agriculture; at least \$1.0 (1.5) billion in damage/costs; no deaths reported.

1988 Drought/Heat Wave - Summer 1988. Drought in central and eastern U.S. with very severe losses to agriculture and related industries; estimated \$40.0 (61.6) billion damage/costs; estimated 5,000 to 10,000 deaths (includes heat stress-related).

1986 Southeast Drought/Heat Wave - Summer 1986. Severe summer drought in parts of the southeastern U.S. with severe losses to agriculture; \$1.0-\$1.5 (1.8-2.6) billion in damage/costs; estimated 100 deaths.

1985 Hurricane Juan - October-November 1985. Category 1 hurricane--LA and Southeast U.S.--severe flooding; \$1.5 (2.8) billion damage/costs; 63 deaths.

Hurricane Elena - August-September 1985. Category 3 hurricane--FL to LA; \$1.3 (2.4) billion damage/costs; 4 deaths.

Florida Freeze - January 1985. Severe freeze central/northern FL; about \$1.2 (2.2) billion damage to citrus industry; no deaths.

1983 Florida Freeze - December 1983. Severe freeze central/northern FL; about \$2.0 (4.0) billion damage to citrus industry; no deaths.

Western Storms and Flooding - 1982 Early 1983. Storms and flooding related to El Nino, especially in the states of WA, OR, CA, AZ, NV, ID, UT, and MT; approximately \$1.1 (2.2) billion in damage/costs; at least 45 deaths.

Gulf States Storms and Flooding - 1982 - Early 1983. Storms and flooding related to El Nino, especially in the states of TX, AR, LA, MS, AL, GA, and FL; approximately \$1.1 (2.2) billion in damage/costs; at least 50 deaths.

Hurricane Alicia - August 1983. Category 3 hurricane--TX; \$3.0 (5.9) billion damage/costs; 21 deaths.

1980 Drought/Heat Wave - June-September 1980. Central and eastern U.S.; estimated \$20.0 (48.4) billion damage/costs to agriculture and related industries; estimated 10,000 deaths (includes heat stress-related).

4. POPULATION CHANGES AND SOCIETAL IMPACTS

The general increase in population since 1900 has placed more people at risk when an extreme weather event occurs. Rapid growth in U.S. coastal population places more people in "harm's way" when hurricanes make landfall. Coastal areas are among the most crowded and developed in the nation. This narrow fringe--comprising less than one-fifth of the contiguous United States land area--accounts for over one-half of the nation's population and housing supply. The population of these areas grew by more than 38 million people between 1960 and 1990. In 1990, over 133 million Americans lived in the 673 coastal counties along the Atlantic and Pacific Oceans, Gulf of Mexico, and Great Lakes, representing about 54 percent of the total U.S. population. Population in the nation's coastal areas increased by 41 percent between 1960 and 1990, slightly faster than the U.S. as a whole. (NOAA Office of Ocean Resources Conservation and Assessment (ORCA), 2003)

For example, the coastal population in Florida increased from approximately one million in 1940, to 4.8 million in 1960, to 12.8 million in 1990 (University of Florida Bureau of Economic & Business Research, 1994). This rate of growth is four times that of the U.S. in general, and is largely due to immigration from other U.S. states. Most of the immigrants prefer to settle close to the shore: seventy-nine percent of Florida's population live within the coastal zone (Culliton et al., 1990). Florida's coastal population increase has not been uniform:

the Atlantic coast counties have seen a 175% increase, while the Gulf has experienced a 160% increase (Antonini and Box, 1996). Important demographic changes have accompanied this growth. Large numbers of Florida residents are retired: they are older, generally wealthier, and have more available leisure time than earlier populations. From 1990-2000, Florida's population has grown by 23.5 % or an increase of 3 million persons.

