Extreme Weather Records

Compilation, Adjudication, and Publication

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In a world with increasing 24/7 media coverage of disasters, carelessness in the use of the word "record" in relation to weather has increased. Several times during the passage and aftermath of Hurricane Katrina (2005), some members of the media referred to the undoubtedly horrific event as the "worst disaster of all time." While economically that may perhaps prove to be true, and such overstatement does capture either the listener's or reader's interest, it leads to a potentially distorted view of weather. As Kunkel et al. (1999) stated, the upward trend in economic losses due to extreme weather events has "led many to conclude that the United States has witnessed changes in the frequency and/or intensity of extreme events. These perceptions are more than idle speculations—they underlie policy decisions with important social, economic, and political ramifications, such as those related to climate change and natural disasters."

As the perception (or the actual occurrence) of more frequent extreme weather events grows, there is more importance placed on recorded archives and verification of "extreme record events." Without the existence of an official governmental or meteorological body that adjudicates and maintains regional or world records of extreme weather events, supportive documentation needed to assess the validity of a weather record event is often hard to find or does not exist. It is imperative to have a central governmental or meteorological body tasked with creating and maintaining a list of extreme weather events, because many factors—such as the type of instrumentation, the site exposure, the calibration of the recording instrument, and even the frequency of measurement—are critical elements of an official evaluation of a weather record. It should be noted that the private sector also maintains a wide range of observing systems and contains many users of weather records. How best to incorporate the private sector in weather record keeping is a subject that goes beyond the scope of this paper, but one whose importance we do not wish to overlook (Pielke et al. 2003).

For the United States, the issue of adjudication of a weather record has led to the creation of a committee tasked with that responsibility. The National Oceanic and Atmospheric Administration (NOAA) established the National Climate Extremes Committee (NCEC) in 1997 "to assess the scientific merit of extreme meteorological/climatological events and provide a recommendation to NOAA management regarding the validity of related meteorological measurements." The committee consists of three members: the chair, representing the National Climatic Data Center (NCDC); a member from the National Weather Service's (NWS's) Office of Climate, Water, and Weather; and a representative from the American Association of State Climatologists (AASC).

The NCEC mission statement maintains that the committee will consider certain weather elements (explicitly, temperature, snow, rain, wind, hail, and atmospheric pressure) (NCDC 2005). The following few additional caveats are also important:

a) The committee only evaluates national records, such that, in general, regional, statewide, or local records are not considered. However, in cases where the measurement of a potential new record has broader significance, such as when questions about network-wide observing practices have arisen as a result of a new reported record, precedence has established that the committee

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can review such records as a means of addressing these broader issues. Furthermore, when any review results in the establishment of a new state or local record or a question about the potential for a new record exists, the NCEC confers with the respective state climatologist, as well as a representative from the local NWS forecast office, and the responsible Regional Climate Center.

b) The committee only adjudicates certain aspects of those elements (e.g., the highest maximum temperature, maximum wind gust, etc.), but the stipulation is made that the list of weather elements may be expanded as additional weather extremes are determined (e.g., greatest monthly rainfall/snowfall).

c) At present, the NCEC does not evaluate records related to remotely sensed measurements, such as radar-derived precipitation or wind speeds (e.g., associated with remotely sensed tornadic winds). The U.S. weather records currently within the NCEC's jurisdiction are given in Table 1.

Validation can be important to ensure the integrity of our climate record and to support our efforts to understand how climate is changing, in addition to subsequent policy decisions. Such an effort in validation is an integral part of the overall effort to ensure proper adherence to sound climatological practices. Also, climate records and validation can have a dramatic impact on commercial interests, such as the engineering trade (as noted by the Army Corps of Engineers; see Krause and Flood 1997) and the insurance trade (e.g., climate change reports from Swiss Re), as well as more localized social or economic interests. For example, the city museum in Coffeyville, Kansas, has a replica on display of its 3 September 1970 hailstone and, until recently, had been promoting it as the world's largest hailstone. When the Aurora, Nebraska, hailstone of 22 June 2003 occurred, the NCEC committee (with three additional members from the local NWS Weather Forecast Office and the NWS Central Region for that evaluation) determined that it was the largest U.S. hailstone in circumference and diameter. They did, however, note that a weight determination of the Aurora hailstone was not possible because "a chunk of the stone hit the gutter of a house resulting in the loss of approximately 40 percent of the stone. The estimate for the portion that remained was

Table 1. U.S. weather elements and characteristics currently within the jurisdiction of the NCEC.