For the years 1980-2003, about 30% of the billion dollar events were either hurricanes or tropical storms. According to Pielke and Landsea (1998), "...all else being equal, each year the United States has at least a 1 in 6 chance of experiencing losses related to hurricanes of at least \$10 billion (in normalized 1996 dollars)." Climate patterns can significantly alter these odds (Gray et al., 1997), and each year the stakes rise due to coastal population growth and development. In 1990, Dade and Broward Counties in south Florida were home to more people than lived in all 109 counties along the Gulf and Atlantic coasts from Texas through Virginia in 1930 (Pielke, 1995). Other coastal zones are vulnerable, and hurricanes have come ashore from Texas to Maine. Yet the U.S. population is flocking to the coasts. The 426 coastal counties have just 11 percent of the territory in the continental U.S., but hold 110 million people -- 45 percent of the population. (In 1940, the population of these counties was 50 million.) Also, insured coastal property values increased by 100% to 300% (depending on location) during the 1980-2003 period.

In the three decades preceding Hurricanes Hugo (1989) and Andrew (1992), few major hurricanes (sustained wind speed greater than 110 miles-per-hour) struck the United States. However, from 1941 through 1950, ten major hurricanes struck the continental United States, seven of which made landfall in Florida. From 1951 through 1960, eight major hurricanes struck the United States, seven along the East Coast. For the next 30 years (1961-1990), the only major hurricane to strike the Florida peninsula was Hurricane Betsy in 1965. Similarly, during this period, no major hurricanes made landfall on the East Coast until the mid-1980s (Ayscue, 1996). However, some studies (Gray et al., 1997) indicate that a return to the more active hurricane seasons typical of the 1940s and 1950s is now occurring.

The combination of more active hurricane seasons, coastal population increases and increasing per capita income along the U.S. East and Gulf coasts provide conditions that may lead to more frequent major disasters. Nationally, the significant increase in the number of homes and businesses built in flood plains over the past fifty years increases the risk and frequency for high-cost flooding events. If these societal trends continue, the costs associated with weather-related disasters will continue to increase, regardless of any factors associated with climate change.

5. SUMMARY AND CONCLUSION

In twenty of the past twenty-four years, the U.S. has experienced at least one weather-related billion-dollar disaster. The only years without at least one billion dollar disaster were 1981, 1982, 1984 and 1987. Since 1988, at least one disaster occurred each year, with only one such event in 1988 and 1990, and seven billion-dollar events in 1998. Two of the 1998 disasters were caused by hurricanes. Overall, hurricanes and tropical storms account for 16 of the 58 events and 28% of the monetary losses (normalized to 2002). The ten major droughts/heatwaves which have occurred since 1980 account for the largest percentage (42%) of weather-related monetary losses. Figures 5 and 6 provide additional statistics for the distribution of events by type.

The clearest evidence which explains the increase in losses due to hurricanes, points to changes in society, not in climate fluctuations. In fact, Pielke and Landsea (1998) state, "It is only a matter of time before the nation experiences a \$50 billion or greater storm, with multi-billion dollar losses becoming increasingly more frequent. Climate fluctuations that return the Atlantic basin to a period of more frequent storms will enhance the chances that this time occurs sooner, rather than later." Another study suggests, adjustments to historical loss data assembled since the late 1940s shows that most of the upward trends found in financial losses are due to societal shifts leading to ever-growing vulnerability to weather and climate extremes. Geographical locations of the large loss trends establish that population growth and demographic shifts are the major factors behind the increasing losses from weather-climate extremes. (Chagnon et al., 2000)

Although some studies (Chagnon et al., 1999) suggest that trends such as population increases, population shifts into higher risk areas, and increasing wealth have been the key factors in weather related disasters (as opposed to historical trends in the frequency or strength of such events), there is evidence that climate change may affect the frequency of certain extreme weather events. An increase in population and development in flood plains, along with an increase in heavy rain events in the U.S. during the past fifty years (Karl et al., 1996), have gradually increased the economic losses due to flooding. If the climate continues to warm, the increase in heavy rain events is likely to continue. While trends in extratropical cyclones are not clear, there are projections that the incidence of extreme droughts will increase if the climate warms throughout the 21st century (Easterling et al., 2000).