Weather element	Characteristic	Value	Date	Location
Temperature	Maximum	56.67°C (134°F)	10 Jul 1913	Greenland Ranch, California
	Minimum	−62.22°C (−80°F)	23 Jan 1971	Prospect Creek, Alaska
	Max 24-h change	39.44°C (103°F)	14–15 Jan 1972	Loma, Montana
Snow	Max 24-h snowfall	1.925 m (75.8 in.)	14–15 Apr 1921	Silver Lake, Colorado
	Max seasonal snowfall (July–June)	28.956 m (1140 in.)	1998–1999	Mt. Baker Ski Area, Washington
	Max snow depth	11.455 m (451 in.)	11 Mar 1911	Tamarack, California
Rain	Max 24 hr	1.092 m (43 in.)	25–26 Jul 1979	Alvin, Texas
	Least annual	0.0 m	1929	Death Valley, California
	Max annual	17.903 m (704.83 in.)	1982	Kukui, Hawaii
	Longest dry period	767 days	3 Oct 1912–8 Nov 1914	Bagdad, California
Wind	Max gust	103.3 m s^{-1} (231 mph)	12 Apr 1934	Mt. Washington, New Hampshire
Hail	Largest (diameter/circumference)	17.78 mm/47.625 mm (7 in./18.75 in.)	22 Jun 2003	Aurora, Nebraska
	Heaviest	0.7575 kg (1.67 lbs)	3 Sep 1970	Coffeyville, Kansas
Pressure	Lowest	892.3 mb (26.35 in. Hg)	2 Sep 1935	Matecumbe Key, Florida
	Highest	1078.6 (31.85 in. Hg)	31 Jan 1989	Northway, Alaska

0.98 pound." Consequently, they concluded, "the Coffeyville hailstone of 1970 weighed 1.67 pounds and will retain the designation of heaviest hailstone weighed and verified in the United States."

It should be noted that the NCEC adjudication process can also have a positive impact on the profession. For instance, the review of the 24-h snowfall record for a New York State site led to improved guidance and renewed emphasis on proper snowfall measurement procedures across the entire network. Those actions resulted from the NCEC's overturning of the New York snowfall record due to a failure to follow proper climatological observing practices. Another positive element of this process is the consistency created by having a single adjudication body for these records across the nation.

The U.S. Army Corps of Engineers released a more extensive compilation (Krause and Flood 1997) of various world and regional weather and climate records in 1997 (Table 2). In contrast to many popular weather books addressing such records, this document had, in many cases, a discussion of the quality of the event's historical record. For instance, the hottest sustained (e.g., not a "heat burst") temperature record for the United States (and accepted by the NCEC as the existing maximum temperature record) is 134°F (56.7°C) at Greenland Ranch (now Furnace Creek Ranch) in Death Valley, California, on 10 July 1913. Krause and Flood (1997) discussed the analysis of climatologist Arnold Court who studied the equipment, the data-collection procedures, and the physical setting associated with the event in detail.

The Army Corps of Engineers' compilation did address a few weather and climate categories not addressed by the NCEC, such as fog, dewpoint, and thunderstorms. Interestingly, neither the NCEC nor the Army Corps of Engineers' compilation addresses the verification of certain well-known and frequently discussed weather phenomena such as tornadoes, hurricanes, and lightning. Consequently, "official" designation of the extremes of such phenomena is generally not undertaken by a U.S. governmental agency. Not surprisingly, the National Severe Storms Laboratory's Web page (www.nssl.noaa.gov) states, for the question "What is the smallest, largest, average size [of tornado]?" that "the answer to this depends on what is being measured."