Regardless of these factors and trends, Americans will continue to cope with major economic and human losses due to hurricanes, droughts, and other weather-related disasters. As new events occur and updated statistics become available, NCDC will continue to update its worldwide web system (as shown in Fig 1, accessible via <http://www.ncdc.noaa.gov/extremes.html>).

6. REFERENCES

Antonini, G. A. and Box, P. W. (1996). A regional waterway systems management strategy for southwest Florida. Technical Report TP-83, Florida Sea Grant College Program, University of Florida, Gainesville.

Chagnon, Stanley A., R.A.Pielke Jr., D. Chagnon, R.T. Sylves and R. Pulwarty., 2000. Human Factors Explain the Increased Losses from Weather and Climate Extremes. *Bulletin of the American Meteorological Society*, Vol. 81, No. 3, March 2000, pp 437-442.

Chagnon, Stanley A., K.E. Kunkel, and R.A. Pielke Jr., 1999. Temporal Fluctuations in Weather and Climate Extremes That Cause Economic and Human Health Impacts: A Review, *Bulletin of the American Meteorological Society*, Vol. 80, No. 6, Jun. 1999, pp 1077-1098.

Culliton, T., Warren, M., Goodspeed, T., Remer, D., Blackwell, C., and McDonough, J. (1990). Fifty Years of Population Change Along the Nation's Coasts, 1960-2010. NOAA, Rockville, MD. NOAA Coastal Trends Series.

Easterling, David R., Gerald A. Meehl, Camille Parmesan, Stanley A. Chagnon, Thomas R. Karl, and Linda O. Mearns: Climate Extremes: Observations, Modeling, and Impacts, *Science*, Sep 22, 2000: 2068-2074.

Gray, W.M., J.D. Shaeffer, and C.W. Landsea, 1997: Climate Trends Associated with Multidecadal Variability of Atlantic Hurricane Activity. *Hurricanes, Climate and Socioeconomic Impacts*, H.F. Diaz and R.S. Pulwarty, Eds., Springer, 15-53.

Karl, Thomas R, R.W. Knight, D.R. Easterling, and R.G. Quayle, 1996. Indices of Climate Change for the United States, *Bulletin of the American Meteorological Society*, Vol. 77, No. 2, Feb. 1996, pp 279-292.

NOAA Office of Ocean Resources Conservation and Assessment, 2003 (ORCA)- Web site, <http://spo.nos.noaa.gov/projects/population/population.html>.

Pielke, R.A., Jr., 1995: Hurricane Andrew in South Florida: Mesoscale Weather and Societal Responses. National Center for Atmospheric Research, 212 pp.

Pielke, R. A. and C.W. Landsea, 1998: Normalized Hurricane Damages in the United States, 1925- 1995, *Weather and Forecasting*, September 1998, pp. 621-631.

University of Florida Bureau of Economic & Business Research (1994). Florida Statistical Abstracts. University of Florida Press, University of Florida, Gainesville.