Recognized weather authorities have published statements about some records associated with tornadoes, tropical cyclones, and lightning, but these statements have not been given official status. For example, Grazulis (1993), the noted tornado historian, has stated that the record for the fastest speed of movement for a tornado (as well as for longest tornado path) is the infamous tri-state tornado of 18 March 1925. This tornado maintained an exact heading for 294.5 km (183 miles) of the 352-km (219-mile) track, at an average speed of 27.7 m s^{-1} (62 mph). Many of Grazulis' (and others) historical findings (e.g., deadliest; biggest outbreak; width, now defined as maximum damage width along the path; strongest remotely sensed winds above surface) regarding tornadoes have found recognition in one of the authors' (Edwards) online tornado frequently asked questions (FAQ) section for the NOAA National Weather Service's Storm Prediction Center (SPC; Table 3, see information online at www.spc.noaa.gov/faq/tornado).

In a similar fashion, for NOAA's Hurricane Research Division (HRD), another of the authors (Landsea) developed with colleagues an extensive online Hurricane FAQ section (see information online at www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html) that addresses many records associated with tropical cyclone activity (most intense, fastest intensification, highest storm surge, largest and smallest in size, etc.). For the most part, the FAQ records are linked to documented professional literature associated with a given storm (Table 4). For example, the HRD Hurricane FAQ cities the analyses of Dunnavan and Diercks (1980) in which the most intense tropical cyclone by central pressure recorded is Typhoon Tip in the northwest Pacific Ocean, which experienced a central pressure of 870 mb.

Lightning records are harder to find in a single literary or online source because a) lightning-detection data can be proprietary, and b) much of the information involving such characteristics as injuries tends to be anecdotal. For example, the lightning detection and analyses firm Vaisala-GAI has determined that the record longest-measured lightning flash was 190 km (118 miles) in length, on 13 October 2001. Although the NCDC publication *Storm Data* provides raw report listings of lightning casualties and injuries, it does not provide an easy compilation or identification of records. With regard to statistical analyses of injuries, damage, and regionality, Curran et al. (1997) assessed the lightning records for the United States from 1959 to 1994. However, for such questions as "what is the greatest number of people killed by a single stroke of lightning?" there are a variety of answers from an equally diverse number of sources.

Table 2. Global records and selected regional weather and climate extremes given by Krause and Flood (1997), except for those listed for the United States by the NCEC (Table 1).

Weather element	Element characteristic	Value	Date	Location
Temperature	World's highest temperature	57.8°C (136°F)	13 Sep 1922	El Azizia, Libya
	World's highest annual mean temperature	34.4°C (94°F)	Oct 1960–Nov 1966	Dallol, Ethiopia
	World's lowest temperature	−89.4°C (−129°F)	21 Jul 1983	Vostok, Antarctica (77°32'S, 161°40'E)
	Northern Hemisphere's lowest temperature	−67.8°C (−90°F)	1) 5, 7 Feb 1892 2) 6 Feb 1933	1) Verkhoyansk, Russia 2) Oimekon, Russia
	North America's lowest temperature	−63.0°C (−81.4°F)	3 Feb 1947	Snag, Yukon Territory, Canada
	Lowest average temperature for a month	−73.2°C (−99.8°)	Jul 1968	Plateau Station, Antarctica (79°15'S, 40°30'E)
Temperature variability	Largest 2-min temperature rise (U.S.)	27.2°C (49°F)	22 Jan 1943	Spearfish, SD
Rainfall	World's greatest 1-min rainfall	31.2 mm (1.23 in.)	4 Jan 1956	Unionville, MD
	World's greatest 60-min rainfall	305 mm (12.0 in.)	22 Jun 1947 24–25 Jan 1956	1) Holt, MO 2) Kilauea Sugar Plantation, HI
	World's greatest 12-h rainfall	1.170 m (46.0 in.)	26 Jan 1980	Grand Ilet, La Reunion Island (21°00'S, 55°30'E) (Tropical Cyclone Hyacinthe)*
	World's greatest 24-h rainfall	1.825 m (72.0 in.)	18 Jan 1966	Foc-Foc, La Reunion Island (Tropical Cyclone Hyacinthe)
	World's greatest 5-day rainfall	4.30 m (169 in.)	23–28 Jan 1980	Commerson, La Reunion Island (Tropical Cyclone Hyacinthe)
	World's greatest measured 1-month rainfall	9.30 m (366 in.)	Jul 1861	Cherrapunji, India
	World's greatest measured 12-month rainfall	26.47 m (1042 in.)	Aug 1860–Jul 1861	Cherrapunji, India
	Northern Hemisphere's greatest 24-h rainfall	1.25 m (49 in.)	10–11 Sep 1963	Paishih, Taiwan
Hail	World's heaviest hailstone	1.02 kg (2.25 lbs)	14 Apr 1986	Gopalganj District, Bangladesh
Aridity	World's lowest average annual precipitation	0.8 mm (0.03 in.)	59-yr period	Arica, Chile
Pressure	World's highest SLP	1083.3 mb (32.0 in. Hg)	31 Dec 1968	Agata, Russia
	World's lowest SLP	870 mb (25.69 in. Hg)	12 Oct 1979	Typhoon Tip (16°44'N, 137°46'E)
Humidity	World's highest average afternoon dewpoint	29°C (84°F)	Average Jun	Red Sea Coast of Eritrea (Ethiopia)