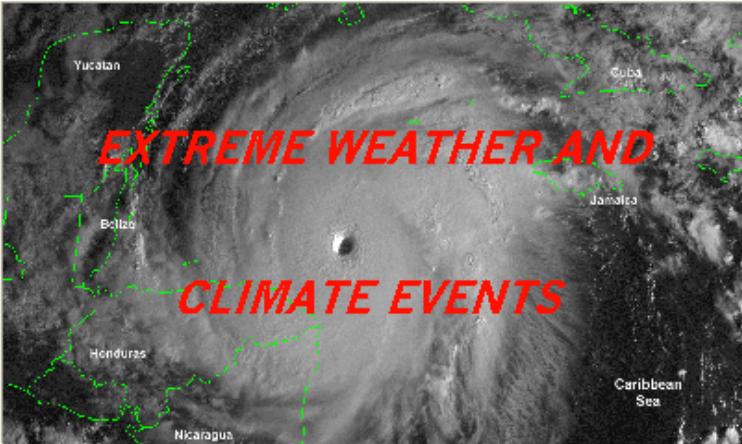
<u>U.S. Hurricanes</u>	<u>Heavy Precipitation</u>	<u>Temperature Extremes & Drought</u>	<u>U.S. Tornadoes</u>
<u>Billion \$\$ Weather Disasters</u>			<u>Worldwide Weather and Climate Events</u>
<u>Global Climate Change</u>			<u>Historical Global Extremes</u>
<u>El Nino/ La Nina</u>			<u>Satellite Images</u>
<u>Climate Monitoring</u>			<u>U.S. Local Storm Reports</u>

Figure 1. Extreme Weather and Climate Events Web System --- www.ncdc.noaa.gov/extremes.html