* Communication with weather officials at La Reunion led to the determination that the rainfall figure for Tropical Cyclone Hyacinthe in 1980 at Grand Ilet listed by Krause and Flood (1997) is invalid; the correct figure is 1095 mm. Therefore, the 12-h rainfall record remains at 1144 mm during Tropical Cyclone Denise (see Table 4).

Table 3. Tornado extremes as given the SPC online tornado FAQ with additional records from recognized tornado sources (e.g., Grazulis 1993).

Tornado characteristic	Value	Date	Location
World's deadliest single tornado	1,300 killed–12,000 injured	26 Apr 1989	Salturia and Manikganj, Bangladesh
U.S. deadliest single tornado	695 dead	18 Mar 1925	MO–IL–IN
U.S. deadliest tornado outbreak	747 dead	18 Mar 1925	MO–IL–IN (includes the Tri-State Tornado deaths)
Biggest (numerical) tornado outbreak	147 tornadoes	3–4 Apr 1974	13 central U.S. states
Calendar month with greatest number of tornadoes	543 tornadoes	May 2003	United States
Widest tornado (diameter*)	Nearly 4,000 m (2.5 miles) in width	22 May 2004	Hallam, NE, F4 tornado
Highest recorded tornadic wind speed**	135 m s^{-1} (302 mph)	3 May 1999	Bridge Creek, OK
Highest elevation tornado	3650 m (12,000 ft)	7 Jul 2004	Sequoia National Park, CA
Longest tornado transport	A personal check carried 359 km (223 miles)	Apr 11 1991	Stockton, KS, to Winnetoon, NE

*"Widest" is now defined as maximum width of tornado damage by the NWS.
**By necessity this value is restricted to the small number of tornadoes sampled by mobile Doppler radars.

It would be useful to have the assemblage of existing weather-extremes records mentioned in governmental documentary or online sources compiled into a single, updateable official source similar in nature to the Army Corps of Engineers' report. As Krause and Flood (1997) discussed, the original purpose for the Army Corps of Engineers in creating a compilation of weather records was "to assist designers of military equipment with information about the extremes of the natural environment." However, more broadly, they also noted that such records have "also been useful teaching and research aids."