Billion Dollar Weather Disasters 1980 - 2003

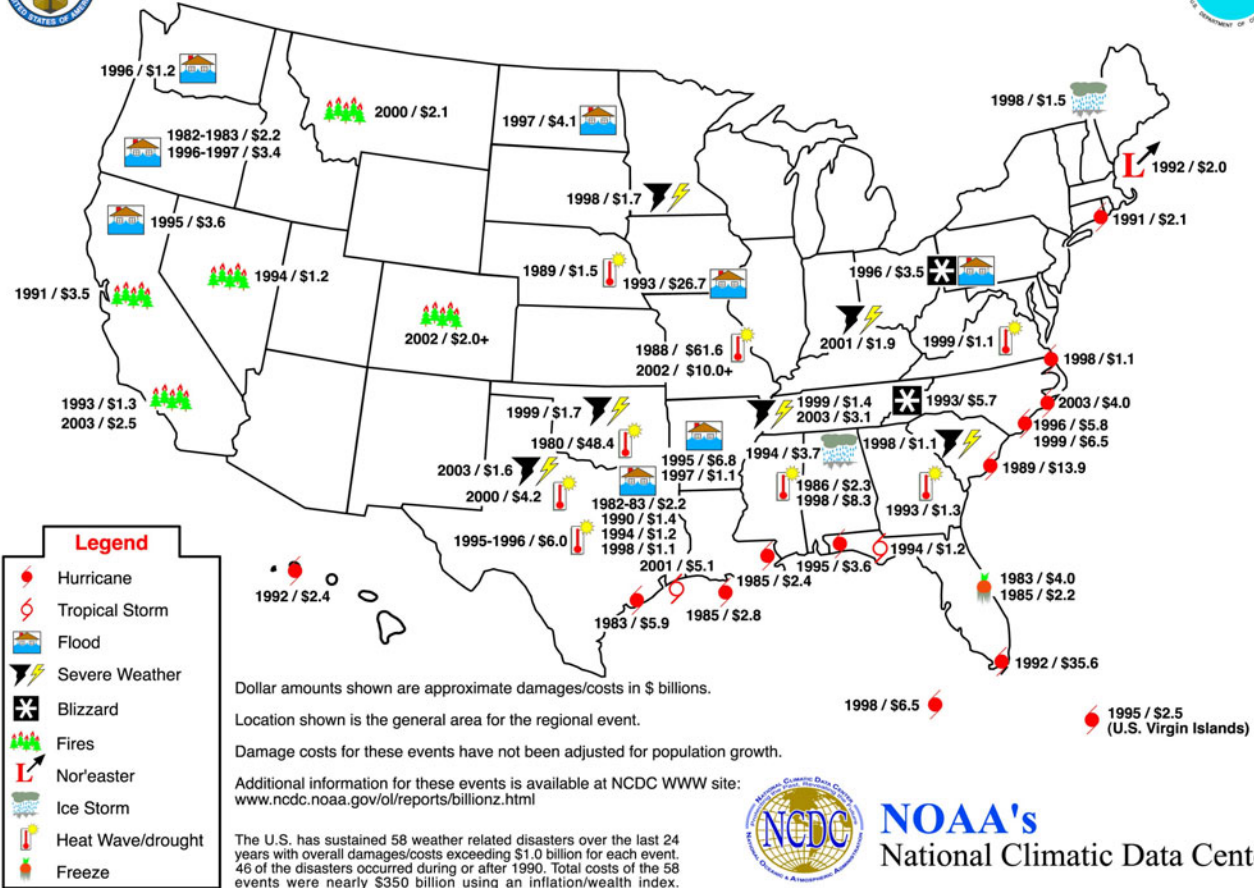


Figure 2. Billion Dollar U.S. Weather Disaster Map, 1980-2003, Adjusted Costs - www.ncdc.noaa.gov/ol/reports/billionz.html



Billion Dollar U.S. Weather Disasters 1980-2003

NOAA / NESDIS / NCDC

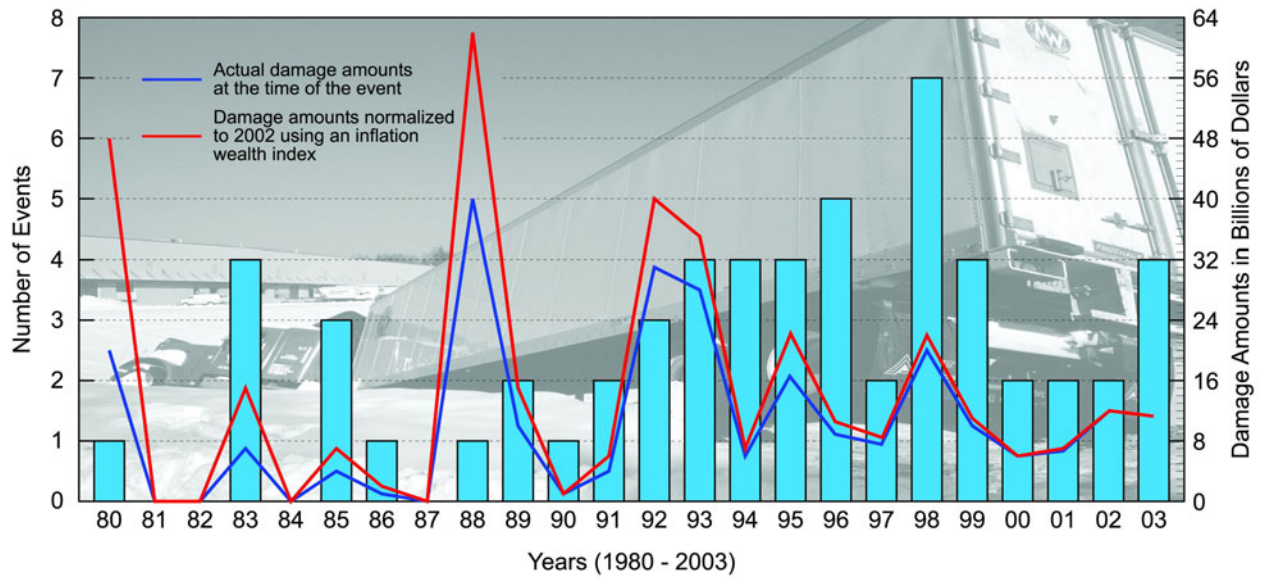


Figure 3. Bar Chart of Annual Number of U.S. Billion Dollar Weather Disasters, 1980-2003



Billion Dollar U.S. Weather Disasters 1980-2003



(Damage Amounts in Billions of Dollars and
Costs Normalized to 2002 Dollars Using GNP Inflation / Wealth Index)

1980	Drought / Heat Wave \$48.4 ~10,000 Deaths				
1983	Hurricane Alicia \$5.9 21 Deaths	Florida Freeze \$4.0 No Deaths	Gulf Storms / Flooding \$2.2 ~ 50 Deaths	W Storms / Flooding \$2.2 ~ 45 Deaths	
1985	Florida Freeze \$2.2 No Deaths	Hurricane Elena \$2.4 4 Deaths	Hurricane Juan \$2.8 63 Deaths		
1986	Drought / Heat Wave \$2.3 ~100 Deaths				
1988	Drought / Heat Wave \$61.6 ~7,500 Deaths				
1989	Hurricane Hugo \$13.9 86 Deaths	N Plains Drought \$1.5 No Deaths			
1990	S Plains Flooding \$1.4 13 Deaths				
1991	Hurricane Bob \$2.1 18 Deaths	Oakland CA Firestorm \$3.5 25 Deaths			
1992	Hurricane Andrew \$35.6 61 Deaths	Hurricane Iniki \$2.4 7 Deaths	Nor'easter \$2.0 19 Deaths		
1993	E Storm / Blizzard \$5.7 270 Deaths	SE Drought / Heat Wave \$1.3 16 Deaths	Midwest Flooding \$26.7 48 Deaths	CA Wildfires \$1.3 4 Deaths	
1994	SE Ice Storm \$3.7 9 Deaths	Tropical Storm Alberto \$1.2 32 Deaths	Texas Flooding \$1.2 19 Deaths	W Fire Season \$1.2 No Deaths	
1995	CA Flooding \$3.6 27 Deaths	SE / SW Severe Wx \$6.8 32 Deaths	Hurricane Marilyn \$2.5 13 Deaths	Hurricane Opal \$3.6 27 Deaths	
1996	Blizzard / Flooding \$3.5 187 Deaths	Pacific NW Flooding \$1.2 9 Deaths	S Plains Drought \$6.0 No Deaths	Hurricane Fran \$5.8 37 Deaths	W Coast Flooding \$3.6 36 Deaths
1997	Midwest Flood / Tornadoes \$1.1 67 Deaths	N Plains Flooding \$4.1 11 Deaths			
1998	New England Ice Storm \$1.5 16 Deaths	SE Severe Wx \$1.1 132 Deaths	MN Severe Storms / Hail \$1.7 1 Death	S Drought / Heat Wave \$8.3 200 Deaths	Hurricane Bonnie \$1.1 3 Deaths
	Hurricane Georges \$6.5 16 Deaths	Texas Flooding \$1.1 31 Deaths			
1999	AR - TN Tornadoes \$1.4 17 Deaths	OK - KS Tornadoes \$1.7 55 Deaths	E Drought / Heat Wave \$1.1 502 Deaths	Hurricane Floyd \$6.5 77 Deaths	
2000	Drought / Heat Wave \$4.2 ~140 Deaths	W Fires \$2.1 No Deaths			
2001	Tropical Storm Allison \$5.1 43 Deaths	Midwest / OH Valley Hail / Tornadoes \$1.9 ~3 Deaths			
2002	30-State Drought \$10.0 No Deaths				
	W Fires \$2.0 ~21 Deaths				
2003	Severe Wx / Hail \$1.6 No Deaths	Severe Wx / Tornadoes \$3.1 41 Deaths	Hurricane Isabel \$4.0 47 Deaths	S California Wildfires \$2.5 22 Deaths	