The World Meteorological Organization (WMO) has specified conditions for taking meteorological observations and for siting and calibrating specific types of instruments. However, documentation and validation of world weather records are not so standardized. Documentation (particularly for older reports) and verification (particularly for remote sites) of world weather records can be difficult. In addition to the fundamental concerns involving the calibration and siting of the instrumentation, other questions involving the assessment of world weather records need to be addressed. Some of these questions include the following:

- *How much validity should be given to historical reports predating modern verification practices?* For example, in the spring of 1360 (the 22nd year of the Hundred Years' War), English King Edward III's army in France encountered a terrible thunderstorm near Chartres, France. Edward III's army was preparing to attack the French when, according to the *Old Chronicles* (Froissart 1961), "hailstones [fell] so prodigious as to instantly kill 6,000 of his horses and 1,000 of his best troops." Is that account of this incident reliable enough so that this event can be documented as the most deadly hailstorm on record?
- *What is the geographical scale of the record (e.g., state, country, region, and continent)?* Should there be specific (fixed) boundaries for records based on political or geographic constraints? If records are based on political or social boundaries, should they be reevaluated if the geopolitical or social situation changes (e.g., the breakup of the former Soviet Union or the expansion of an urban metropolitan area)? For example, the Storm Prediction Center (SPC) tornado FAQ notes that Oklahoma City, Oklahoma, has had more tornadoes occur within its city limits than any other urban area. It also states that the number varies because "city limits and tornado reporting practices have changed over the years."

Table 4. Tropical cyclone extremes as given by NOAA's HRD online tropical cyclone FAQ, many of which have been provided originally by Holland (1993).

Tropical cyclone characteristic	Value	Date	Location
Most intense by central pressure	870 mb (25.69 in.)	12 Oct 1979	Typhooon Tip in the northwest Pacific Ocean
Most intense by maximum sustained surface wind	95 m s^{-1} (185 kt, 215 mph)	12 Sep 1961	Typhoon Nancy in the northwest Pacific Ocean
Fastest intensification	100 mb (976–876 mb) in just under 24 h	Sep 1983	Typhoon Forrest in the northwest Pacific Ocean
Highest storm surge	13 m (42 ft)	5 Mar 1899	Tropical Cyclone Mahina; Bathurst Bay, Queensland, Australia
Largest rainfall associated with tropical cyclones			
12 h	1144 mm (45.0 in.)	7–8 Jan 1966	Tropical Cyclone Denise in South Indian Ocean
24 h	1825 mm (71.8 in.)	7–8 Jan 1966	Tropical Cyclone Denise in South Indian Ocean
48 h	2467 mm (97.1 in.)	8–10 Apr 1958	Unnamed tropical cyclone in South Indian Ocean
72 h	3240 mm (127.6 in.)	26 Jan 1980	Tropical Cyclone Hyacinthe in South Indian Ocean
10-day	5678 mm (223.5 in.)	18–27 Jan 1980	Tropical Cyclone Hyacinthe in South Indian Ocean
Largest tropical cyclone (winds from center)	Gale winds (17 m s^{-1}) 34 kt, 39 mph) extending 1,100 km (675 miles) from center	12 Oct 1979	Typhoon Tip in northwest Pacific Ocean
Smallest tropical cyclone (winds from center)	Gale winds (17 m s^{-1}, 34 kt, 39 mph) extending 50 km (30 miles) from center	24 Dec 1974	Tropical Cyclone Tracy near Darwin, Australia
Longest-lasting tropical cyclone	31 days	10 Aug– 10 Sep 1994	Hurricane/Typhoon John in northeast and northwest Pacific Basins
Longest distance traveled by tropical cyclone	13,500 km (8,500 st. miles)	28 Nov– 8 Dec 1960	Hurricane Ophelia in west Pacific basin
Tropical cyclone with longest-lasting category-5 winds	5.50 days	9–14 Sep 1961	Hurricane Nancy in west Pacific basin
Deadliest tropical cyclone	300,000 dead (estimated)	12 Nov 1970	Bay of Bengal (Bangladesh Cyclone of 1970)
Atlantic hurricane records			
Most intense Atlantic hurricane by central pressure	882 mb (26.05 in.)	19 Oct 2005	Hurricane Wilma in the Caribbean Sea
Most intense Atlantic hurricane by maximum sustained surface wind	85 m s^{-1} (165 kt, 190 mph)	17–18 Aug 1969 and 7 Aug 1980	Hurricanes Camille and Allen in the Gulf of Mexico
Earliest calendar-date Atlantic hurricane	1200 UTC 7 Mar 1908	7–9 Mar 1908	Unnamed tropical cyclone (22.7°N, 60.7°W)
Latest calendar-date Atlantic hurricane	1200 UTC 31 Dec 1954	30 Dec 1954– 5 Jan 1955	Hurricane Alice
Largest number of concurrent hurricanes in Atlantic Ocean	Four hurricanes	1) 22 Aug 1893 2) 25 Sep 1998	1) Four unnamed tropical cyclones 2) Georges, Ivan, Jeanne, and Karl
Most active Atlantic hurricane season (Jun–Nov)	27 tropical storms (15 of which became hurricanes)	2005	Storms up to and including Zeta
Deadliest U.S. hurricane	8,000 dead (estimated)	8 Sep 1900	Galveston, Texas