legend



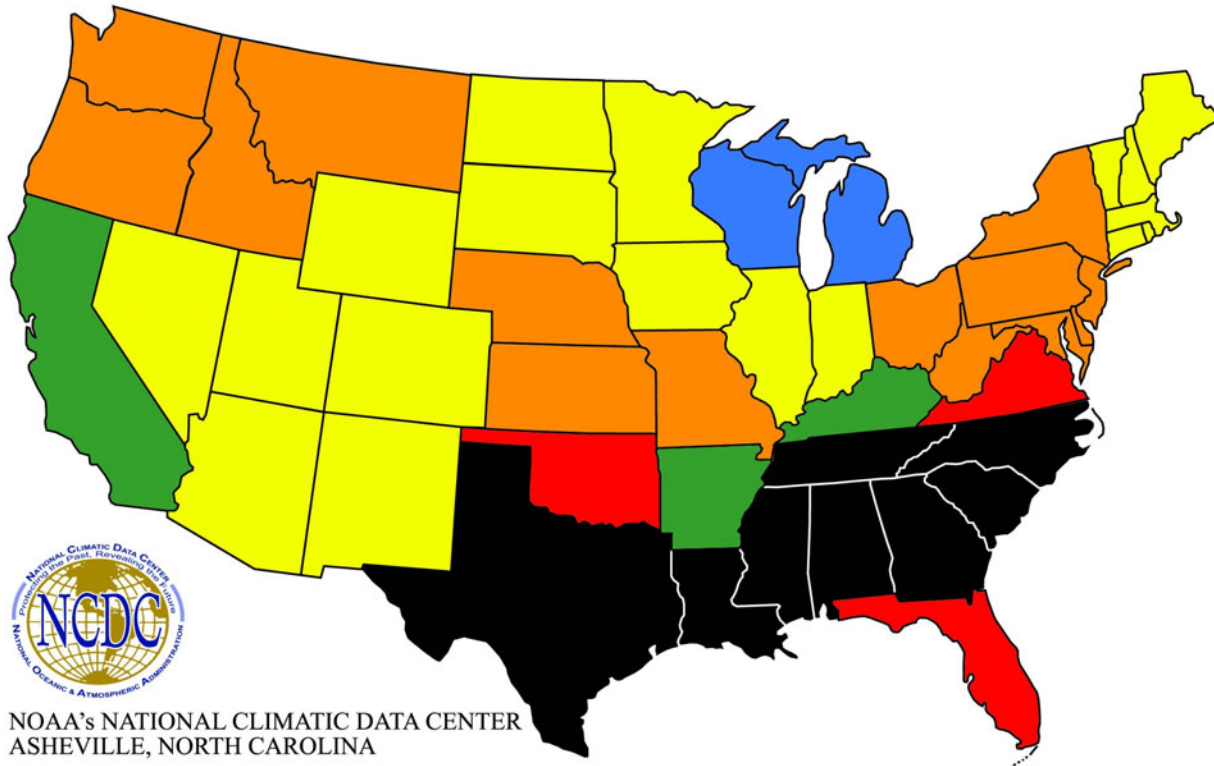
Source:
National Climatic Data Center
Asheville, NC 28801-5001
www.ncdc.noaa.gov/oa/reports/billionz.html

< 5	5-20	20-30	30-40	> 40
Amounts in Billions of Dollars				

Figure 4. Billion Dollar U.S. Weather Disasters, 1980-2003 - Chronological Chart



Billion Dollar Climate and Weather Disasters 1980 - 2003



NOAA's NATIONAL CLIMATIC DATA CENTER
ASHEVILLE, NORTH CAROLINA

NUMBER OF EVENTS	DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	NORMALIZED DAMAGES (Billions of Dollars)	PERCENT DAMAGE
1 - 3	Tropical Storms/Hurricanes	16	28.0%	102	29.2%
4 - 6	Non-Tropical Floods	12	21.0%	55	15.8%
7 - 9	Heatwaves/Droughts	10	17.0%	144	41.2%
10 - 12	Severe Weather	7	12.0%	13	3.7%
13 - 15	Fires	6	10.0%	13	3.7%
16 - 20	Freezes	2	3.5%	6	1.7%
	Blizzards	2	3.5%	9	2.6%
	Ice Storms	2	3.5%	5	1.4%
	Noreaster	1	1.5%	2	0.7%
		58		349	

Figure 5. Distribution of Events by Type and State, Showing Total Normalized Losses for Each Category



Billion Dollar Event Frequency Versus Cumulative Damage Amount 1980-2003

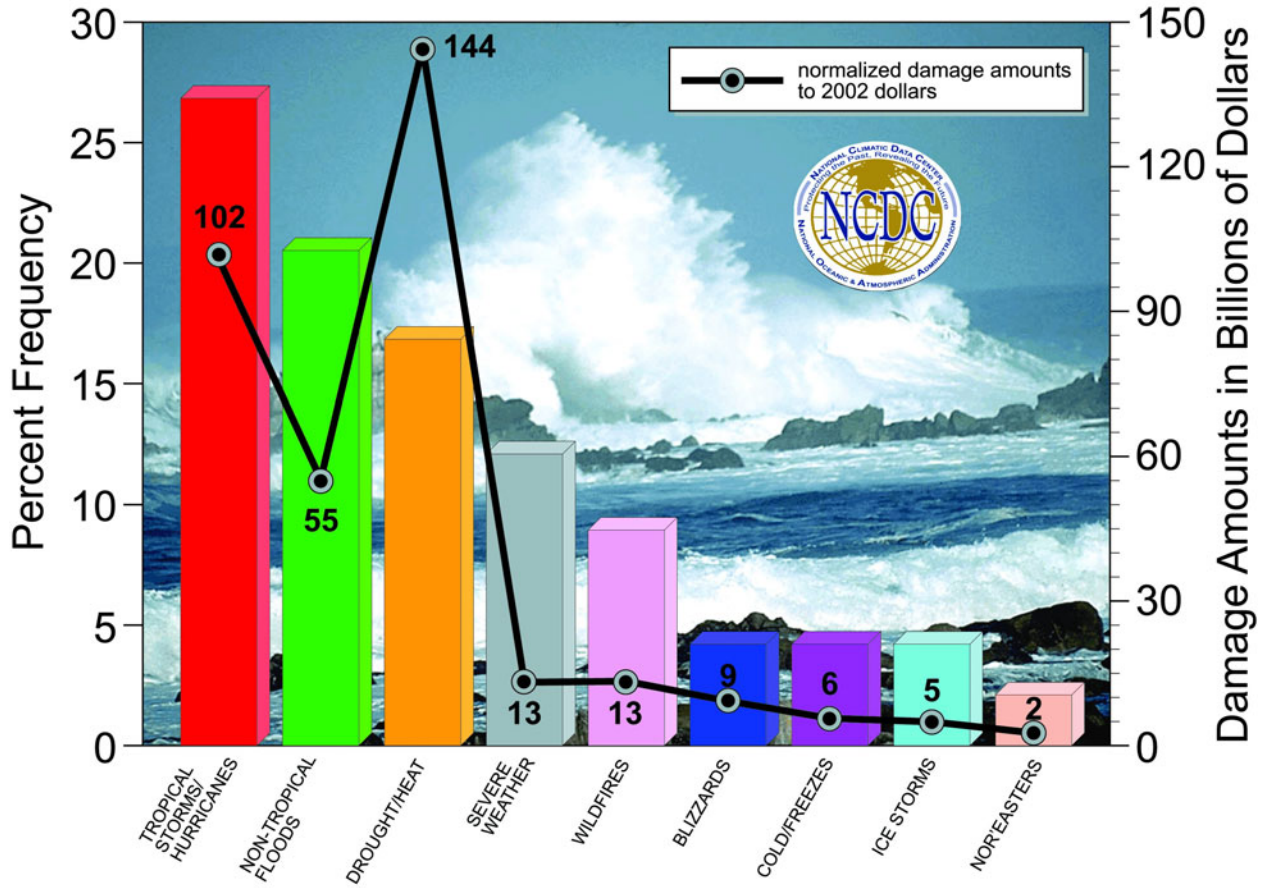


Figure 6. Distribution of Event Frequency by Cumulative Damage Amount, 1980-2003