- *What are the temporal boundaries for records and are they adequately noted?* Several times in recent coverage of news events, phrases, such as "worst disaster of all time" or "worst disaster in history" have been used to refer to recording time periods of 50–150 years. For example, the 2005 hurricane season set a record for the greatest number of tropical cyclones in the Atlantic basin (the North Atlantic Ocean, Gulf of Mexico, and Caribbean Sea) with 27 tropical storms, 15 of which became hurricanes. This is an explicit "record" going back to 1851, when the quantitative database starts. However, the reliability of the hurricane data is such that there could have been busier hurricane seasons before the advent of aircraft reconnaissance (in the mid-1940s) and especially before routine satellite surveillance (in the mid-1960s), because some tropical systems could have simply been "missed" or underclassified without the use of this modern equipment. Thus, for this particular record, it is suggested that 1966 be utilized as the start date for a reliable temporal boundary for Atlantic hurricanes (Blake et al. 2005).

  A related question involves whether climatic proxy records can be used to establish an extreme weather record. For instance, Crowley (2000) concluded that recent reconstructions of Northern Hemisphere temperatures and climate forcing over the past 1000 years indicate the very large late-twentieth-century warming is unparalleled over the past millennium. Others have disagreed (e.g., Knappenberger et al. 2001). Can secular and reconstructed climate records, especially those devised across disparate data sources, time scales, or analytical methodologies, be reconciled with regard to establishing climate extremes? And, what are specific categories for which records of weather elements should be kept? Although "most intense" or "hottest" are frequent weather characteristics to which records are applied, many other categories are also possible.
- *How should weather archiving address distinct nonmeteorological (secular) trends in the data?* Secular influences are especially troublesome for climatological analysis and media reporting of severe local storms, for example, because of the numerous, often overlapping, and occasionally contradictory subjectivities involved in the thresholding, reporting, and gathering of event reports. Doswell and Burgess (1988) discussed the highly judgmental and inconsistent nature of the Fujita-scale system for rating tornadoes. Grazulis (1993) cited this and many other factors in the increased reporting of tornadoes with time, especially "weak" ones producing F0–F1 damage. Because of such large secular variations in tornado data, Brooks et al. (2003) were compelled to use tornado days instead of raw tornado reports as a variable in compiling a statistically based tornado hazard climatology. Similar problems, as well as marked reporting discontinuities across political and jurisdictional boundaries, have been identified with aspects of U.S. severe thunderstorm reports (Doswell et al. 2005).

In much of the world outside the United States, where the documentation of severe and extreme weather events may be even less consistent and more nonstandard, the problem of detrending or filtering secular artifacts from the record is an even greater challenge. This clearly must affect any weather extremes database or standardization effort; specifically, it will require prominent mention of caveats in the discussion of the contrasting weather datasets (e.g., Dixon et al. 2005).

Fundamentally, while there is general agreement that a weather-extremes record database is needed, questions remain (particularly at the global scale) as to how extensive an extremes record database should be established; how such a database can be maintained; and, importantly, what procedures, agency, and personnel can be used to adjudicate claims. We offer a couple of alternative proposals for accomplishing this task.

First, a global Climate Extremes Committee similar in nature to the NCEC for the United States might be created under the auspices of WMO. As with the NCEC, it would be tasked with evaluating and adjudicating extreme weather claims for the globe as a whole. However, we believe that NCEC-style format is probably less practical from a global perspective. The NCEC committee was established to bring together the varied institutions best able to address new records. However, because the WMO already exists and the structure for such an effort already exists through the Commission for Climatology (CCl) Open Programme Area Groups (OPAGs), there is less of a need for a central climate extremes committee than for the United States.

Alternatively, and more effectively in our opinion, the development of a climate/weather extremes archive might be best handled by one of the existing

WMO's CC1 OPAGs, such as Group II (Monitoring and Analysis of Climate Variability and Change). Within OPAG II, a working structure for global monitoring activities and a working relationship with other countries involved in climate monitoring already exists, so a climate extremes focus is a natural extension of activities already underway within the WMO.

Fundamentally, in either case, under international auspices, a lead contact for each WMO region might then be tasked with maintenance and verification of extreme climate/weather records in their respective region with oversight by an international committee. Because weather records are often used as indicators that the Earth's climate is changing and/or becoming more extreme, confirmation of new weather-extreme records should continue to be recognized as a high priority in the meteorology community.

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FOR FURTHER READING

Blake, E. S., E. N. Rappaport, J. D. Jarrell, and C. W. Landsea, 2005: The deadliest costliest, and most intense United States tropical cyclones from 1851 to 2004 (and other frequently requested hurricane facts). NOAA Tech. Memo. NWS TPC-4, 51 pp.

Brooks, H. E., C. A. Doswell, III, and M. P. Kay, 2003: Climatological estimates of local daily tornado probability for the United Stats. *Wea. Forecasting,* **18,** 626–640.

Crowley, T. J., 2000: Causes of climate change over the past 1000 years. *Science,* **289,** 270–277.

Curran, E. B., R. L. Holle, and R. E. López, 1997: Lightning casualties and damages in the United States from 1959 to 1994. *J. Climate,* **13,** 3448–3464.

Dixon, P. G., and Coauthors, 2005: Heat mortality versus cold mortality—A study of conflicting databases in the United States. *Bull. Amer. Meteor. Soc.,* **86,** 937–940.

Doswell, C. A., III, and D. W. Burgess, 1988: On some issues of United States tornado climatology. *Mon. Wea. Rev.,* **116,** 495–501.

——, H. E. Brooks, and M. P. Kay, 2005: Climatological estimates of daily local nontornadic severe thunderstorm probability for the United States. *Wea. Forecasting,* **20,** 577–595.

Dunnavan, G. M., and J. W. Diercks, 1980: An analysis of Syper Typhoon Tip (October 1979). *Mon. Wea. Rev.,* **108,** 1915–1923.

Froissart, Sir John, 1961: *The [old] Chronicles of England, France and Spain (H.P. Dunster's Condensation of the Thomas Johnes Translation*). Dutton & Co, 616 pp.

Grazulis, T. P., 1993: *Significant Tornadoes.* Environmental Films, 1326 pp.

Holland, G. J., 1993: Ready reckoner. Global Guide to Tropical Cyclone Forecasting, World Meteorological Organization WMO/TC-No. 560, Rep. TCP-31, 9.28–9.29.

Knappenberger, P. C., P. J. Michaels, and R. E. Davis, 2001: Nature of observed temperature changes across the United States during the 20th century. *Climate Res.,* **17,** 45–53.

Krause, P. F., and K. L. Flood, 1997: Weather and climate extremes. U.S. Army Corps of Engineers Topographic Engineering Center Rep. TEC-0099, 89 pp.

Kunkel, K. E., R. A. Pielke, and S. A. Changnon, 1999: Temporal fluctuations in weather and climate extremes that cause economic and human health impacts: A review. *Bull. Amer. Meteor. Soc.,* **80,** 1077–1098.

NCDC, cited 2005: National Climate Extremes Committee. [Available online at www.ncdc.noaa.gov/oa/climate/monitoring/extremes/ncec.html.]

Pielke, R., Jr., and Coauthors, 2003: The USWRP Workshop on the weather research needs of the private sector. *Bull. Amer. Meteor. Soc,* **84,** ES53–ES67.